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Emotional memory for basic emotions in amnesia

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Emotional memory for basic emotions in amnesia

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Abstract

Emotions are ubiquitous in everyday life, and can often be re-experienced accurately after long periods. Emotions also have a strong mutual influence on other memory systems (most notably episodic memory), but rely on different neuroanatomical structures, and can function independently – often reported in amnesic patients. However, unlike episodic memory, many fundamental questions about the structure of emotions remain unresolved. The two most influential accounts of the organisation of affect (the dimensional and categorical theories) are surprisingly divergent, an issue not addressed by the fact that emotion memory studies tend to be based on two rather than many emotion categories. Moreover, the field lacks sophisticated empirical tools for analysing discrete emotions, and calculating their specificity. Using a novel set of controlled emotional stories, the present thesis investigated the re-experience of four discrete classes of emotion (anger, fear, sadness, and happiness) in three samples: neurologically-normal participants (N=32), Korsakoff's syndrome patients (N=20), and age-matched controls (N=20). The results suggest that: (1) The most durable form of emotional memory encodes affective *valence*. Discrete emotions can be reliably re-experienced, but require stronger forms of emotion elicitation than valence. (2) Remarkably, severely amnesic Korsakoff's syndrome patients show a preserved ability to re-experience discrete emotions, at similar levels of intensity to neurologically-normal age-matched controls. Furthermore, the intensity of discrete emotions, in patients and controls, appears to be related to core executive functions; (3) Using a novel methodological approach, it is clear that the brief experience of certain discrete emotions (e.g., happiness) also increases the specificity of other emotions (e.g., anger and fear). Thus, the present thesis provides a unique attempt to reconcile the dimensional and categorical theories of emotions, and allows the investigation of specific basic emotions, while accounting for the experience of other basic emotions.

Keywords: emotional memory; discrete emotions; re-experience of emotions; amnesia

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Vitam impendere vero

— Juvenal

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Thesis Summary

The present thesis investigates the relationship between the re-experience of discrete basic emotions and episodic memory. The first topic of investigation addresses the fundamental structure of affect. The view that affective experience is best described by a distinct set of basic emotions is supported by a generous and increasing body of behavioural, physiological, and neuroanatomical evidence. However, frequent accounts that certain basic emotions are also highly inter-related (especially on the negative spectrum) are yet unreconciled with the categorical view of affect. A range of experimental work addresses this issue, by investigating the stability of emotion valence and discrete emotions. A second issue is the re-experience of basic discrete emotions, following normal or impaired episodic recall. For example, amnesic patients have long been shown to retain and re-experience emotions, despite their episodic memory impairment, but it is yet unknown whether emotional memory can encode and re-activate a full range of specific discrete emotions. Several studies investigate the re-experience of basic emotions in neurologically normal and amnesic participants.

The first study (presented in Chapter 2) investigated the hierarchical organisation of emotions in an affective conditioning paradigm involving four basic emotions (anger, fear, sadness, and happiness). A group of neurologically normal participants listened to and recalled four sets of stories consisting of a neutral beginning and a different emotional ending for each target basic emotion. The results showed that basic emotions were successfully associated with the neutral beginnings after 30 minutes. However, after one week they appeared to lose their affective specificity, while still retaining the correct positive or negative valence. This is the first experimental report that the most durable form of emotional memory encodes affective valence – and is in line with neuroscientific accounts arguing that phylogenetically older neural systems produce the most stable affect. The data is re-analysed, focusing on the emotional re-experience of the initially neutral and emotional material after one week. While the beginnings of the stories failed to elicit the corresponding target basic emotions, the detailed recollection of the passage that had initially generated the specific basic emotion triggered the selective re-experience of that emotion. These

findings suggest that the process of detailed recollection of emotional events is central for a full affective re-experience. This psychological process has a range of practical and therapeutic applications, such as maximising happiness, improving elite sport performance, and managing emotional disorders.

In the second study (Chapter 3), the emotional memory for a set of four discrete emotions (anger, fear, sadness, and happiness) is for the first time tested in a sample of 20 Korsakoff amnesic patients. Despite a significant episodic memory impairment, the amnesic patients were able to experience the four basic emotions at similar levels of intensity and with a similar specificity to that of neurologically normal controls. Notably, even those patients who failed to remember any parts of the emotional stories, still reported intense emotions with moderate levels of emotional accuracy. Previous reports that negative emotions (e.g., sadness) are experienced for longer by amnesic patients, in the absence of episodic recall, were not confirmed. The findings suggest that even in the absence of most episodic details, the attempt to recall a past event is capable of re-eliciting its original emotional specificity, and this applies equally to all of the four basic emotions. The relationship between a range of neuropsychological variables and emotional memory was also investigated. Importantly, the magnitude of episodic memory impairment was not associated with emotional intensity or accuracy. However, executive functions such as flexibility/rule shifting and problem solving were strongly associated with both emotional accuracy and specificity. Thus, the emotional memory seems to be dependent on the ability to process, monitor, and update information relevant to an emotional event, rather than remember the relevant information over time. Notably, this finding was observed independently for each of the four basic emotions.

Chapter 4 addresses the presently unanswered challenge of analysing simultaneously a full set of discrete emotions. Every emotion induction procedure is likely to elicit, alongside the target basic emotion, a range of other (non-target) emotions, at various levels of intensity. Thus, it becomes essential to establish the degree to which the target emotion has been discretely experienced. A novel computational solution is proposed to establish the emotional intensity (i.e., the overall intensity of an emotional experience described by the ratings of several distinct basic emotions), specificity (i.e., the discrete experience of any basic emotion) and emotional accuracy (i.e., the discrete experience of the intended, target basic emotion). The proposed technique provides a novel parsimonious analysis for three key aspects of emotional experience (intensity, specificity, and accuracy), replacing a succession of individual statistical comparisons with a single data transformation, reducing the risk of loss of statistical power and an increased Type II error. Data from the previous studies are re-analysed and reinterpreted using an exploratory approach, presenting the new set of indices for affective intensity, specificity, and accuracy side-by-side with the traditional method of analysis involving the common ratings of discrete emotions. A summary of the main findings suggests that the specific re-experience of happiness is substantially reduced after the brief interference of a negative emotion experience. Conversely, in certain cases, the specific re-experience of certain classes of negative emotions (e.g., anger and fear) is enhanced by the brief interference of a positive emotion (happiness). The limitations and possible implications of these findings are discussed at the end of the chapter.

In summary, the present thesis reported a range of novel findings, most notably the first evidence that valence is likely to be encoded in the most stable form of emotional memory (compared to discrete emotions), and that the process of active recollection is central for the re-experience of basic emotions. Moreover, attempting to actively recall an event appears to trigger specifically any of the basic emotions that were initially elicited by the event, regardless how much of the event is recalled – and indeed, even when almost nothing of the event is recalled episodically. This surprising phenomenon seems to be explained by the finding that the intensity and accuracy of emotional memory appears to be associated with key executive function abilities and not episodic memory.

Chapter 1. General Introduction

Chapter 1. General Introduction

The present thesis draws from two bodies of affective sciences literature. The first relates to the structure of affect, and specifically to the evidence supporting the existence of discrete classes of emotions. The second relates to the ability to re-experience emotions over time (emotional memory) both in the presence and more interestingly in the absence of the episodic recall of the stimuli which elicited the emotions in the first place. Both these research areas on their own (despite some largely historic and to a lesser extent ongoing disagreement) stand on a significant amount of empirical evidence. On the one hand, the neural substrates of discrete emotions show large overlaps, but few, and unequivocally unique areas are significantly associated with each of the four basic emotions commonly investigated in the literature (i.e., anger, fear, sadness, and happiness). On the other hand, both neurologically unimpaired and amnesic patients show an ability to re-experience past emotions following a brief or complete re-encounter of the original stimulus. The big questions of the present thesis are: how do discrete classes of emotions fit in the overall structure of affect, what are the differences (if any) between discrete emotions in terms of how they are re-experienced over time, and how much of the affective experience can be encoded in emotional memory and re-experienced over time in the absence of episodic recall. More broadly, are discrete emotions able to be re-experienced accurately, in the absence of episodic recall?

1.1 Towards a unified theory of emotions

Intellectual efforts to explore, understand, explain, and as much as possible manage the processes that underpin what are currently called emotional or affective experiences have had a long presence in human history. The earliest recorded attempts to explain emotions, although distinctly different from the present requirements of the scientific method, are commonly attributed to the influential ancient Greek philosophers of Plato (c. 423 – c. 348 BCE) and his student Aristotle (384–322 BCE). The study of emotions in a philosophical context has continued since Antiquity, with contributions from major Western philosophers such as Lucius Annaeus Seneca (4 BCE – 65 CE), Thomas Aquinas (1225-1274), René Descartes (1596-1650), Baruch Spinoza (1632-1677), John Locke (1632-1704), David Hume (1711-1776), to name just a few, and leading up to William James (1884) and the dawn of scientific enquiry in Psychology. The long-running endeavour to understand the experience of emotions is a strong testimony to their significance to human identity, and their ubiquity in everyday life.

As a further reflection of the importance of emotions for understanding the internal mental experience of being human and its outward manifestation, all major schools of thought that followed the scientific enquiry in Psychology have formulated influential if often at times irreconcilable theories of emotions. The breadth of differences between the various approaches is testament to the complexity of emotional experiences and their interaction with other mental and biological functions (currently called cognitive and physiological). Competent reviews of both historical and current theories of emotions have been undertaken previously by other scholars (Power & Dalgleish, 2008; Scherer, 2000). The most important conclusion of such reviews is that for the most part of its long history, the enquiry into the nature of emotions has been marked by a considerable lack of consensus within the community, even regarding fundamental questions such as what emotions *are*, and how we can define them. Even presently, the vast debate and wealth of approaches to the study of emotions are major obstacles to a unifying theory of emotions.

Relatively recent advances in the field of neuroscience have contributed significantly to the understanding of emotions. The investigation of subcortical brain structures and cortical regions associated with the experience of emotions has provided insights about the experience (and thus existence) of different emotions, and has provided the necessary empirical rigour for understanding the interaction between emotions and other cognitive functions. The field of "affective neuroscience" (a term coined by the Estonian-born, American psychologist Jaak Panksepp, 1992) is attracting an increasing interest from psychologists and non-psychologists alike. For example, cross-species studies have confirmed that basic processes of emotional experience are organised within primitive subcortical regions of the brain that are similarly found in other mammals. Moreover, neuroscientific advances in our understanding of the nature of the primary affective processes and their neuroanatomical underpinnings can help inform better clinical models of psychiatric disorders and advance psychiatric practice.

Nonetheless, presently, agreement on the structure and manifestations of emotions is still lacking. Two dominant views on the structure of affect have stood prominent in the literature: the discrete and dimensional approaches. Discrete emotion theorists, famously tracing the origins of their ideas to Darwin’s work, have suggested the existence of a varying number of basic emotions (e.g., anger, fear, sadness, happiness, etc.), which are universally displayed and recognised (Darwin, 1872/1998; Ekman, 1992; Ekman, 1999). The dimensional approach assumes the existence of two or more continuous dimensions (valence and arousal being the most frequently employed being), that describe and distinguish between different emotion states (Barrett & Russell, 1999; Russell, 1994; Russell & Mehrabian, 1977).

1.1.1 Emotions as discrete classes of affect

The evidence for the existence of discrete basic emotions is vast. A brief summary of the main supportive findings include: common cross-cultural facial expressions and eliciting events, and presence of these emotions in other primates (Ekman & Friesen, 1975) and in infants (Izard, Huerber, Risser, McGinnes, Dougherty; 1980); individual autonomic nervous system response patterns (Stephens, Christie, & Friedman, 2010), cardiorespiratory activity (Rainville, Bechara, Naqvi, & Damasio, 2006); different but partly overlapping neural structures (Hamann, 2012; Murphy, Nimmo-Smith, & Lawrence, 2003; Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012; Vytal & Hamann, 2010); specific changes in cognition, judgment, and behaviour (Lench, Flores, & Bench, 2011, but see for a dissenting view Lindquist, Siegel, Quigley & Barrett, 2013).

Originally, these various sources of evidence proposed *different* combinations of basic emotions. However, recent powerful and comprehensive meta-analysis (Murphy et al., 2003; Tettamanti et al., 2012; Vytal & Hamman, 2010) of the neuroscientific evidence seems to consolidate agreement in favour of four (i.e., anger, fear, sadness, and happiness), or possibly five (i.e., the above and disgust) primary classes of affect, which have also, historically, been most consistently reported in the literature (Damasio et al., 2000). As the conceptual representation of emotion states is relatively broad across cultures, with overlapping but not identical linguistic inventories, other emotions are often seen as combinations of these basic emotions or as socially learned variants of these emotions. For example, grief, guilt and loneliness are all variants of basic sadness, (Bower, 1992).

Despite the increasing evidence supporting the theory of discrete emotions, its fundamental assumptions have continued to be scrutinised and challenged, in the search for alternative formulations of the structure of affect. At least four such assumptions seem to conflict with the most common empirical evidence.

Firstly, the central idea that the affective experience is underpinned by a small number of distinct and supposedly independent emotions neither predicts nor explains the common finding that basic emotions are often co-activated. Thus affective experience seems to be almost always described by a blend of basic emotions, best predicted by the distinction between positive and negative affect.

Secondly, although basic emotions are supposed to transcend cultural and social divides, there appears to be a lack of one-to-one mapping of emotion terms between languages (often even within families of languages). Moreover, despite a scientifically driven attempt to assign specific emotion labels to each discrete emotion, the *common language* of most people use an assortment of terms to refer to different instances of supposedly the same discrete emotion.

Thirdly, there continues to be a notorious failure to identify a unique pattern of activation of the autonomous nervous system. Subjective experiences of discrete emotions are not readily associated with unique visceral manifestations.

Fourthly, if universal, but also specific emotion classes have evolved as distinct evolutionary adaptations, then the range (in number) and scope (in definition and function) should be equally unambiguous and definitive. Unfortunately, the exact number of discrete emotions has continued to be an infamous shortcoming of the theory of discrete emotions, whose only resolution has been the circumstantial and changing consensus between scientists. Equally, the definition of each discrete emotion, and their exact adaptive function seem to vary with the circumstances in which they are elicited.

Opposing views to the categorical theory of discrete emotions have built around the argument that affective experiences correlate strongly with a small number of orthogonal dimensions. Valence and arousal have been most frequently and reliably reported (Mayer & Gaschke, 1988; Meyer & Shack, 1989; Russell & Feldman Barrett, 1999; Watson, Wiese, Vaidya, & Tellegen, 1999), with various other dimensions also proposed, such as dominance (Mehrabian, 1996; Russell, 1977), anticipated effort, attentional activity, and situational control (Smith, & Ellsworth, 1985). Most recently, Lövheim (2012), proposed a novel account of the organisation of affect, suggesting that the combinations of the levels of three monoamine neurotransmitters (i.e., dopamine, noradrenaline, serotonin) involved in the affective experience, might explain the experience of a distinct set of eight discrete emotions.

The arguments in favour of dimensional emotion theories have received support from physiological correlates of emotional stimuli, such as heart rate and skin conductance levels, though the breadth and depth of evidence appears more modest than that supporting the categorical accounts. Wundt (1904) developed the first dimensional model, which was later supported by Scherer's (2002) research showing that people tend to perceive the meaning of stimuli as either positive or negative (the valence dimension) and tend to respond to them either passively or actively (the activation dimension). Others proposed the use of independent bipolar dimensions of pleasure–displeasure, arousal, and dominance–submissiveness (Russell; 1994), dominance (Mehrabian, 1996; Russell, 1977), anticipated effort, attentional activity, and situational control (Smith, & Ellsworth, 1985), rather than a small number of discrete emotion categories. In general, valence and arousal have been most frequently and reliably reported dimensions (Mayer & Gaschke, 1988; Russell & Barrett, 1999). In a dimensional taxonomy, all emotion categories vary quantitatively (Russell & Steiger, 1982) and are mapped within a bipolar dimensional space. However, the dimensional approaches (and their mostly correlational empirical support) have received heavy criticism from every new piece of evidence in favour of basic emotions – especially since, at least conceptually, the two accounts seem mutually incompatible. For example, one of the most important dimensions (arousal) appears to be confounded with the intensity of emotions (Reisenzein, 1994; Wintre & Vallance, 1994).

1.1.2 Core affect and the psychological construction of emotional experiences

The view of emotions as various manifestations of core affect evolved from the family of dimensional theories of emotions (i.e., the circumplex model; Russell, 1980, 2005) and comes to answer the fundamental issues raised above. At a structural level, the core affect is defined by two dimensions (or axes): pleasure-displeasure, and activation-deactivation (Yik, Russell, & Steiger, 2008). Both these dimensions are supposed to be expressed simultaneously, in a singular experience, which bridges the previous concepts of emotion and mood - thus at times being a continuous experience, not necessarily directed at an eliciting agent (much like mood), but at other times, can become very intense and overtly linked to an eliciting stimulus (much like pain, or the classical concept of emotions).

The core affect is defined as having two fundamental characteristics. Firstly, it is unique to each individual, and greatly variable from situation to situation (Kuppens et al., 2007). Secondly, it changes in response to many internal and external influences, but most notably only in relation to cognitively processed information (Russell, 2009). When information is not consciously attended, its influence on core affect is said to diminish. Of course, this account fails to acknowledge the experience of emotions in the absence of conscious processing of the stimuli, such as either through masked presentation beyond the perception threshold (Morris, Öhman, & Dolan, 1998; Pessoa, 2005; Whalen, et al., 1998), in clinical cases of amnesia (Feinstein, Duff, & Tranel, 2010; Hamann, Cahill, McGaugh, & Squire, 1997), or the more common everyday occurrence of the "petit madeleine" effect (Proust, 1982/1921). The concept of core affect is not equivalent to the full spectrum of emotional experiences, but it is an intermediary concept between emotion and mood, whose manifestation is highly individual and situation specific.

The role of core affect in the emotional experience is through a series of processes known as psychological construction (Russell, 2009), which define (1) the behavioural and experiential components of the emotional episode (e.g., facial movement, vocal tone, peripheral nervous change, attribution of causation, conscious subjective experience, etc.), (2) the associations between the different components, and (3) the categorisation of the pattern of components as a specific emotion. Thus, psychological construction is responsible for the subjective experience (i.e., individual token events), which may or may not be perceived and classed as discrete (or not so discrete) emotional experiences. The process of psychological construction is not meant to provide a deterministic account of the emotional experience, by acknowledging that this is individual to each person, and specific for each situation. It rather contrasts the biological construction assumed by the theory of discrete emotions, and provides a framework which accommodates the notorious variation of emotional experiences between different cultures, people, and situations.

The psychological constructivist model provides a novel explanation for the origin and role of discrete emotion classes. In managing everyday situations, people often have to be able to describe and identify the emotions they are feeling, and also be able to communicate this to other people. Thus, emotion words (such as fear, anger, sadness) are seen as answering a social need to communicate, rather than an empirical need to classify uniform processes. In everyday situations, the components of psychological construction (detailed above) are occurring in various forms. And while each emotional experience is different, some similarities will emerge, as a matter of degree (some situations more similar than others). In an attempt to organise, compare, understand and communicate, people assign certain experiences to certain classes, without all situations being equal. For example, one situation might feel like a perfect example of what the experience of fear would be, while other situations might be only mediocre or borderline examples. However, although the subjective experience of emotion is organised, understood, and communicated using the familiar mental categories of anger, fear, sadness, shame, etc. the processes by which they were experienced are fundamentally unique. They are only reported as fear, or anger, or happiness, because people need to refer to their emotional experiences (either for own reflection or for communication) using a system which is efficient, useable and which is also recognised by other people.

In conclusion, instead of relying on a series of distinct processes specifically developed for the experience of a limited set of basic emotions (anger, fear, sadness, etc.), the psychological constructivist view argues that all emotional experience originate from core affect, and a multitude of other processes (e.g., behavioural, cognitive, experiential, somatic, neural, etc.) unique to each individual and to each situation. And the fundamental dimension of core affect are valence (positive or negative) and activation (or arousal).

Although the dimensional and categorical classifications of emotions appear to be mutually exclusive, it has been proposed that the two theories can coexist successfully. This would be made possible by viewing the two theories as describing different and complementary aspects of emotional experience. This argument was recognised by the hierarchical model of emotions (Tellegen, Watson, & Clark, 1999), which proposed that valence is a fundamental dimension of affect, superimposed on a series of discrete classes of affect. However, to this date it remains largely under-investigated, and will be experimentally addressed in Chapter 2.

In summary, the affective science literature is markedly fragmented, notably in respect to fundamental questions about the structure of affect. Any comprehensive theory of emotions should seek to bring together its most systematically validated arguments. To this end, understanding the structure and manifestation of emotional experiences seems to best be served by harmonising the presently opposing dimensional and categorical theories of emotions. Encouragingly, experimental techniques allow the measure of discrete emotions and valence. The present thesis will employ the measure of discrete emotions, while also retaining and analysing the underlying dimension of valence. Chapter 2 is dedicated to further exploring the relationship, and also the difference between basic classes of affect and their positive or negative valence.

1.2 Emotions, consciousness and the concept of self

The experience of emotions is an intimate aspect of human existence, frequently associated with, and described as a part of the concept of self (Panksepp, 2004). The neural seat of consciousness (and possibly of the "self") has been suggested as lying deep in the subcortical regions of the brain. Neuroscientific evidence suggests that the midbrain, one of the phylogenetically oldest brain regions is responsible for the most basic forms of consciousness, the generation of the representation of “self”, and the initiation of basic affective states (Davidson & Hugspeth, 1995; Ross, Homan, & Buck, 1994).

Recently, the evidence of neuroscientific basis of consciousness of the concept of self has been discussed by others (Gennaro, 2012; Merker, 2007; Morin, 2006). The concept of consciousness and self in humans has been described across at least two levels – a basic system originating in the brainstem (Parvizi & Damasio, 2001) and a superior form of consciousness involving the prefrontal cortex (PFC; Mantyh, 1982; Sesack, Deutsch, Roth, & Bunney, 1989). A similar hierarchical organisation of emotions seems to reflect the organisation of the self/consciousness. It is well recognised that basic discrete emotions essentially involve more phylogenetically recent cortical structures (Hamman, 2012). Thus, discrete emotions may play a role in higher forms of consciousness (also involving cortical structures), while affective valence may help define experiences associated with lower level of consciousness and self.

The distinction between the two levels of the affective experience: a low level (valence) and a higher level (discrete classes of emotion) has also been linked to agency. Positive and negative emotions (sometimes referred to as “basic emotional energies”; Panksepp, 2004, pp. 315) can exist in the absence of a causing agent. In this sense, happiness is not the same as positive affect, but a higher, more complex form of positive emotional energy. Notably, in most cases, discrete emotions such as anger, fear, sadness (in the sense of loss, or separation, rather than a general sense of dejection or “*un-happiness*” – an umbrella term for negative affect), and happiness (with the meaning of excitement, or joy, rather than a general sense of elation – more readily associated with the overarching concept of positive affect), unmistakably require an agent. The integration of agent-related judgements presumably requires to various extents more complex cognitive functions like episodic memory, judgement, planning, and foresight. However, the most common forms of everyday emotion derive their rich cognitive ramifications from interactions with higher brain functions, and can also be triggered at various levels of the neuroaxis by minimal stimuli as a form of classical affective conditioning.

1.3 Memory for emotions and emotional memory

Memory for past emotions has been argued to be generally accurate (Levine, Lench, & Safer, 2009), and emotional stimuli and events are usually remembered more vividly than emotionally neutral information (Todd, Talmi, Schmitz, Susskind, & Anderson, 2012). However, studies investigating explicit memory for emotions have reported consistent biases in remembering the emotional experience triggered by past events. In a review of studies on the accessibility of emotional self-report, Robinson and Clore (2002) argue that retrospective emotion reports can potentially be subject to general semantic memory biases (when episodic details are relatively inaccessible) and to episodic memory biases (e.g., peak and recency effects). Reports of biases in the implicit memory for emotions have been far fewer than in the case of explicit memory (Levine, Lench, & Safer, 2009).

Memory for negative arousing stimuli was reported to be less prone to distortion than the memory for neutral stimuli. Kensinger and Schacter (2006) used a reality monitoring paradigm (Johnson, 1988; Johnson & Raye, 1981) in which they presented aurally (via headphones) a series of words, half of which were also presented visually (on a screen) and asked participants to perform a letter height decision task (i.e., indicate whether the first letter of the word they were presented was taller than the last letter of the word; e.g., in the word “toes” the letter “t” is taller than the letter “s”). They later asked participants to identify which words had been presented visually. The results indicated that the emotional stimuli showed lower misattribution rates than the emotional stimuli both in an incidental and intentional encoding scenario. The findings remained robust even within the same presentation modality, that is, when names of objects were presented on a screen followed or not by the picture of the object, and participants were asked to judge the physical dimensions of the objects (i.e., whether or not they could fit in a show box). Because the orienting tasks required participants in both experiments to build a mental representation of the target stimuli (i.e., imagine the written word or the image of the object), the authors concluded that negative emotional items can increase the ability to discern between the internal generation and external presentation of a stimulus, and that in this respect the memory for negative emotional items can be less prone to distortion than the memory for neutral material.

Moreover, a number of biases have been revealed to affect the experience of emotions and their recall, such as, moments of peak intensity increase recalled emotion; changes in appraisals of past situations influence memory for emotions; false memories for emotions can be assimilated with real memories; recent experiences and current goals alter the emotional response). More recently, the study of emotional memory in amnesia has received an increasing attention, especially in the last two decades. For example, the preserved ability to encode and retrieve emotional information has been reported in patients with both unilateral (LaBar, LeDoux, Spencer, & Phelps, 1995) and bilateral hippocampal damage (Bechara et al., 1995). Remarkably, the ‘after-effects’ of certain discrete emotions (sadness) seem to be better preserved in amnesics than in non-neurological controls, while other emotions (happiness) show no significant differences (Feinstein, Duff, & Tranel, 2010).

1.3.1 Differences between implicit and explicit emotions

Research investigating emotional memory has followed the distinction between explicit and implicit memory (Levine & Safer, 2002; Levine, Lench, & Safer, 2009). Studies examining the explicit memory for emotions focused on people’s ability to encode and store emotional experiences in memory and deliberately retrieve them at a later time (e.g., Morewedge, Gilbert, & Wilson, 2005; Wirtz, Kruger, Scollon, & Diener, 2003). By contrast, studies investigating the implicit memory for emotions tested associative learning, using, for example, fear conditioned visual stimuli (Öhman & Soares, 1998; Kuriyama, Soshi, Fujii, & Kim, 2010) and the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994). Furthermore, studies involving amnesic patients offered a new avenue of research into implicit emotional memory (Claparède, 1911/1951; Feinstein, Duff, & Tranel, 2010; Turnbull & Evans, 2006).

1.3.2 Biases Affecting Explicit Memory for Emotion

In agreement with studies of explicit memory for emotions, Robinson and Clore (2002) proposed an "accessibility model" of emotional self-report. According to this theory, affect was assumed not to be stored directly in memory and thus, emotional experiences could only be reported and studied as they are being felt (see for previous formulations of this view, Christianson & Safer, 1996; Kahneman, 1999; Ross, 1989; Wyer, Clore, & Isbell, 1999). Later emotional reports were thought to be only representations of the original emotion, based on available information at the time of recall. These information sources were identified as the episodic memory for the context that had triggered it and situation-specific and identity-related beliefs about what type of emotion could have been felt in those circumstances. The accessibility model states that when people attempt to recall a past emotion, they first access episodic memory for the event, as being the most specific source of information. If this is not available, they next turn to their beliefs about what a typical emotion would be for the particular type of situation. And if those beliefs do not suffice, or are not formed yet, people would then retrieve their beliefs about what their emotions are in general. Robinson and Clore argued that, for this reason, that any attempt to recall an emotional experience automatically involves a loss of information. Therefore, any report of past emotions would be susceptible to biases affecting episodic memory and situation-and identity-specific beliefs. This view on emotional self-report was supported by a growing body of research documenting the factors influencing people's recollections of emotions, among which the most documented are the peak-and-end effect (Fredrickson, 2000), the current appraisals of past events (Levine, 1997), and individual differences, such as personality traits (Feldman Barrett, 1997; Safer & Keuler, 2002) and motivation and emotion regulation strategies (Cutler, Larsen, & Bunce, 1996; Lench & Levine, 2010).

1.3.2.1 Peak-and-end effect.

Fredrickson and Kahneman (1993) reported recency and peak intensity effects of explicit memory for emotions. They asked participants to rate the intensity of their emotions after a series of emotional video clips. Peak intensity and final emotional reaction were the main factors affecting the subsequent recall of the overall intensity of their emotions (see also for a review of the peak-and-end rule Fredrickson, 2000). The current emotional state is another predictor of the intensity of recalled emotions. Safer, Bonanno, and Field (2001) found in a longitudinal study that after five years from the death of their spouses, when widows and widowers were asked to remember the grief they felt earlier, reported intensity of emotions was more highly correlated with current grief than with actual past emotion.

1.3.2.2 Current appraisals of past events.

Levine (1997) argued that current appraisals of past events influence the explicit memory for emotions evoked by those events. People's memories for the intensity of emotions elicited by the 1992 withdrawal of Ross Perot from United States presidential campaign varied accordingly with their later attitudes towards the candidate. Furthermore, certain beliefs were found to influence the memory for some discrete emotions, but not for others (Levine, Prohaska, Burgess, Rice, & Laulhere, 2001). After the verdict of a famous criminal trial held in Los Angeles (People vs. O.J. Simpson), participants' later appraisals about the desirability of the outcome affected their memory for *happiness* and *anger*, but not surprise at the announcement of the decision. Conversely, participants who later reported they were expecting the verdict, underestimated their initial surprise, but recalled correctly how happy or angry they were at hearing the result of the trial. A very similar pattern was found at two months and more than a year after the verdict, which suggest the biases remain stable over time. The effect of appraisals on emotional memory was supported not just by correlational findings, but experimental studies as well. Safer, Levine, and Drapalski (2002) manipulated participants' post-event knowledge and found that when informed about the outcome of an event (results of university examinations), participants distorted their recollections of emotions (intensity of test anxiety, positive emotions and negative emotions) at the time of the event (before and during the exam) in accordance with the grades they obtained. No such distortion was found when participants were asked to recall their emotions before they found out their grades.

1.3.2.3 Individual differences.

Individual differences, such as personality traits, motivation and emotion regulation strategies were reported to influence explicit memory for emotions. High ratings on negative personality traits (e.g., neuroticism, depression, anxiety) tended to be associated with overestimation of past negative emotions (pre-psychotherapy distress, and momentary negative emotions), while high score on positive personality traits (e.g., extroversion, ego-strength) with underestimation of initial distress and with the recall of more positive emotions (Feldman Barrett, 1997; Safer & Keuler, 2002). People's motivation and goals were also found to predict distortions in memory for emotions. Lench and Levine (2010) reported that participants who were generally motivated by positive outcomes, responding to information signalling potential reward via a behavioural activation system (approach motivation) and showed an approach goal to a challenging task (wanted to successfully complete the task) later overstated the intensity of happiness experienced during the task. However, participants who tended to be motivated by negative outcomes, employing a behavioural inhibition system (avoidance motivation) and showed avoidance goals (wanted to avoid failure on the task) later recalled higher levels of anxiety than they declared during the task. Emotion regulation strategies seemed also to affect people's memories for past emotions. Cutler, Larsen, and Bunce (1996) asked university undergraduates to complete a daily mood report over four weeks and then, at the end of the study, to recall the mood they experienced during the reporting period. Biases in memory for emotions were analysed from the perspective of the emotion regulation strategies employed by the students. Participants who showed a repressive coping style underestimated negative emotions, while highly anxious participants overstated the intensity of negative emotions.

1.3.2.4 "Foreign" emotions.

Studies following a line of research originating in the area of eyewitness testimony have reported that memories for emotions can be just as easily implanted as memories for events (Laney & Loftus, 2008; see also Porter, Yuille, & Lehman, 1999, for an earlier account using a more laborious design). Hundreds of studies going back to the 1970's, revealed the malleability of our memory for events. When people are presented new and misleading information about an event they had previously experienced, their recollections become distorted (misinformation effect; Loftus 1979, 1995; Loftus & Palmer, 1974; see also Wright & Loftus, 1998 for a review). More recently, this memory bias has also been replicated in other fields that could potentially attempt to deliberately change people's memories, such as advertising (Braun, & Loftus, 1998; Braun-LaTour, LaTour, Pickrell, & Loftus, 2004) and media (Sacchi, Agnoli, & Loftus, 2007). The area was further expanded when an emotional dimension was introduced and the misinformation effect was successfully replicated. Laney and Loftus used a simple false feedback paradigm to create false memories of emotional childhood events, and then asked participants to remember the intensity of the emotions experienced at the time. Participants with true memories for the events reported the same levels of fear, sadness, confusion, disgust, and responsibility as those who never experienced the events, but only thought they did as a result of the false feedback.

However, a framework such as the accessibility model cannot account for situations in which people do not consciously retrieve a past emotional experience, but do show signs of employing past emotions when dealing with current situations. For example, in a recent study Kuriyama et al. (2010) reported that after a fear conditioning paradigm, event recognition decayed, but emotional recognition increased. Moreover, this effect was obtained despite the stimuli being very similar (pictures of a car driving along a typical city street, shot from the driver's viewpoint, controlled for image complexity and recall cues). These findings suggest that despite a loss in episodic memory and undifferentiated situational and identity factors, people's recognition of past emotions associated with neutral stimuli remains unaltered, and possibly improves, over certain periods of time. Therefore, despite being a useful tool for understanding emotional memories which require a deliberate recall of the encoding experience (i.e., explicit emotional memory, see Levine et al., 2009), access to past emotions is also obtained through a different system (i.e., implicit memory for emotions, see Levine et al., 2009), which does not involve the conscious recollection of the emotional event, and which remains unexplained by the accessibility model.

1.3.3 Biases Affecting Implicit Memory for Emotion

The implicit memory for emotions is often linked with an influential account of the relationship between emotions and cognition, given by the Somatic Marker Hypothesis (SMH; Damasio, 1994, 1996). According to the SMH, emotions originate from the subjective perception of the complex range of homeostatic changes that occur in given situations, or from their representation in the brain. For example, in the case of decision-making, for every option that is being contemplated, a somatic state is generated, which acts as an indicator (somatic marker) of the value attached to the option that is considered. These somatic representations in the brain are continuously updated. In addition, the SMH claims that somatic memories may be associated with the stimuli that caused the somatic change. These learned somatic reactions may be activated when re-experiencing similar stimuli, causing an anticipated perception of these emotions (see, for a critical review of SMH, Dunn, Dalgleish, & Lawrence, 2006).

1.3.3.1 Current goals.

Current goals were reported to influence implicit memory for emotions. Ferguson and Bargh (2004) presented participants with stimuli useful for successfully performing a task that they were induced to either care about or not. When participants were motivated to perform well, they later showed a more positive implicit attitude towards the stimuli than participants who were presented with the task but were instructed that their performance would not be important for the experiment.

1.3.3.2 Implicit evaluative procedure.

Olson and Fazio (2006) assessed the influence of an implicit evaluative conditioning procedure on automatic racial prejudice. Participants in the control condition showed an implicit prejudice by responding faster to positive words after white faces than after black faces. This effect was reversed after participants were exposed to a conditioning phase in which black face were paired with positive words. Therefore, further experiences and current emotions were shown to distort implicit memory for emotions.

1.3.3.3 Variable associative patterns.

Changes in activation of associative patterns were argued to represent another bias in implicit memory for emotions (Gawronski & Bodenhausen, 2006). When a stimulus is associated with different attitudes and affective responses, subtle cues can determine which associative pattern is activated and this directs the emotional response. For example, Foroni and Mayr (2005) found that different contexts distort the emotional preference for flowers over insects measured using the Implicit Association Test (IAT).

Participants were asked to read a fictional post-nuclear war scenario in which either flowers or insects were contaminated and thus should be avoided by any means in order to ensure survival. At the same time, the other target category (i.e., insects and flowers respectively) represented the only indirect food resource for humans, and accordingly acquired a positive valence. In a separate condition, participants were instructed to try and think of flowers/insects as negative or positive and to perform the IAT with the appropriate association in mind. The results showed that the fictional scenario was able to reduce the implicit emotional preference for flowers over insects, but not the direct instruction to imagine that flowers are good and insects are bad. The findings suggest that a single reading of fictional scenarios can successfully activate different associative patterns leading to changes in implicit emotional responses.

In conclusion, the memory for emotions elicited by affective stimuli and events is often influenced by a range of internal (cognitive) and environmental factors (described above). However, despite the many reports that valence and affective category also have a distinctive influence on memory for emotions, its direction and mechanisms remain disputed. A distinct opportunity to study emotional memory consists in investigating the implicit affective associations that form between eliciting stimuli and emotional experiences.

1.4 Emotional memory and affective re-experience in amnesia

The subjective sense of remembering emotional events has been shown to be driven by different neural systems than the recollection of non-emotional memories (Ulrike, Lile, & Phelps, 2012). Nonetheless, as discussed in the previous section, episodic memory systems can influence the assessment of the emotional value of a stimulus over time. The context and details surrounding the initial emotion elicitation can be accessed and their retrieval and re-processing influence the present affective value of the stimulus. Moreover, emotions can also be re-experienced prior to the conscious episodic recall of the eliciting situation (using affective conditioning paradigm; Dawson, Rissling, Schell, & Wilcox, 2007; De-Houwer, Thomas, &

Baeyens, 2001; St-Laurent, Moscovitch, Levine, & McAndrews, 2009) and indeed even when neurological deficits cause episodic memory systems to be permanently and severely disrupted – such as in the case of densely amnesic patients (see Buchanan, 2007; Haman, 2001).

The ability to access (or more precisely re-experience) past emotions directly, prior to or in the absence of other forms of memory (most notably episodic memory) has led to the conclusion that affect benefits from a dedicated neural system for encoding, storage and retrieval of subjective emotional experiences, called emotional memory (Squire, 2004). Although preferentially processing and encoding affective experiences, the system is highly interconnected and strongly influences other memory systems, such as episodic and semantic memory (Dunsmoor, Murty, Davachi, & Phelps, 2015; LaBar, 2004; Phelps, 2004; Phelps, LaBar, & Spencer, 1997).

An extensive body of literature investigating the memory for emotionally arousing material has identified the amygdala as a key brain region for emotional memory (Brierly, Medford, Shaw, & David, 2004; Canli, Zhao, Desmond, Glover, & Gabrieli, 1999; Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000; Hamann, 2001; LaBar & Cabeza, 2006; LaBar, LeDoux, Spencer, & Phelps, 1995; Phelps, 2006; Phelps & LeDoux, 2005). As a bilateral subcortical structure shared with other mammalian species, the role of the amygdalae in the memory for aversive or appetitive stimuli was first identified in animal studies (see for a review McGaugh, 2000). Extensive human research has confirmed the role of the amygdala in emotional memory and its modulating influence on other forms of memory when encoding emotional material. Non-declarative (e.g., conditioned responses) and declarative form of memory (episodic and semantic) for emotionally enhancing stimuli has been shown to be modulated by the amygdala (Adolphs, 1999; Adolphs, Cahill, Schil, & Babinsky, 1997; Buchanan, Tranel, & Adolpsh, 2005; Denburg, Buchanan, Tranel, & Adolphs, 2003; LeDoux & Muller, 1997). Through its interactions with a wide range of neural structures (e.g., anterior hippocampus, anterior and posterior parahippocampal gyrus, the left lateral prefrontal cortex, and right ventral parietal cortex), the amygdala can influence perceptual processing, semantic elaboration, and attention in the formation of emotional memories (Murty, Ritchey, Adcock, & LaBar, 2010). Lesion studies have shown that the amygdala preferentially processes gist and emotional memories, while surrounding medial temporal structures are involved in the memory for general episodic material (Adolphs, Tranel, Buchanan, 2005). The neuromodulatory effect of arousal on memory (rather than valence) seems to be the most important contribution of the amygdala to emotional memory (Phelps, LaBar, Anderson, O'Connor, Fulbright, & Spencer, 1998). The amygdala's contribution to emotional memory appears to be lateralised, with the right (and not left) amygdala involved in the retrieval of aversive, high-intensity emotions (Buchanan, Tranel, & Adolphs, 2006). The left amygdala appears to have a specific role in the enhanced perception of negative arousing stimuli (Anderson & Phelps, 2001).

In the last decade, the amygdala's role as the central structure in processing the retrieval of emotional memories has come under increased scrutiny. Recent studies have confirmed amygdala's role in processing negative, high-intensity emotions (i.e., fear, and ager), but also showed that other basic emotions can be experienced even following extensive amygdala lesions (Feinstein, Adolphs, Damasio, & Tranel, 2011; see also an earlier reports Anderson & Phelps, 2000; Phelps, O'Connor, Gatenby, Gore, Grillon, & Davies, 2001). Amygdala-lesioned patients were shown to be able to experience positive and negative emotions, and displayed a typical arousal to positive stimuli, but a severely impaired response to negative arousing stimuli. Other structures (i.e., the insular cortex) may play a greater role than the amygdala in modulating the arousal of both positive and negative stimuli, as well as integrating both cognitive and affective processes, while the amygdala may have a selective role in the arousal of negative stimuli (Berntson, Norman, Bechara, Bruss, Tranel, & Cacioppo, 2011).

1.4.1 The experience and re-experience of emotions

The investigation of emotional experience prior to or in the absence of episodic recall presents a unique opportunity to study emotional memory systems. The emotional experience following the recollection of past events is thought to activate the original emotion (emotional memory), as well as potentially elicit new emotions (Levine &

Safer, 2002). It is widely recognised that the actual (physical) or imagined (metal) experience of an emotional situation can elicit an affective response (Destun & Kuiper, 1999; Turner, Simons, Gilbert, Frith & Burgess, 2007). Thus, when re-living a past event through conscious recollection it is impossible to discern between the re-experienced emotions (triggered by the affective associations created initially and stored in emotional memory systems), and the potential experience of new emotions, as a response to the mental (imagined) encounter of the affectively potent stimuli. In order to isolate the re-experience of emotions from the possible experience of “new emotions”, the contribution of episodic memory systems needs to be suppressed.

Affective conditioning paradigms offer an accessible solution to this problem. Presenting an emotionally neutral stimulus in the context of an emotional situation, allows to later assess the emotional response to the affectively conditioned stimulus in the absence of the recollection of the actual emotional event. An alternative opportunity to study affective re-experience is offered by neurological patients with selective lesions to episodic memory systems (amnesic patients). This is particularly relevant as Pavlovian conditioning to emotionally stimuli can take place both through direct or indirect experience such as following observation or verbal instruction (Olsson & Phelps, 2004, 2007), the latter proving to be more ethically appropriate experimental paradigms for this patient group.

1.4.2 Emotional memory in amnesia

Amnesic patients have long been reported to show intact emotion-based learning. Possibly the earliest account is the classic case study of an elderly woman suffering from the Korsakoff’s syndrome (Claparède, 1911/1951). The Swiss neuropsychiatrist Eduard Claparède introduced himself with a handshake every time he came to see her. However, when he started hiding a sharp pin in his hand, which would surprise the patient and inflict a small amount of pain during the handshake, she would later adamantly refuse to shake his hand, despite her inability to recall any previous handshakes or their displeasing outcome.

Since this early report, emotional memory was shown to be in amnesic patients. The enhancing effect of emotion on perception and memory are intact in amnesia. For example, Hamann, Cahill, and Squire (1997) showed that emotional arousal of either positive or negative valence enhances the recall and recognition of visual emotional stimuli (pictures) to the same extent as for non-amnesics. Similar effects were reported when amnesics and neurologically normal controls listened to emotionally arousing stories. Recognition memory for the emotional elements of the stories was similarly enhanced for amnesics and controls (Hamann, Cahill, McGaugh, & Squire, 1997). However, the flexibility of the emotional memory seems to be limited in amnesia. Following a successful acquisition and extinction of an affectively conditioned fear response, hippocampal amnesic patients showed an inability to reinstate the fear response in the same context, unlike neurologically normal controls (LaBar & Phelps, 2005). Thus, environmental contexts and hippocampal activity seem to regulate the expression of latent affective conditioning.

The recall of both positive and negative emotional autobiographical memories appears to be intact for purely amnesic patients, with brain lesions confined to hippocampus (Buchanan, Tranel & Adolphs, 2005). However, more extensive lesions including the hippocampus, amygdala and the parahippocampal cortices lead to a selectively reduced memory for negative and highly emotional events from one's own past. Amygdala's role of integrating emotion, perception and cognition was reported to be crucial in cueing the emotional significance of mnemonic events and re-activate the neural connections required for the affective re-experience – as seen in rare cases of Urbach-Wiethe patients with a selective calcification of the amygdala and periamygdaloid gyri (Markowitsch & Staniloiu, 2011).

Emotional memory is preserved in amnesic patients when more complex contingency patterns of emotional experience are used. Turnbull and Evans (2006) presented the case of SL, an 85-year-old man with a dense anterograde amnesia following a left posterior artery infarction. In spite of his inability to form new episodic memories, SL showed unimpaired learning of the Iowa Gambling Task (Bechara et al., 1994; Damasio, 1994), at levels comparable or even better than age-matched controls on three separate sessions, spanning across three weeks, even when the reward-contingency pattern was shifted between sessions. The findings, thus, show that amnesic patients can preserve an intact ability to encode and utilise emotional memories even when presented with complex patterns of valence learning (see also, Evans-Roberts & Turnbull, 2011).

The emotional experience of patients with severe amnesia (following circumscribed bilateral damage to the hippocampus) endures after the explicit memory for the eliciting event has faded (Feinstein, Duff, & Tranel, 2010). Notably, the effects were found for both sadness and happiness. A series of film clips induced either sadness or happiness. A post-induction memory test revealed that the amnesic patients retained little or no information about the clips, but they continued to experience more elevated levels of sadness and similar levels of happiness when compared to the non-neurological controls (whose memory for the film clips was intact). The results indicate that the emotional experience of amnesic patients surpasses their limited memory for episodic events. The two basic emotions (happiness and sadness) seemed to indicate a different pattern of stability across time (with sadness being more enduring than happiness), although the lack of information about the patients psychiatric history (e.g., depression) poses a significant limitation on the validity of this later conclusion.

In summary, affective systems are able to function independently of episodic memory. However, the literature has not yet integrated the structure and forms of affect supported by the strongest empirical base, namely the discrete classes of emotions. As presented in the earlier sections of this chapter, the affective experience can be reliably described by a distinct set of basic emotions, but it remains unknown how such discrete classes of affect relate to episodic memory, and how they are re-experienced in amnesia.

1.5 Korsakoff syndrome aetiology, neuropathology and cognitive performance

In 1887 Sergei Sergeievich Korsakoff (Victor & Yakovlev, 1955) described a neurological syndrome characterised by general confusion, ataxia (loss of muscle coordination), and nystagmus (abnormal saccadic back and forth eye movements when looking at moving visual stimuli). Korsakoff also described the associated chronic changes in mental functioning, most notable of which were the temporally graded loss of memory for past events (retrograde amnesia), and the inability to form new memories (anterograde amnesia). Years later (Gudden, 1896), Korsakoff's observations were linked to the previous reports of three patients made by Karl Wernicke in 1881. Wernicke described symptoms of fatigue, vomiting, headaches, ocular impairment, and a staggered gait (Thomson, Cook, Guerrini, Sheedy, Harper, & Marshall, 2008). Over the last century a considerable amount of knowledge was gained about the two disorders, which have become synonymously known as Wernicke-Korsakoff syndrome. It is generally agreed that the syndrome has an acute and chronic form of presentation, which are referred to as Wernicke's encephalopathy and Korsakoff's syndrome, respectively.

The onset of Wernicke's encephalopathy is sudden and is usually marked by disorientation, confusion, and apathy. The patient is often unable to maintain a coherent conversation and the state of confusion is accompanied by ataxia and oculomotor symptoms, although considerable variability exists between patients (Reuler, Girard, & Cooney, 1985). If patients are diagnosed early and treated promptly the symptoms of Wernickes' encephalopathy can be reversed. However, failure to diagnose and treat the disorder, may result in the permanent brain damage known as Korsakoff syndrome.

In Korsakoff syndrome the confusion from the acute phase clears and the patient is typically left with a profound memory impairment. The defining feature of the Korsakoff syndrome is the inability to retrieve recent memories and remember new events, in the context of otherwise preserved cognitive functioning. Other common symptoms include confabulation (Falsification of memory in clear consciousness – making up stories or events) and hallucinations (sensory perception of stimuli that are not actually present), apathy, lack of initiation, as well as signs of gait and ocular disorders. Symptoms can range from relatively mild to severe.

The acute phase of the Wernicke's encephalopathy can sometimes be mute, and patients appear to present directly with the Korsakoff syndrome symptoms (Blansjaar & Van Dijk, 1992). Many have argued that based on the common neuropathology of the two syndromes, they should be considered as a single syndrome, with an early (acute) and late (chronic) stage.

1.5.1 Aetiology

It is now fully recognised that the Wernicke-Korsakoff syndrome is a condition that occurs as a result of a severe avitaminosis (nutritional deficiency), especially a lack of thiamine (vitamin B1). Thiamine is not synthesised in the body, and internal stores usually last for a few weeks. Thus, if the intake or the absorption of thiamine are reduced for an extended period, the patient is at risk of developing Wernicke's encephalopathy.

Currently, most cases of thiamine deficiency are associated with chronic alcohol abuse. Long-term over-consumption of alcohol can lead to thiamine deficiency in three ways: (1) by decreasing absorption of thiamine from the gastrointestinal tract following stomach and liver damage, (2) by impairing thiamine utilisation in the cells, and (3) by causing inadequate nutritional thiamine intake through an imbalanced diet (Thomson & Marshall, 2006). However, non-alcohol related cases have been reported in cases of prisoners of war (De Wardener & Lennox, 1947), severe pregnancy sickness (hyperemesis gravidaru, Yoon, Chang, & Lee, 2005), gastrointestinal disorders (Shimomura, Mori, Hirono, Imamura, & Yamashita, 1998), anorexia (Handler & Perkin, 1982), and following certain surgical procedures, such as laparotomy for small bowel obstruction or bariatric surgery (Aasheim, 2008; Deb, Law-Min, & Fearnley, 2002). Other chronic conditions may cause a thiamine deficiency including AIDS, thyrotoxicosis, metastatic cancers, long-term dialysis and congestive heart failure (when treated with long-term diuretic therapy).

Emergency clinical practice has also been responsible for a number of Wernicke-Korsakoff cases, when severely malnourished patients were administered intravenous glucose. For such patients with depleted levels of thiamine a glucose supplement can precipitate or worsen Wernicke's encephalopathy by driving thiamine intracellularly. Current good clinical practice demands administration of thiamine prior to or simultaneously with glucose infusion in patients at high risk for Wernicke-Korsakoff syndrome. This is usually done using a multivitamin intravenous fluid (banana bag) containing thiamine, magnesium, folate, and other vitamins (Krishel et al., 1998; Li et al., 2008).

Wernicke's encephalopathy is considered a medical emergency. Untreated, it leads to death in up to 20% of cases, or to the Korsakoff's syndrome in 85% of survivors (Kopelman Thomson, Guerrini, & Marshall, 2009). The recommended treatment involves intravenous administration of thiamine, usually for over 30 minutes. The long-term rehabilitation involves thiamine supplementation and a correction of the triggering factors. Where a history of alcohol misuse or dependency is suspected, abstinence is paramount to recovery.

1.5.2 Neuropathology

The pathology of Korsakoff patients involves primarily lesions to the dorsomedial nucleus of the thalamus and to the mammillary bodies (Victor, Adams, & Collins, 1989). Neuronal loss, micro-haemorrhages and gliosis have also been identified in the paraventricular and periaqueductal grey matter, the mammillo-thalamic tract, the anterior thalamus, as well as secondary lesions in the medulla, pons, and cerebellum. The diencephalic lesions are thought to play a major role in amnesia.

Neocortical atrophy, especially in the frontal and parietal lobes has also been reported for Korsakoff patients (Jernigan, Schafer, Butters, Cermak, 1991; Oscar-Berman & Marinkovic, 2007; Shimamura, Jernigan, & Squire, 1988). This was associated with the enlargement of the lateral ventricles, and the widening of the sylvian and interhemispheric fissures, particularly between the frontal lobes. However, frontal atrophy is a common characteristic of alcoholics independent of thiamine deficiency.

1.5.3 Cognitive performance

The cardinal cognitive impairment of Korsakoff syndrome patients is the episodic memory deficit (amnesia), affecting both the memory for past events (retrograde amnesia), and new memories (anterograde amnesia). Immediate registration of information is usually at normal levels, as patients are able to repeat information in the absence of any delay (Joyce & Robbins, 1991; Wiegersma, De Jong, Dieren, 1991). However, after a distracting activity, memory performance is severely impaired (Butters & Cermak, 1980; Kopelman, 1985). Some information may be learned during an initial learning trial, but following interference from distracting information, memory performance decays significantly. This marked sensitivity to interference is the most prominent feature of anterograde amnesia.

Although similar in most respects to the anterograde amnesia of other aetiologies, Korsakoff patients often present unique features leading from their frontal executive deficits. Most notable are the motivational and arousal deficits, which could contribute to their severe memory problems. Korsakoff patients usually display apathy, passivity and lack initiation. These deficits may interfere with the encoding and retrieval of information (Oscar-Berman, 1980). However, Korsakoff patients show better learning when information is emotionally relevant, or arousing (Kopelman, 1986; Markowitsch, Kessler, & Denzler, 1986), although benefits are usually not preserved in the long-term (Davidoff, Butters, Gerstman, Zurif, Paul, & Mattis, 1984; Grandholm, Wolfe, & Butters, 1985). The ability to acquire new motor and perceptual skills and performance on implicit memory tasks is usually preserved (Cohen & Squire, 1980; Martone, Butters, Payne, Becker, & Sax, 1984).

Retrograde amnesia is also commonly found in Korsakoff patients, and usually presents with a marked temporal gradient: the more recent the event, the poorer the memory or the lower the likelihood of it being remembered at all. The retrograde amnesia often covers a relatively limited period prior to the onset of Wernicke's encephalitis (Seltzer & Benson, 1974), although cases have been reported when the retrograde amnesia was extensive (Kopelman, 1989; Zola-Morgan, Cohen, & Squire, 1981, 1983). Originally, two concurrent explanations were proposed for the retrograde memory deficit: a gradually developing anterograde amnesia (meaning that patients fail to remember in the first place these remote periods of their lives), and a general retrieval deficit, which sets in during the acute phases of the disease (Albert, Butters, & Levin, 1979; Butters & Albert, 1982). However, cases have been reported were prior to the onset of Korsakoff's syndrome, patients were able to provide detailed accounts of their earlier life, which after the acute phase of the disease were completely forgotten (Butters & Cemark, 1986). Since then, alternative explanations have been suggested for the temporal gradient of the retrograde amnesia, according to which information from different time periods might be accessed using different forms of memory. Recent events are anchored in a spatial and temporal context, held in episodic memory systems which are deficient in Korsakoff patients. Events from the distant past are thought to lose their contextual qualities, but can still be retained through continued rehearsing and retelling in semantic memory systems – thought to be generally intact in Korsakoff patients with limited neural lesions. However, the majority of Korsakoff patients have a long history of alcohol abuse and the extent and severity of their brain lesions is widely variable. Semantic memory deficits have also been reported in Korsakoff syndrome patients, for information acquired prior to the onset of the disease (Verfaellie, Reiss, & Roth, 1995), and this was also more pronounced for recent information than for older material. This suggests that recent memories of Korsakoff patients, whether episodic or semantic, are more vulnerable than information acquired earlier in their lives. Notably, the extent of retrograde amnesia seems to be related to frontal lobe functioning (Kopelman, 1989; Verfaellie et al., 1995), which could play a role in planning and initiating memory retrieval (Dall'Ora, Della Sala, & Spinnler, 1989; Stuss & Benson, 1986).

Korsakoff syndrome patients normally lack awareness into their memory deficit. Early neurological reports documented that Korsakoff patients display both amnesia and confabulation (Bonhoeffer, 1901, 1904). Indeed the first report of confabulation as a neurological symptom describing the false recollections of amnesic patients made without conscious knowledge of their falsehood belongs to Korsakoff (1889/1996). The term used by Korsakoff can be directly translated into English as “pseudoreminiscences”, and was later replaced by confabulation. Since then, confabulation was reported for many other aetiologies of amnesia (Johnson, Hayes, D’Esposito, & Raye, 2000). Bonhoeffer (1904) was the first to distinguish between “momentary” and fantastic/florid confabulations. Momentary confabulations were commonly assigned to the patient's attempt to fill gaps in memory, when provoked with questions from an examiner. Fantastic confabulations are usually spontaneous, appear to exceed the need to account for memory lapses and their content is usually grandiose and wish-fulfilling (Berlyne, 1972; Fotopoulou, Conway, Tyrer, Birchall, Griffiths, & Solms, 2008). More recent evidence suggested that that spontaneous confabulations are aetiologically different from the provoked memory distortions or intrusions (Kopelman 1987; Schnider, 2003). However, currently some disagreement persists regarding the exact taxonomy of and possible subtypes of confabulation (for discussions see DeLuca, 2000; Metcalf, Langdon, & Coltheart, 2007).

Despite amnesia (which can be severe), general intelligence is usually preserved in Korsakoff patients (Butters & Cermak, 1980). IQ scores as measured by the Wechsler Adult Intelligence Scale – Revised (WAIS-R) are usually in the average range, with the exception of the Digit Symbol subtest – a measure of visuomotor performance, where Korsakoff patients are taxed by their neurological oculomotor impairment (Parkin & Leng, 1993). Performance on the Wechsler Memory Scale – Revised is markedly impaired. The discrepancy between IQ and Delayed Memory Quotient can be as high as three standard deviations (Butters, Salmon, Cullum, 1988).

Korsakoff patients often show deficits in a number of domains other than memory. Visuospatial and visuoperceptual functioning impairment was documented in a number of tasks, such as digit-symbol and symbol-digit substitution, and embedded figures tests (Jacobson, Acker, & Lishman, 1990). Some patients can show deficits in problem solving and concept formation, deficits linked with impaired frontal executive control (Becker, Butters, Rivoira, & Milliotis, 1986). Performance on other clinical tests of frontal lobe functioning such as the Wisconsin Card Sorting Test, Verbal Fluency and Trail-Making B is sometimes impaired (Jacobson et al., 1990; Squire, 1982).

In conclusion, Korsakoff patients are characterised by anterograde amnesia, which can range from mild to severe and may be associated with diencephalic damage. Temporally graded retrograde amnesia is also present and it may be associated with frontal lobe damage. Procedural and semantic learning are often (although not always) preserved. Additionally to the memory impairment, Korsakoff patients can present impaired executive functioning especially on tasks requiring spatiotemporal processing. However, despite the memory and executive function deficits, intellect and working memory are relatively intact. This might suggest that certain frontal dysfunctions might be specific to Korsakoff patients and necessarily a result of chronic alcohol abuse.

1.6 Aim and objectives of the thesis

The aim of the current thesis is to bridge the significant gap in the literature between discrete emotions and emotional memory in the absence of episodic recall. The study of discrete emotions is an active area of enquiry, focused on exploring the fundamental differences between basic emotions, mostly in terms of expression and influence on cognition. The study of the powerful affective processes that exist even in the absence of the episodic memory support have mostly been studied in emotional versus neutral situations or for positive and negative emotions. Affective scientists investigating emotional memory have not addressed discrete emotions systematically, and it is becoming increasingly recognised that discrete classes of emotion (and not just positive and negative affect) can best reveal the richness of people's emotion experiences. More specifically, the re-experience of a full set of discrete basic emotions has never been systematically compared in the presence and absence of the recall of episodic material. Isolating the emotional experience from the episodic memory can be done firstly by eliciting and measuring old emotions before and after the conscious and detailed recollection of the emotional material. Secondly, the separation of the emotional and episodic memory processes can be observed by comparing the emotional re-experience of a sample of neurologically normal individuals and amnesic patients in a similarly controlled emotion elicitation paradigm. The present thesis will conduct both. The simultaneous study of four discrete emotions is the paramount dimension of the thesis, the tradition distinction between positive and negative affect cannot be discounted by empirical evidence, and will be integrated in the design.

The first objective of the thesis is to investigate the hierarchical position of valence in relation to the four discrete classes of emotions (anger, fear, sadness, and happiness). The empirical question addressed is whether the valence of an affectively conditioned stimulus can be re-experienced for longer than its discrete category.

The second objective is to investigate which aspects of an emotional event need to be recalled in order to elicit the original discrete emotions. The emotional re-experience of both neutral and emotional material, over one week following the presentation and episodic recall of four sets of stories generating discrete basic emotions will be compared between *anger*, *fear*, *happiness*, and *sadness*. This will be the first direct investigation comparing the stability of affective valence and discrete emotions over time. The first two objectives are addressed in Chapter 2.

The third objective of the thesis (see Chapter 3) is to examine the differences in the re-experience of the four discrete classes of emotions (anger, fear, sadness and happiness) between amnesic (Korsakoff's syndrome) patients and neurologically normal controls. This study allows to investigate the relationship between episodic recall and the experience of each of the four discrete emotion classes, and also, the relationship between core executive functions and the intensity of the emotional re-experience of the four distinct basic emotions.

Finally, the fourth objective of the present thesis is to introduce the concepts of affective intensity, specificity and accuracy, and develop a computational method for calculating the respective indices for negative and overall affect from the individual intensities of the most common four basic emotions (anger, fear, sadness, and happiness). The conceptual and procedural definitions of the indices and a first application of the indices on the datasets collected during the previous two studies are presented in Chapter 4.

1.7 Ethical considerations and governance

The studies undertaken as part of this PhD project have been reviewed and approved by the Ethics Committee of the School of Psychology, Bangor University, the NHS Wales, North Wales Research Committee – West , and Betsi Cadwaladr University Health Board R&D Internal Review Panel – West. Chapter 2 presents data collected during a first experiment involving undergraduate students in the School of Psychology of Bangor University, and has been approved by the Ethics Committee of the School of Psychology, Bangor University. Chapter 3 presents data collected during a second experiment, involving amnesic patients and age-matched controls, and was reviewed and approved by both the Bangor University and the local NHS research ethics and R&D review panels of the Betsi Cadwaladr University Health Board (BCUHB). A further substantial amendment was submitted for the second experiment to allow the recruitment of Korsakoff's syndrome patients from a single location in England (The Victoria Care Home, Worksopp, Nottinghamshire, run by Dukeries Healthcare Ltd.) The detailed application and approval documents are included in Appendices A, B, and C.

Chapter 2. Emotional memory in neurologically intact individuals: affective valence is more enduring than discrete emotion classes and active recollection is essential for re-experience

2.1 Abstract

Discrete classes of emotions (anger, fear, etc.) have been associated with distinct patterns of behaviour, physiology and neuroanatomy. However, a substantial overlap exists between negative emotions, suggesting a hierarchical grouping into two basic categories of positive or negative affect, with subordinate classes for discrete emotions. This organisation is consistent with the evolutionary development and the neuroanatomy of emotion systems, but has been little investigated. Firstly, the present study investigated for the first time the hierarchical organisation of affect in the context of emotional memory. Secondly, the emotional re-experience of both neutral and emotionally discrete material is studied over one week. A novel set of emotional stimuli (narrative vignettes) was developed, consisting of a neutral beginning and four emotional *endings*, eliciting *anger*, *fear*, *sadness*, and *happiness*. A group of 32 university students listened to four different stories (one for each emotion), recalling them after 30 minutes and again seven days later, while providing self-report measures of discrete emotions during each session. Firstly, as expected, after 30 minutes, the presentation of the initially neutral story beginnings reliably elicited the discrete emotion associated with the *content* of each story. Notably, after seven days, the story beginnings no longer elicited the earlier emotional specificity, but evoked the correct affective valence. Moreover, the participants reported experiencing the correct discrete target emotion only after a detailed recall of the passage that had initially generated the emotion. The results suggest, firstly, that experiences of discrete emotions lose their affective specificity with time, but still retain the correct valence. Secondly, the findings show that a detailed recollection of emotional events is central for a full affective re-experience. This is the first experimental report that the most durable form of emotional memory encodes affective valence – and is in line with neuroscientific accounts arguing that the phylogenetically older neural systems produce the most stable affect. Furthermore, the findings suggest that a detailed recollection of emotional events is central for a full affective re-experience. This psychological process has a range of practical and therapeutic applications, such as maximising happiness, improving elite sport performance, and managing emotional disorders.

Keywords: discrete emotions; emotion valence; emotional memory; hierarchical model of emotions; affective re-experience.

2.2 Introduction

Some of the earliest systematic descriptions of emotions have been notably categorical (Aristotle, trans. 1975; Darwin, 1872/1998; James, 1884), and this is presently the view dominating empirical research. The landmark findings that specific emotional states reliably produce similar patterns of facial expressions across distant cultures (Ekman & Friesen, 1971; Izard, 1971) and in infants (Izard, Huerber, Risser, McGinnes, Dougherty; 1980) formed the basis of the current theory of discrete emotions. This argues for the existence of an innate set of distinct, universal, and basic emotions, with a specific physiology and an automatic appraisal mechanism which requires minimal cognitive processing (although an extended appraisal system can coexist, see Ekman, 1999). A generous body of empirical evidence has reported that discrete basic emotions show individual autonomic nervous system response patterns (Cacioppo, Berntson, Klein, & Poehlmann, 1997; Collet, Vernet-Maurym, Delhomme, & Dittmar, 1997; Stephens, Christie, & Friedman, 2010), cardiorespiratory activity (Bloch, Lemeignan, & Aguilera, 1991; Rainville, Bechara, Naqvi, & Damasio, 2006), involve different, but partly overlapping neural structures (Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012; Vytal & Hamann, 2010), and elicit specific changes in cognition, judgment, and behaviour (Lench, Flores, & Bench, 2011, but see for a dissenting view Lindquist, Siegel, Quigley & Barrett, 2013). However, despite the overwhelming evidence in favour of a distinct set of basic emotions, there is still ongoing disagreement on the number and range of discrete emotions, with four primary classes of affect (*anger*, *fear*, *sadness*, and *happiness*) being most consistently reported in the literature (see Damasio et al., 2000).

Opposing views to the categorical theory of discrete emotions have built around the argument that affective experiences correlate strongly with a small number of orthogonal dimensions. Valence and arousal have been most frequently and reliably reported (Mayer & Gaschke, 1988; Meyer & Shack, 1989; Russell & Feldman Barrett, 1999; Watson, Wiese, Vaidya, & Tellegen, 1999), with various other dimensions also proposed, such as dominance (Mehrabian, 1996; Russell, 1977), anticipated effort, attentional activity, and situational control (Smith, & Ellsworth, 1985). Most recently, Lövheim (2012), proposed a novel account of the organisation of affect, suggesting that the combinations of the levels of three monoamine neurotransmitters (i.e., dopamine, noradrenaline, serotonin) involved in the affective experience, might explain the experience of a distinct set of eight discrete emotions.

2.2.1 The hierarchical model of emotions

The discrete and categorical accounts are currently the most actively investigated theories of emotions, but both suffer from significant limitations, and appear to be mutually exclusive. Arousal (one of the two fundamental dimensions of core affect) has long been dismissed as a reliable affective dimension, on the argument that it seems confounded with the intensity of emotions (Reisenzein, 1994; Wintre & Vallance, 1994), and the empirical evidence supporting the other dimensions remains currently modest. However, valence (positive or negative) has continued to pose a direct challenge to the categorical account. Proposed discrete emotions (especially on the negative spectrum) show a significant concurrent validity (Watson & Clark, 1992), suggesting that they are all underpinned by a common latent construct, perhaps best labelled 'negative affect'. Thus, the similarities of negative emotions on one hand and the contrast between positive and negative affect on the other remain difficult to reconcile with the purist interpretation of the theory of discrete emotions.

These findings have been used to advance a compromise between the categorical and dimensional theories, in the form of a hierarchical system of emotions (Watson & Clark, 1992; Watson & Tellegen, 1985). Positive and negative affect has, thus, been argued to be a more fundamental dimension of emotion, with emotion category as a secondary level with various discrete classes (Tellegen, Watson, & Clark, 1999). Thus, the long established findings regarding basic emotions could be fitted in a parsimonious model that recognises valence as a fundamental dimension of affect.

The affective neuroscience literature seems to offer convergent and influential support for the hierarchical account. Findings derived initially from work in non-human animals suggest that a basic valence system is located in the primitive areas of the upper brain stem, specifically in the periaqueductal grey (PAG; Bailey & Davies, 1942; 1943;

Bandler & Shipley, 1994). In more recent evolutionary history these have become differentiated into discrete emotion systems distributed across a range of structures such as the hypothalamus, amygdala, anterior cingulate, nucleus accumbens, and others (Vytal & Hamann, 2010). Panksepp (2004) recognised that "basic emotional energies" (p. 315) of either a positive or negative nature can be triggered in the PAG by minimal stimuli, possibly as a result of affective conditioning, and can be transmitted upwards in the neuroaxis, to interact with a variety of higher brain structures, sometimes resulting in the experience of discrete or more complex classes of emotions. Therefore, the hierarchical organisation of affect seems to be benefit from a direct neuroanatomical mapping.

However, thus far this theory remained largely untested. Empirical momentum behind the study of discrete emotions appears to have eclipsed the arguments favouring this integrative approach, while proponents of dimensional theories have preferred to avoid discrete emotions altogether (Russell & Feldman Barrett, 1999). As a result, to date, the hierarchical theory, that valence is the fundamental ingredient of any emotional experience, upon which distinct classes of emotions are constructed, rests solely on correlational evidence from self-report measures (Tellegen, Watson, & Clark, 1999).

The hierarchical account is eminently testable. An important consequence of this model is that discrete emotion categories should be the most transient and disruptable forms of emotional experience, while emotional valence should remain accessible over time, even after the specificity of emotion category has faded. This assumption can be readily tested in the framework of emotional memory. A stimulus encountered in an emotional situation can cause the re-experience of that emotion over time – in an affective conditioning paradigm (Tranel & Damasio, 1993). The question of interest is whether the re-experienced emotion elicited by the affectively conditioned stimulus indeed retains its emotional valence (positive or negative), even after losing its emotional specificity, or if once the emotional specificity is lost, the emotional valence of the stimulus is lost as well. A critical aspect of the question is demonstrating the selective affective conditioning of discrete classes of emotions. Although the range of emotional stimuli for eliciting discrete emotions is vast (Coan & Allen, 2007), affective conditioning studies have either employed generic positive and negative emotions (see

Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010 for a meta-analysis of evaluative conditioning studies), or selective discrete emotions – most commonly fear and anger (Kuriyama, Soshi, Fujii, & Kim, 2010), but never a full set of discrete emotions.

2.2.2 Episodic recall and the re-experience of past emotions

Retrieved emotional experiences play an important role in everyday decision making (Bechara, 2004; Bechara, Damasio, & Damasio, 2003; Levine, 1997; Pfister & Böhm, 2008), influencing performance in various fields of activity (Cohen, Tenenbaum, & English, 2006; Hanin & Syrjä, 1995; Straw & Cummings, 1996; Sun & Wu, 2011), affecting our subjective feeling of well-being (Diener, Suh, Lucas, & Smith, 1999), and featuring as a critical factor in a range of clinical disorders (LaBar & Cabeza, 2006; see for a review, Leppänen, 2006). It is generally agreed that emotions and episodic memory are characterised by a bidirectional interaction: episodic recall can precede and trigger the re-experience of emotions, and in turn emotions can also precede and trigger episodic recall. For example, past emotions are frequently re-experienced following the recollection of the eliciting event (see for a review Holland & Kensinger, 2010). Conversely, a memory can be elicited by the presentation of a stimulus or situation associated with the relevant emotions, without the intentional episodic recollection of the event (Berntsen & Rubin 2002) – particularly in the case of patients with post-traumatic stress disorder (PTSD; Rubin, Boals, & Berntsen, 2008).

The subjective sense of remembering is largely believed to involve the emotional re-experiencing of the original context (see for a review, Buchanan, 2007) and the degree to which affect is influenced by the recall of past events is regularly measured in experimental psychology to assess emotional reactivity (e.g., Damasio et al., 2000; Rainville, Bechara, Naqvi, & Damasio, 2006; Salas, Radovic, & Turnbull, 2011). Furthermore, the affective re-experience of critical past events is an important therapeutic factor in a number of clinical settings, especially in Post-Traumatic Stress Disorder (PTSD; see for a review Ehlers, Hackmann, & Michael, 2004), depression (Reynolds, & Brewin, 1999), and the resolution of problematic experiences (Watson &

Rennie, 1994). It also serves as the basis for emotion focused therapy, and in particular process-experiential interventions, which aims to increase the awareness of moment-by-moment emotional experiences and associate them with new meaning (see Greenberg, Rice, & Elliott, 1993, and also Angus & McLeod, 2004). Conversely, applied work in the domain of elite sports performance recommends the *avoidance* of complete re-experiencing – which risks the recollection of previous failure (Hardy & Ringland, 1984; Sun & Wu, 2011).

Despite the growing recognition of the importance of re-experienced emotions, and their impact on successful therapeutic interventions, general wellbeing and behavioural performance in applied settings, the factors affecting the reliving of emotions remain under-investigated. The greatest insight gained thus far relates to the form and context in which emotions are re-experienced, as opposed to the *content*. For example, the clinical psychology literature has long recognised the role of the vividness of mental imagery (see for a review Hackman & Holmes, 2004, and also Karatzias, Power, Brown, and McGoldrick, 2009; Wheatley et al., 2007). Qualitative analyses have also revealed that the use of vivid and concrete language during recall enhances the emotional re-experience (Watson, 1996). Surprisingly, however, there appears to have been no previous investigations of the way in which discrete emotions elicited by recollections of episodic material relate to the *original* emotions. Perhaps the most *significant* question is ‘which aspects of an event need to be recalled for the original emotion to be re-evoked?’ Does the affective experience begin as soon as a memory is recounted, being automatically trigged by the range of associations, or is only the complete re-experiencing of the episode sufficient to adequately elicit the original emotion?

Recent neuroanatomical evidence directed the selection of the range of basic emotions whose re-experience should be investigated separately. Two of the latest neuroanatomical meta-analyses (Lench, Flores, & Bench, 2011; Vytal & Hamann, 2010) concluded that anger, fear, happiness, sadness, and perhaps disgust activate unique and consistent neural pathways in the brain, with specific changes in cognition, judgment, behaviour, experience, and physiology (see for a dissenting view Lindquist, Siegel, Quigley & Barrett, 2013). These findings expand an already growing body of empirical evidence reporting that discrete basic emotions show individual autonomic nervous system response patterns (Collet, Vernet-Maurym, Delhomme, & Dittmar, 1997; Stephens, Christie, & Friedman, 2010), cardiorespiratory activity (Bloch, Lemeignan, & Aguilera-T, 1991; Rainville et al., 2006; Schwartz, Weinberger, & Singer, 1981), and involve different neural circuits (Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012). Therefore, an insightful study of the relationship between emotions and memory should differentiate between the four primary emotions (anger, fear, happiness, and sadness) which have been consistently reported in the literature (Damasio et al., 2000).

Firstly, the present study investigated the stability of valence and discrete emotions (i.e., anger, fear, sadness, and happiness) over time. The empirical question addressed is whether the valence of an affectively conditioned stimulus can be re-experienced for longer than its discrete category. A preliminary objective was to establish that the vignettes would elicit the target emotion (anger, fear, sadness, and happiness) selectively. Then, we sought to confirm that the emotional *content* of the stories retained its original emotional specificity over time (i.e., the *content* of the fearful stories was continuing to elicit more fear than any other emotion, etc.). Finally, the changes in emotion intensity after the presentation of the affectively conditioned story *contexts* over time were compared. To support the hierarchical organisation of affect, the *contexts* of the stories should continue to retain their emotional valence (positive or negative), even when the selective experience of discrete emotions has been lost.

Secondly, the episodic recall and associated affective re-experience, for the four sets of stories (anger, fear, happiness, and sadness) was investigated. The aim was to investigate the degree to which the neutral story *stems* succeeded in producing the re-experience of the original emotion elicited by the story *endings*. The expected finding was that if participants remembered the emotional ending and re-experienced the appropriate emotion *after* recollection, the detailed presentation of the beginning of the story *alone* would change their affective state, causing them to report increased levels of the target emotion.

2.3 Method

2.3.1 Participants

Thirty-two Bangor University students (11 male), with ages between 18 and 31 (*M*=20.78, *SD*=3.35), screened for neurological and psychiatric history took part in the study in return for the usual amount of course credits or University's standard participant payment rate (up to a maximum of £12). Recruitment was made on an opportunity sample basis.

2.3.2 Stimuli and Measures

Four novel sets of emotional vignettes were used in the present study. Each set consisted of four stories, written in the second person, and targeting a different emotion (anger, fear, happiness, and sadness). An equally controlled set of such stories has never been developed before (cf., Kuriyama, Soshi, Fujii, & Kim, 2010). Each story differed in narrative content, but employed an identical plot design, number of recall units, and number of characters eliciting the target emotion. All stories in a set shared an identical and emotionally neutral beginning (also referred to as *context*, or *stem*), which defined the time, place and introduced the main agent of the story (i.e., the character subsequently responsible for eliciting the target emotion). Each of the four stories in a set continued with a different plot (also referred to as *content*, or *ending*) presenting a series of events aimed at eliciting a specific discrete emotion. Pilot data demonstrated that the stories show emotional specificity (i.e., selective elicitation of the target emotion at a significantly higher intensity than any non-target emotions), and comparable levels of intensity between target emotions. With stimuli producing this level of experimental control, it is possible to investigate the extent to which episodic recall triggers the re-experience of emotions, and to study the temporal effects of memory on emotion.

The four sets of stories are included in Appendix D. Following the classical protocol of Turner and Greene (1977), a propositional analysis (Kintsch & van Dijk, 1978) confirmed that each story consisted of 60 propositional units, each corresponding to an individual recall unit (Kintsch, 1994) – see Appendix E. Recall was measured by comparing the transcripts of the audio recordings of participants' recollections of the stories to the original scripts and counting the number of propositional units correctly reproduced.

Momentary ratings of emotional experience were collected using the *anger*, *fear*, *happiness*, and *sadness* questionnaires, extracted from the Visual Analogue Mood Scales (VAMS; Stern, 1997). Participants were asked to indicate the momentary intensity of each of the four discrete emotions by answering the question "How angry/afraid/sad/happy do feel right now?" Responses were self-recorded on a 100mm vertical visual analogue scale, anchored at the two ends by schematic faces representing a neutral expression and the target emotion and matching verbal labels (i.e., Neutral, Angry, Afraid, Happy, and Sad). The VAMS have been reported to have high validity and test-retest reliability (see Stern, 1997), and were also validated for use with various clinical populations (Arruda, Stern, Somerville; 1999).

2.3.3 Design

The study employed an overall 3x4x3 repeated-measures design, consisting of three phases (Presentation, Recall after 30 minutes, and Recall after 7 days), four stories, one for each discrete emotion (anger, fear, sadness, and happiness), and three time points when emotion intensity ratings were collected: at the start of the session (Baseline), after the presentation of the story *contexts* and after the presentation or recall of the story *content*. The vignettes were presented via the auditory modality, and order was counterbalanced across participants.

2.3.4 Procedure

The study was advertised as investigating the effect of experiential stories on the ability to perform mental calculations (which acted as a filler task). The mental calculation task consisted of 120 seconds of basic single digit additions and subtractions and was administered after each emotional story. The task was chosen for its emotion regulation function (see Kanske, Heissler, Schönfelder, Bongers, & Wessa, 2010), and was used to prevent emotional carry-over effects from one story to another. As part of the study's cover story, the number of correct equations solved in the two minute interval was argued to be the measure of interest.

The first two of three phases (Presentation and Recall after 30 minute) took part in a single session, and all the participants returned for a second session, seven days later, when the last phase of the study took place (Recall after 7 days). At the beginning of the first phase (Presentation), participants provided baseline measures of momentary emotional experience. Next, they listened to four emotional stories (one from each set, and targeting a different emotion) and, each time, were asked to imagine that they were experiencing what is happening in the story. Emotional measures were taken after the *beginning* (*context*) and *ending* (*content*) of each story, and were then followed by the mental calculation task. In the second phase (Recall after 30 minutes), participants were presented again with the story *contexts* as memory cues for the vignettes they were requested to recall. Next, they were asked to reproduce from memory the remaining part of the story (*Content*), with as much detail as possible. As before, emotional measures were taken after story *contexts* and *contents*. In the last phase of the study (Recall after 7 days), participants provided a baseline measures of momentary emotional experience, and followed the same procedure as in the second phase (Recall after 30 minutes).

The presentation order of the four sets of stories was counterbalanced using a composite latin-square, balanced for story set (Set 1 – 4) and target emotion (anger, fear, sadness, happiness), as shown in Table 1.

Table 1.

The composite balanced latin-square used to determine the presentation order for the story stems and endings. Both the story stem (Set 1 – 4) and target emotion (anger, fear, sadness, happiness) were counterbalanced.

Participant	First story	Second story	Third story	Fourth story
1	Stem 1 - anger	Stem 2 - fear	Stem 4 - sadness	Stem 3 - happiness
2	Stem 1 - fear	Stem 2 - happiness	Stem 4 - anger	Stem 3 - sadness
3	Stem 1 - happiness	Stem 2 - sadness	Stem 4 - fear	Stem 3 - anger
4	Stem 1 - sadness	Stem 2 - anger	Stem 4 - happiness	Stem 3 - fear
5	Stem 2 - anger	Stem 3 - fear	Stem 1 - sadness	Stem 4 - happiness
6	Stem 2 - fear	Stem 3 - happiness	Stem 1 - anger	Stem 4 - sadness
7	Stem 2 - happiness	Stem 3 - sadness	Stem 1 - fear	Stem 4 - anger
8	Stem 2 - sadness	Stem 3 - anger	Stem 1 - happiness	Stem 4 - fear
9	Stem 3 - anger	Stem 4 - fear	Stem 2 - sadness	Stem 1 - happiness
10	Stem 3 - fear	Stem 4 - happiness	Stem 2 - anger	Stem 1 - sadness
11	Stem 3 - happiness	Stem 4 - sadness	Stem 2 - fear	Stem 1 - anger
12	Stem 3 - sadness	Stem 4 - anger	Stem 2 - happiness	Stem 1 - fear

13	Stem 4 - anger	Stem 1 - fear	Stem 3 - sadness	Stem 2 - happiness
14	Stem 4 - fear	Stem 1 - happiness	Stem 3 - anger	Stem 2 - sadness
15	Stem 4 - happiness	Stem 1 - sadness	Stem 3 - fear	Stem 2 - anger
16	Stem 4 - sadness	Stem 1 - anger	Stem 3 - happiness	Stem 2 - fear

2.3.5 Data Analysis

Emotional experience ratings from the visual analogue scales were converted into numeric values ranging from 0-100 (Stern, 1997). The emotion ratings after the *context* of all four stories during the first phase were not collected for 10 participants. Missing data was excluded on a pairwise basis. Their data were excluded pair-wise from all subsequent analyses. The ratings of the negative target emotions were split into target emotions (e.g., *anger* for *anger* stories) and non-target emotions (e.g., fear and sadness for *anger* stories). Repeated-measures ANOVAs followed-up by planned contrasts were used to compare the intensity and recall accuracy scores of the four sets of emotional stories. Simple Bonferroni corrections were applied to the family-wise alpha rate (α=.05) for planned contrasts, and the Holm–Bonferroni method was used for all other multiple tests (Holm, 1979). The relevant α value is reported separately for each test, where it was different from the standard value.

2.4 Results

2.4.1 The stability of discrete emotions and affective valence

The stability of valence and affective category following the affective conditioning of discrete emotions was investigated over time. Firstly, two preliminary analyses were performed to establish the emotional experience at Baseline (before the affective conditioning task) and to confirm that the verbal emotional stimuli elicited the four target emotions (anger, fear, sadness, and happiness) selectively, that is, at higher levels than any non-target emotion. Secondly, it was shown that the recall of the vignettes retained their emotional specificity over time. Finally, the main study question was addressed by comparing the changes of emotion intensities from Baseline after the presentation of the story *contexts* 30 minutes after the affective conditioning and seven days later.

2.4.1.1 Emotion Ratings at Baseline and after the Presentation of Story Endings

At Baseline (see Figure 1), happiness (M=45.42, SD=28.44) was dominant compared to all other (negative) emotions: *anger* (M=4.39, SD=8.07), *fear* (M=7.18, SD=9.91), and *sadness* (M=5.21, SD=10.91). This was confirmed by a significant ANOVA ($F(1,30)=53.15$, $p<.001$, $\eta_p^2=.624$), and follow-up t-tests (*happiness* vs. *anger*, $t(30)=8.10$, $p<.001$, $d=1.96$, $\alpha=.017$; *happiness* vs. *fear*, $t(30)=7.61$, $p<.001$, $d=1.80$, $\alpha=.017$; *happiness* vs. *sadness*, $t(30)=7.57$, $p<.001$, $d=1.87$, $\alpha=.017$).

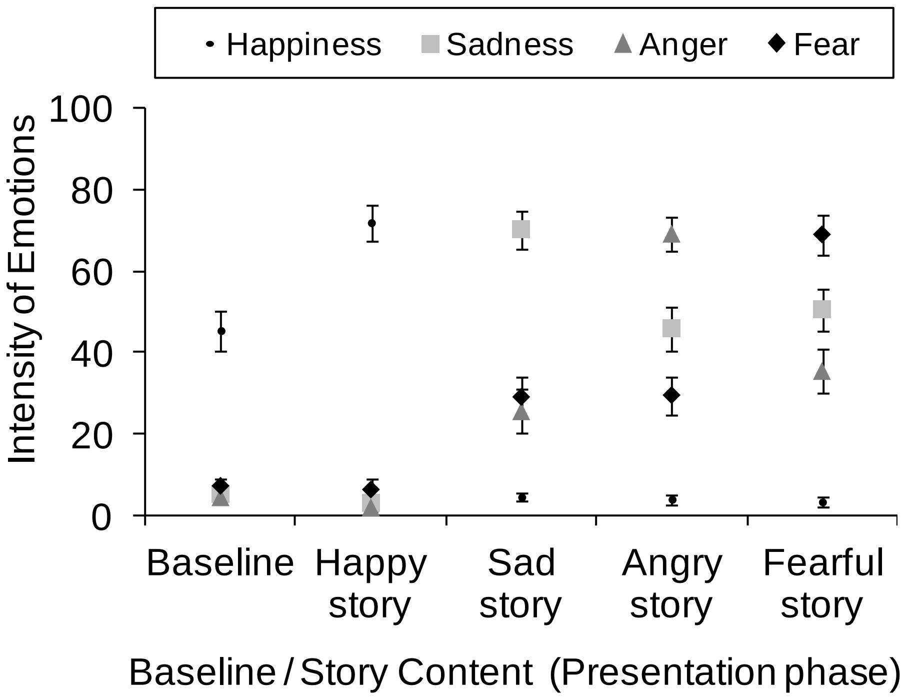

Figure 1. The mean ratings of discrete emotions at Baseline and after Presentation. The emotion ratings at the start of the study and after the presentation of the emotional *content* of all stories (x-axis) are grouped by target emotion. *Happiness* was the dominant emotion at Baseline. The intensity of the target emotion was significantly higher than the intensity of any non-target emotions, for all stories. The intensity of *happiness* after the *happy* stories was higher than at Baseline. The error bars represent ±1 SE of the mean.

The presentation of the emotional stories, as expected, elicited the discrete target emotions at significantly higher levels of the than any of the non-target classes (see Table 2). Furthermore, even though *happiness* was the dominant emotion at the start of the session, after the happy stories, participants reported even higher levels of *happiness* (M=71.95, SD=27.07) than at Baseline ($t(30)=4.29$, $p<.001$, $d=.96$, $\alpha=.013$).

Table 2.

The specificity of emotion elicitation after Presentation and Recall. *The content of emotional vignettes elicited the target emotion selectively both when they were presented to participants (Presentation) and also when they were later recalled (Recall after 30 minutes, and Recall after 7 days). Differences between the target emotions and the other discrete emotions reached significance, at all-time points. The only exception was that anger stories, after 7 days, elicited only marginally more anger than sadness (p=.044) which did not meet the Bonferroni corrected statistical significance level (α=.017).*

Target Emotion	Non-target Emotion	Presentation				Recall after 30 minutes				Recall after 7 days			
		F	p	α	η_p^2	F	p	α	η_p^2	F	p	α	η_p^2
Anger	Happiness	226.06	<.001 *	.017	.863	101.13	<.001 *	.017	.737	16.12	<.001 *	.017	.309
	Fear	43.35	<.001 *	.017	.573	50.53	<.001 *	.017	.584	16.68	<.001 *	.017	.317
	Sadness	21.12	<.001 *	.017	.370	21.93	<.001 *	.017	.379	4.37	.044	.017	.108
Fear	Happiness	147.73	<.001 *	.017	.804	104.93	<.001 *	.017	.745	31.3	<.001 *	.017	.465
	Anger	29.17	<.001 *	.017	.448	30.13	<.001 *	.017	.465	19.14	<.001 *	.017	.347
	Sadness	8.91	<.001 *	.017	.198	11.67	<.001 *	.017	.245	9.81	<.001 *	.017	.214
Sadness	Happiness	191.72	<.001 *	.017	.842	105.89	<.001 *	.017	.752	34.3	<.001 *	.017	.488
	Anger	61.91	<.001 *	.017	.632	53.59	<.001 *	.017	.605	34.09	<.001 *	.017	.486
	Fear	56.75	<.001 *	.017	.612	50.35	<.001 *	.017	.590	34.96	<.001 *	.017	.493
Happiness	Anger	242.79	<.001 *	.017	.871	151.4	<.001 *	.017	.808	105.8	<.001 *	.017	.746
	Sadness	232.12	<.001 *	.017	.866	170.44	<.001 *	.017	.826	103.8	<.001 *	.017	.742
	Fear	176.06	<.001 *	.017	.828	170.54	<.001 *	.017	.826	105.29	<.001 *	.017	.745

2.4.1.2 Emotional Stability of Story Contents over Time

It was essential to establish that the recall of stories continued to elicit the discrete target emotion selectively, after 30 minutes and one week. To test this assumption, emotion changes from Baseline were calculated for the ratings of anger, fear, sadness and happiness, after 30 minutes and seven days. Positive (happiness) and negative (anger, fear, sadness) stories were analysed separately (see Figure 2). For the negative stories, the changes from Baseline of the target emotions were averaged together for each participant and labelled “Target Emotions (A/F/S)”. The changes of the most intense non-target negative emotions (e.g., the higher value between the intensities of fear and sadness for the angry story) were labelled “Non-Target Emotions (A/F/S)”. For the happy stories, the higher of the ratings of anger, fear, and sadness (which were close to zero after Presentation) were retained for analyses and labelled “Non-Target Emotions (A/F/S)”.

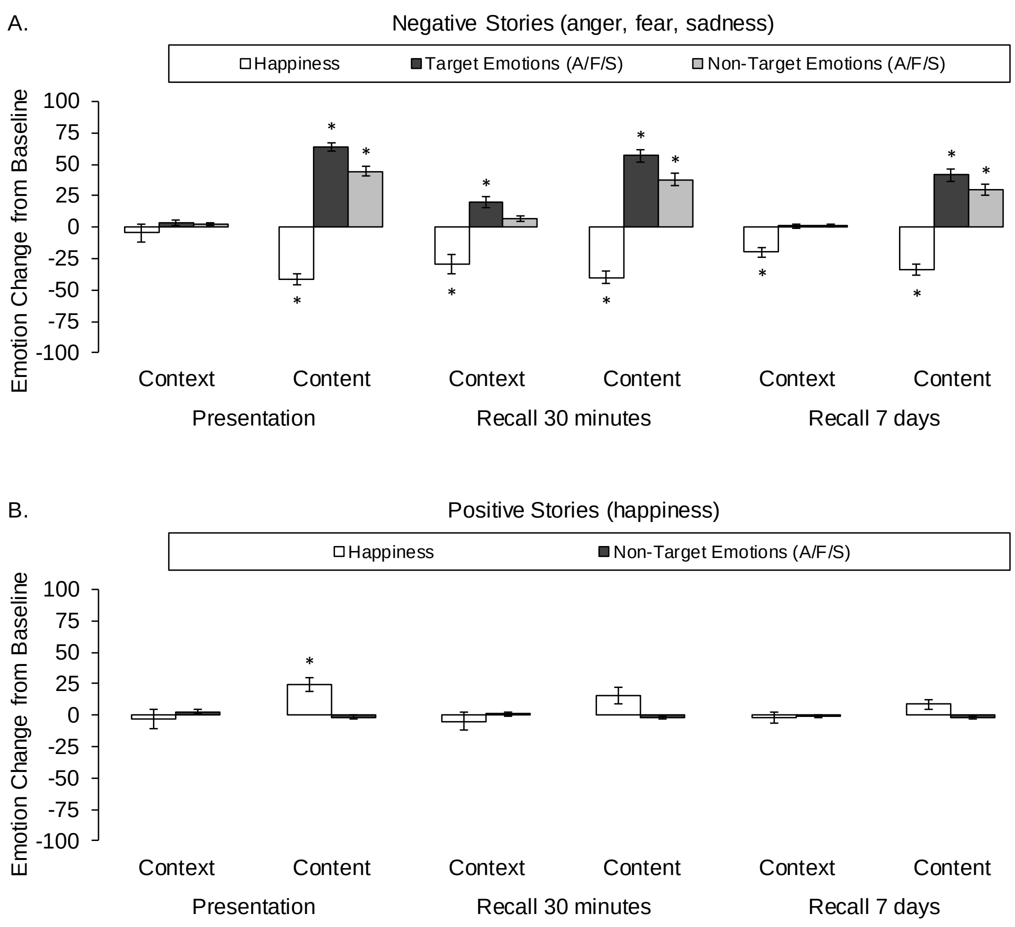

Figure 2. The average changes in the intensity of emotions from Baseline.
after the presentation of the semantically neutral *context* and the presentation and subsequent recall of the emotional *content* of all stories. **A.** The *content* of negative stories produced a selective activation of target emotions, and to a lesser extent negative non-target emotions, while reducing the Baseline level of happ*i*ness. The *context* of the negative stories did not change the Baseline affect at Presentation (before the emotional *content* of the stories was revealed), but after 30 minutes elicited selectively the target emotion, and reduced the Baseline levels of *happiness*. Surprisingly, after seven days, the *context* of emotional stories had lost the ability to selectively elicit the target (or even non-target) negative emotions, but continued to significantly reduce the Baseline level of *happiness*. All changes remaining significant over time. **B.** The *content* of *happy* stories increased the Baseline level of *happiness*, but, after correcting the α level, only the increase at Presentation reached significance. The *context* of the *happy* stories failed to change the Baseline affect. All error bars represent ±1 SE of the mean.

The emotional *content* of negative stories reduced the Baseline levels of *happiness* at Presentation (M=-41.30, SD=27.51), and increased the intensities of target emotions (M=63.91, SD=20.20), and the other negative non-target emotions (M=44.15, SD=21.54). After 30 minutes, the emotion changes from Baseline showed a similar pattern (*happiness*, M=-39.97, SD=29.11; negative target emotions, M=56.67, SD=25.62; and non-target emotions, M=38.00, SD=26.25), and again seven days later (*happiness*, M=-34.22, SD=26.44; target emotions, M=41.54, SD=31.14; and non-target emotions, M=30.19, SD=25.75). T-tests confirmed that all emotion changes from Baseline were significant even after correcting the α level for multiple comparisons (see Table 3). Notably, increases of the target emotions were significantly higher than those of non-target negative emotions, at Presentation ($t(30)=5.38$, $p<.001$, $d=.94$, $\alpha=.025$), after 30 minutes ($t(30)=5.25$, $p<.001$, $d=.72$, $\alpha=.025$), and one week ($t(30)=3.88$, $p<.001$, $d=.39$, $\alpha=.025$), confirming the preserved emotional specificity of the stories.

Table 3.

Emotion changes from Baseline after the presentation and recall of the stories. *The contexts of the negative stories significantly increased the negative emotions compared to Baseline levels, and decreased the happiness ratings after 30 minutes. One week later, the contexts of negative stories significantly decreased the levels of happiness, but without activating the target negative emotions, and only modestly increasing the non-target negative emotions (change which failed to reach significance when α level was corrected for multiple comparisons). The content of negative stories reliably reduced the level of happiness and increased the target and non-target negative emotions.*

Stories	Affect	Emotions	Comparison	Story *Context*					Story *Content*				
				df	*t*	*p*	*α*	*d*	*df*	*t*	*p*	*α*	*d*
Happiness	Positive	Happiness	Presentation vs Baseline	20	-0.35	.73	.008	.07	30	4.28	<.001*	.008	.75
			Recall 30 min vs Baseline	20	-0.72	.479	.013	.17	30	2.44	.020	.01	.43
			Recall 7 days vs Baseline	30	-0.44	.664	.025	.08	30	2.20	.034	.013	.36
	Negative	Anger, Fear, Sadness	Presentation vs Baseline	20	1.63	.118	.01	.35	30	-1.08	0.287	.05	.19
			Recall 30 min vs Baseline	20	0.20	.841	.05	.04	30	-1.50	0.142	.017	.26
			Recall 7 days vs Baseline	30	-0.59	.563	.017	.10	30	-1.33	0.193	.025	.22
Anger, Fear, Sadness	Positive	Happiness	Presentation vs Baseline	20	-0.68	.503	.05	.15	30	-8.62	<.001*	.05	1.50
			Recall 30 min vs Baseline	20	-3.80	<.001*	.007	.83	30	-7.89	<.001*	.025	1.37
			Recall 7 days vs Baseline	30	-5.21	<.001*	.005	.89	30	-7.87	<.001*	.017	1.29
	Negative	Target Emotions	Presentation vs Baseline	20	1.47	.158	.016	.32	30	18.17	<.001*	.013	3.16
			Recall 30 min vs Baseline	20	4.42	<.001*	.006	.96	30	12.70	<.001*	.01	2.21
			Recall 7 days vs Baseline	30	0.72	.477	.025	.12	30	8.12	<.001*	.008	1.33
		Non-target Emotions	Presentation vs Baseline	20	2.13	0.46	.012	.46	30	11.78	<.001*	.007	2.05
			Recall 30 min vs Baseline	20	3.82	<.001*	.008	.83	30	8.32	<.001*	.006	1.45
			Recall 7 days vs Baseline	30	2.51	.017	.010	.43	30	7.13	<.001*	.006	1.17

The *happy* stories increased the already dominant Baseline level of *happiness* at Presentation (*M*=24.55, *SD*=32.96), after 30 minutes (*M*=15.85, *SD*=37.27), and seven days (*M*=8.65, *SD*=23.85), without affecting the minimal levels of the negative emotions (Presentation, *M*=-1.64, *SD*=8.69; after 30 minute, *M*=-1.94, *SD*=7.41; after seven days, *M*=-2.00, *SD*=9.17). However, when correcting for multiple comparisons, only the change in *happiness* at Presentation reached significance, with a moderate effect size (see Table 3).

In conclusion, the emotional *contents* of stories retained their discrete emotion specificity both after 30 minutes and seven days. The negative stories reduced vigorously the levels *happiness* from Baseline, and substantially increased the intensity of negative emotions, suggesting that the stories elicited emotions of a negative valence. Notably, the increases in negative *target* emotions were significantly greater than for *non-target* negative emotions, confirming that the stories also retained their intended emotional specificity throughout the seven days. At the same time, the happy stories consistently increased the already high levels of *happiness* reported at Baseline. Thus, the affective valence and discrete emotion category were accurately re-experienced after the presentation and recall of the story *contents*. This allowed the investigation of the valence and emotion specificity of the affectively conditioned story *contexts*.

2.4.1.3 Affective Valence and Emotional Specificity of Story Contexts over Time

The semantically neutral story *contexts* were expected to preserve the Baseline emotional experience at Presentation, but produce an emotional change of a similar valence and discrete emotion class as the story *endings* after 30 minutes. Over time, it was hypothesised that the specificity of the emotion class might be lost, but that the story *contexts* would continue to retain the correct emotional valence – thus supporting the argument that valence is a more stable form of affect than discrete emotions.

The *contexts* of the negative stories (see Figure 2, A.) were, as expected, emotionally neutral when they were first read to participants, at Presentation. The emotion changes from Baseline for *happiness* (*M*=-4.62, *SD*=31.05), the negative target emotions (*M*=3.14, *SD*=9.83), and non-target emotions (*M*=2.05, *SD*=4.41) were non-significant (see Table 3). After 30 minutes, the story *contexts* retained the valence and emotion specificity of their associated stories. The levels of *happiness* decreased from Baseline (*M*=-29.43, *SD*=35.49), while the target emotions increased strongly (*M*=19.67, *SD*=20.41), and to a lesser extend so did the intensities of the non-target negative emotions (*M*=6.86, *SD*=8.24). All emotion changes were significant (Table 3), with large effect sizes (Cohen's *d* between .83 and .96). A follow-up t-test revealed that the increase in target emotions was significantly higher than in non-target emotions ($t(20)=3.48$, $p=.002$, $d=.82$, $\alpha=.025$), confirming the successful conditioning of the story *contexts.* Thus, after 30 minutes, the initially neutral story *contexts* acquired both the valence and emotion category of the negative story *endings*, specifically for anger, fear, and sadness.

As expected, a week later, the story *contexts* of the negative stories failed to elicit their respective target emotions (*M*=1.21, *SD*=9.77), or any other negative (non-target) emotions (*M*=1.06, *SD*=2.46). All changes of negative emotion from Baseline levels were non-significant (see Table 3). However, the story *contexts* continued to significantly decrease the Baseline levels of *happiness* (*M*=-20.06, *SD*=22.47), showing that participants accurately retained the valence of the negative stories (Table 3), even in the absence of a specific experience of a discrete negative emotion. This suggests that valence was a more stable form of affect than emotion category.

The *contexts* of the happy stories (Figure 2, B.) were neutral at Presentation just as in the case of the negative stories. Emotion changes from their Baseline were modest for both *happiness* (*M*=-2.67, *SD*=34.87) and negative emotions (*M*=2.71, *SD*=7.61), and they were not significant (see Table 3). Unlike the negative stories, emotion changes from Baseline remained non-significant after 30 minutes (*happiness*, *M*=-5.41, SD=32.69; negative emotions, M=0.33, SD=7.51) and seven days (*happiness*, M=-2.03,SD=26.97; negative emotions, M=-0.79, SD=7.92). However, as seen previously, even after the detailed recall of the stories' emotional *content* the intensity of *happiness* was not significantly different from the already high levels at Baseline (see Table 3). Thus, range effects could have been responsible for the non-significant changes of emotion intensities, as the Baseline levels of *happiness* were already very high and could have proven difficult to increase further, while the levels of negative emotions were already close to the minimum levels, and could not have decreased further.

In conclusion, the story *contexts* showed a successful affective conditioning after 30 minutes. Both the emotional valence and specific discrete affect classes of the stories were experienced accurately after the presentation of the initially neutral story *contexts*, and before the recall of the *anger*, *fear*, *sadness*, and *happiness* stories. However, after seven days, the story *contexts* lost their discrete emotion class specificity, but still retained accurately the corresponding emotional valence. Thus, the results suggest that affectively conditioned stimuli can remain emotionally salient, by retaining a positive or negative valence, even after they have lost the ability to elicit discrete classes of emotions.

2.4.2 The re-experience of discrete emotions after seven days

The second aim of the study was to investigate the differences between the re-experience of the original emotion after the delayed *re*-presentation of the story *stems* and the recollection of the story *endings*. Two sets of preliminary analyses were performed. Firstly, the intensity and specificity of target emotions after the first presentation of the stories was examined (i.e., initially, each story elicited the target emotion significantly more than any other discrete emotion, and there were no significant differences between the intensities of target emotions). Secondly, the memorability of each emotional story was investigated at Recall 1 and Recall 2 (i.e., the differences in the proportion of details reported at the recollection of each emotional story, after 30 minutes and seven days). Then, finally, the main analysis was carried out to investigate the differences in emotional re-experience between the presentation of story *stems* and the recall of the story *endings,* seven days after the initial presentation.

2.4.2.1 Emotional Intensity and Specificity of Story Endings, at Presentation

Ideally, the emotional stories should each strongly elicit the *target* emotion, and the intensity of each of the four target emotions should be similar across stories. As shown in Figure 3, at Presentation, the target emotions of *anger* (M=68.1, SD=4.4), *fear* (M=69.6, SD=5.4), *sadness* (M=73.5, SD=4.5), and *happiness* (M=72.0, SD=4.6) were similar. A paired-samples ANOVA failed to reveal a main effect of Emotion.

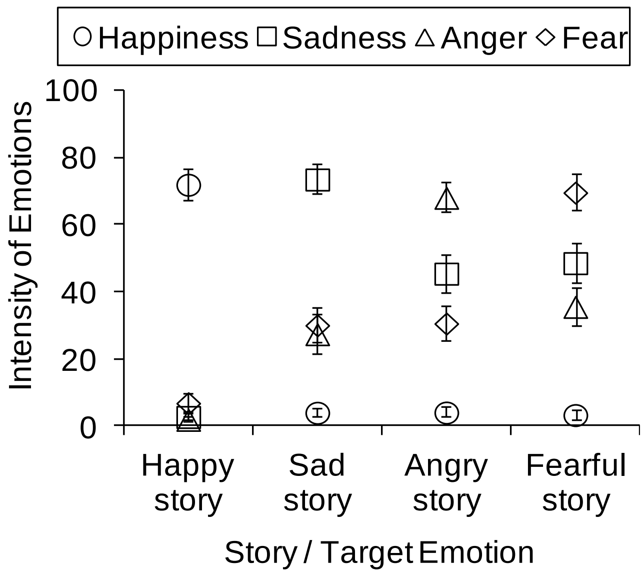

Figure 3. Discrete emotion elicitation after presentation of story *endings*.
The mean ratings of discrete emotions (*legend*) for all story *endings* (*x-axis*) at Presentation are grouped by target emotion. The intensity of the target emotion was significantly higher than the intensity of *any* non-target emotions, for all groups of stories. Differences in the intensity of the target emotions were non-significant. The error bars represent ±1 *SE* of the mean.

Emotional specificity was analysed, for each story, by comparing the intensity of the *target* emotion (see above) with all *non-target* emotions (means ranging from 2.9-48.7, and standard deviations from 1.1-5.8). A separate repeated-measures ANOVA found a main effect of *Emotion* for the *anger* stories ($F(2.48, 74.4)=53.13$, $p<.001$; degrees of freedom corrected using the Greenhouse-Geisser estimate of sphericity,

ε=.83), fearful stories (F(3, 90)=47.01, p<.001), sadness stories (F(1, 30)=53.15, p<.001), and *happiness* stories (F(1, 30)=151.67, p<.001; lower-bound estimate of sphericity was used to correct the degrees of freedom, ε=.33).

In conclusion, the emotional stimuli elicited the target emotion selectively (i.e., at higher levels of intensity than the non-target emotions), thus showing emotional specificity for each of the four sets of stories. This finding supports the validity of the novel emotional stimuli, and that the targeted discrete emotion was adequately elicited. Notably, as an added dimension of experimental control, all target emotions were also comparable in intensity.

2.4.2.2 Recall Accuracy of Story Endings across Time

This set of investigations sought to reveal a stable and comparable proportion of story details remembered across time from Recall 1 (30 minutes after Presentation) to Recall 2 (seven days later) for the four sets of emotional stories. Every story had the same number of recall units (i.e., propositional units), and, thus, the memory scores are reported as percentages (see Figure 4).

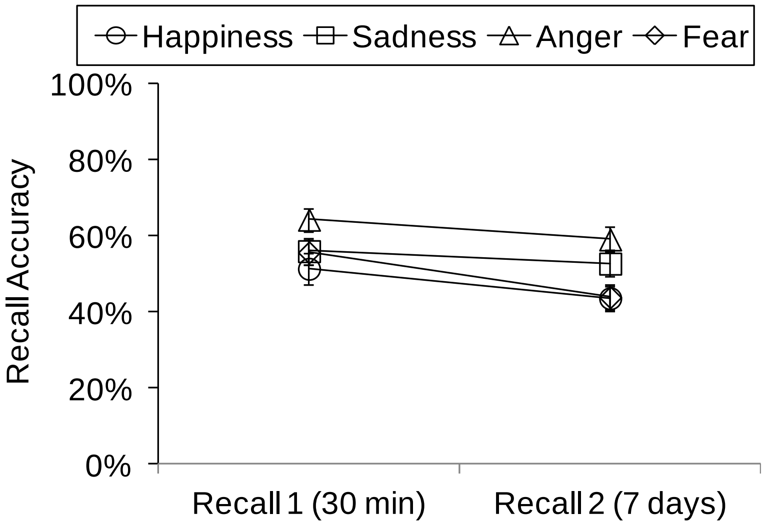

Figure 4. Recall accuracy of story *endings* after 30 minutes and seven days.
The recall accuracy for all story *endings* at 30 min and seven days after the initial presentation decayed slightly over time. *Anger* stories were significantly better remembered than all other stories. The error bars represent ±1 *SE* of the mean.

Differences in recall accuracy after 30 minutes (Recall 1; means and standard deviations ranging from 51.5-64.4%, and 3.0-4.3%, respectively) and seven days (Recall 2; means ranging from 44.0-59.2%, and standard deviations from 3.0-3.5%) were analysed (see Figure 4). The recall accuracy scores of all stories decreased over time. A 2x4 repeated-measures ANOVA reported a main effect of Emotion (F(3, 90)=9.05, p<.001), a main effect of *Time* (F(1, 30)=25.84, p<.001, r=.67), and a non-significant Time*Emotion interaction (F(2.50, 75)=2.88, p=.050; degrees of freedom corrected using the Greenhouse-Geisser estimates of sphericity, ε=.83). Simple contrasts of the main effect of Emotion, revealed that the recall of angry stories was higher than for fearful stories (F(1, 30)=22.23, p<.001, r=.65), sad stories (F(1, 30)=9.55, p=.004, r=.49), and happy stories (F(1, 30)=16.57, p<.001, r=.59).

In conclusion, the stories were remembered well seven days after the initial presentation, with a modest decay in accuracy over time and only one notable difference between the target emotions. *Anger* stories were significantly better recalled than the other classes of emotional stories, but all memory scores at Recall 2 fall within a close range around the 50% mark (44.0-59.1%), which suggests that at the beginnings of all the stories participants are already aware of how the stories end.

2.4.2.3 Differences between the Re-experience of Emotions after Story Stems and Endings

The preliminary analyses have established, firstly, that the initial presentations elicited the target emotions discretely and at comparable levels, and, secondly, that the four sets of stories were remembered well seven days after the initial presentation. The above findings allowed the investigation of the degree to which the detailed presentation of the beginning of the well-known stories, and the recollection of the ending would influence emotional experience at Recall 2 (seven days after Presentation). The Baseline measure of emotions refers to the reports at the start of the session. The *stem* and *ending* time points refer to emotional reports after the presentation of the *stems* and recall of *endings*. A likely result was that memories of an emotional event would affect participants' emotional experience when *reminded* of the story by its initially neutral beginning. Three analyses were performed to investigate this issue.

2.4.2.3.1 Emotional experience at Baseline.

When participants' ratings of discrete emotions at the beginning of Recall 2 were analysed, *happiness* (*M*=44.4, *SD*=5.1) was dominant over all other emotions: *anger* (*M*=3.3, *SD*=1.6), fear (*M*=3.9, *SD*=2.1), and *sadness* (*M*=6.5, *SD*=2.5), as shown in Figure 5.

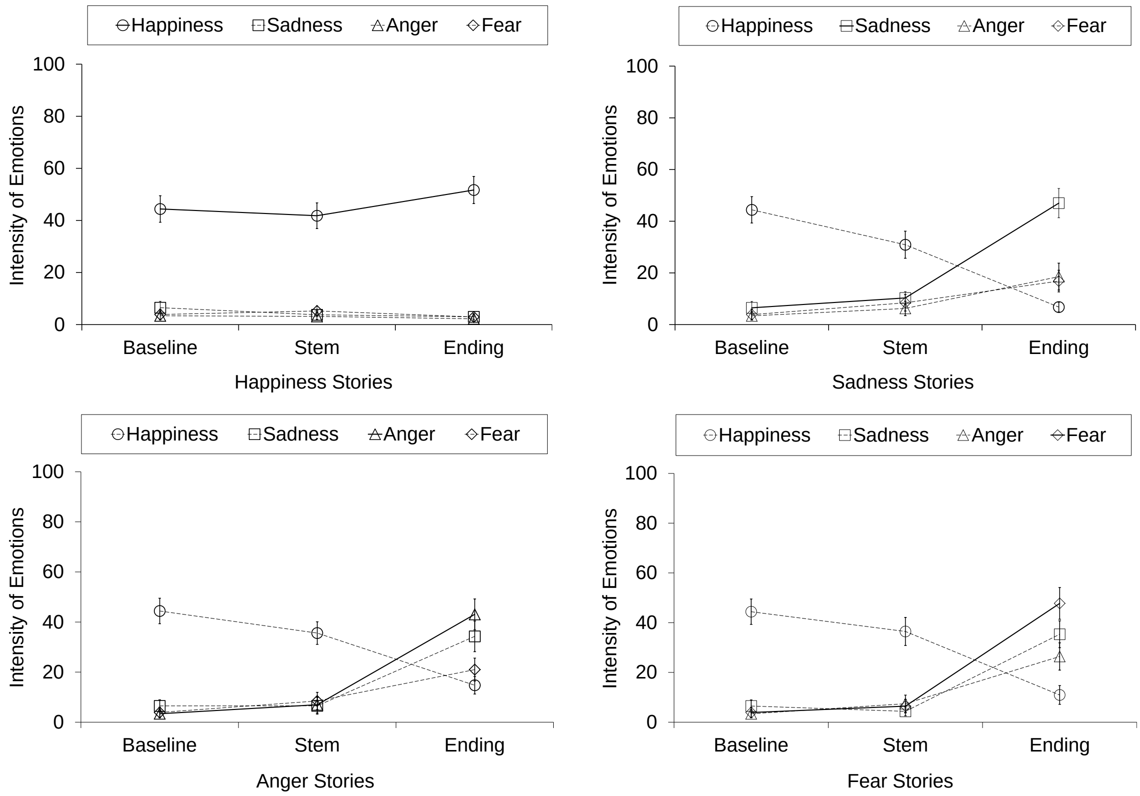

Figure 5. Emotional re-experience at seven days after the initial presentation.
The negative target emotions (i.e., in sad, angry and fearful stories) remained unchanged after the presentation of the story stems, but dramatically increased after the recollection of the story *endings*, particularly for the target emotions. Solid lines show the target emotion. The error bars represent ±1 *SE* of the mean.

A repeated measures ANOVA revealed that this finding was significant ($F(1, 29)=36.12$, $p<.001$; degrees of freedom reported using the lower-bound estimate of sphericity, $\varepsilon=.33$). Simple contrasts confirmed that the intensity of *happiness* was significantly higher than sadness ($F(1, 29)=32.61$, $p<.001$, $r=.73$), fear ($F(1, 29)=49.20$, $p<.001$, $r=.79$), and *anger* ($F(1, 29)=51.76$, $p<.001$, $r=.80$). These findings confirmed the expectation, commonly found in ‘neutral’ affective states – that *happiness* was the dominant emotion at Baseline.

2.4.2.3.2 Happiness following story stems.

A key issue was whether the presentation of the neutral stem, known to have preceded an emotional event in the past, was sufficient to produce a *re-experience* of the original emotions. An initial analysis targeted the changes in *happiness*, as it was the dominant emotion at the start of Recall 2. However, the intensity of *happiness* was not significantly different after Baseline (see above) and after *any* of the four story *stems* (*anger*, *M*=35.8, *SD*=25.3; *fear*, *M*=34.2, *SD*=32.1; *sadness M*=30.2, *SD*=30.7; and *happiness*, *M*=40.6, *SD*=28.7) – as confirmed by a non-significant paired-samples ANOVA. Thus, surprisingly, the presentation of the story *stems* did not affect participants' *happiness*, despite unimpaired *recall* of the *endings* and a later elicitation of a clear *emotional response* after each story ending was formally recalled.

2.4.2.3.3 Re-experiencing the target emotion after story stems and endings.

Although the story *stems* did not affect the intensity of *happiness*, a further analysis investigated if the *stems* succeeded in cueing the *target* emotion of the story ending (i.e., the intensity of *fear* elicited by *fearful stories*, etc.). This analysis was only relevant for the negative emotions (anger, fear and sadness), given that participants reported a high level of *happiness* at Baseline (*M*=41.3, *SD*=28.5), which changed little after the presentation of the *stem* (*M*=40.6, *SD*=28.7) and the recall of the ending of the happy stories (*M*=50.6, *SD*=30.3). A repeated-measures ANOVA showed that the difference between the ratings of *happiness* did not reach significance.

Anger. The levels of anger were negligible at the beginning of Recall 2 (Baseline; *M*=3.6, *SD*=9.2), continued to be low after the *stem* (*M*=3.6, *SD*=7.9), but were dramatically increased after the recall of the ending (*M*=42.2, *SD*=33.9). A one-way repeated-measure ANOVA was significant ($F(1, 29)=35.80$, $p<.001$; degrees of freedom corrected using the lower bound estimate of sphericity, $\varepsilon=.50$) and paired samples t-tests revealed that the intensity of the target emotion after the recall of the ending was greater than at Baseline ($t(29)=5.98$, $p<.001$, $r=.74$) and after the Stem ($t(29)=6.07$, $p<.001$, $r=.75$), but there was no difference between Baseline and Stem.

Fear. The ratings of Fear were low at Baseline ($M=4.2$, $SD=12.2$), and after the Stem ($M=6.3$, $SD=15.7$), but increased dramatically after the recall of the story ending ($M=52.2$, $SD=35.8$). A significant one-way repeated-measures ANOVA ($F(1, 29)=45.34$, $p<.001$; degrees of freedom corrected using the lower bound estimate of sphericity, $\varepsilon=.50$) was followed up by paired samples t-tests, which revealed that the intensity of fear after the Ending was greater than both at Baseline ($t(29)=7.34$, $p<.001$, $r=.81$) and after the Stem ($t(29)=6.57$, $p<.001$, $r=.77$), but there was no difference between Baseline and Stem.

Sadness. Finally, the intensity of sadness at Baseline ($M=8.5$, $SD=15.9$) was at a low level, increased slightly after the Stem ($M=10.4$, $SD=14.0$), and raised substantially after the Ending ($M=48.5$, $SD=32.1$). A one-way repeated-measures ANOVA reported a significant result ($F(1, 29)=40.38$, $p<.001$; degrees of freedom corrected using the lower bound estimate of sphericity, $\varepsilon=.50$). Similarly with the other negative emotions, paired samples t-tests revealed that fear was more intense after the recall of the *endings* than both at Baseline ($t(29)=6.83$, $p<.001$, $r=.79$) and Stem ($t(29)=6.43$, $p<.001$, $r=.77$), but the difference between Baseline and Stem was not significant.

In sum, the intensities of negative target emotions were unchanged after the presentation of the story stems, seven days after the initial encoding – although the detailed recollection of the story *endings* immediately afterwards produced a selective elicitation of the appropriate target emotions.

2.4.2.4 The emotional re-experience after story contexts and the recall of story endings

An intriguing possibility is that the emotional re-experience after the presentation of the story *stems* (both after 30 minutes and 7 days) was related to the subsequent explicit recall of the story *endings*. It is at least theoretically possible that participants may have automatically (and silently) recalled the story *endings*, while listening to the story stems, or while they considered providing the self-report ratings of emotions after the story stems. To test this hypothesis a set of correlations were performed between the re-experience of the target emotion after the presentation of the story *stem* and the subsequent recall accuracy. The analyses were carried out for each negative emotion (anger, fear, sadness) after 30 minutes and 7 days from the first presentation (see Figure 6).

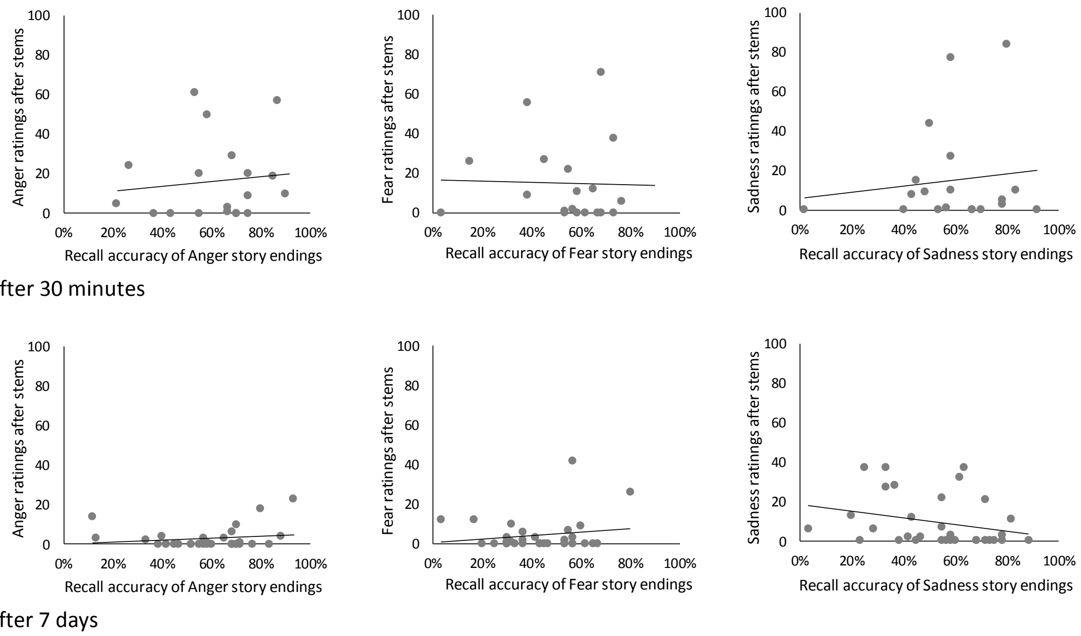

Figure 6. The correlations between the re-experience of the target emotion after the presentation of the story *stems* and the subsequent recall of the story *endings*.

As shown in Figure 6 A., after 30 minutes, the correlations between the emotional experience ratings after the presentation of the story *stems* and the recall accuracy were non-significant for the *anger* stories (*r*(19)=0.11, *p*=.642), fear stories (*r*(19)=-0.03, *p*=.903), and sadness stories (*r*(19)=0.12, *p*=.617). Similarly, after seven days, all correlations remained non-significant (see Figure 6 B.): *anger* stories (*r*(32)=0.18, *p*=.334), fear stories (*r*(32)=0.17, *p*=.358), and sadness stories (*r*(32)=-0.27, *p*=.130). These results are in line with the previously reported findings that the recall of the story *endings* was not correlated with the recall accuracy. The lack of any correlation suggest an absence of empirical support for the idea that participants may have recalled the story *endings* automatically, and silently, during or immediately after the presentation of the story.

2.5 Discussion

The present study reports a newly developed set of stories, designed to investigate a range of four basic emotions: three of which have been traditionally labelled as ‘negative’ (i.e., *anger*, *fear*, *sadness*), and one ‘positive’ (*happiness*). The stimuli elicited the target emotion discretely, at similar levels of intensity.

This is the first direct investigation comparing the stability of affective valence and discrete emotions over time. As first proposed by the hierarchical theory of emotions (Tellegen et al., 1999), and supported by evidence from affective neuroscience (Panksepp, 2004), emotion valence was expected to outlast the experience of discrete emotions. A series of self-referential vignettes elicited selectively four commonly investigated discrete emotions (anger, fear, sadness, and happiness). After the presentation of semantically neutral *contexts* preceding the emotional events in the stories, participants were able to experience selectively the discrete emotions elicited by the associated episode after a short period of time (i.e., 30 minutes). However, over the course of a week, the story *contexts* lost their affective specificity, carrying only a *flavour* of the associated emotions, in the form of either positive or negative affect. The loss of the emotional specificity of the story *contexts* could not be explained by an affective reappraisal of the stories, since the detailed episodic recall elicited the target emotions discretely and accurately every time.

2.5.1 Valence, discrete emotions and the hierarchical organisation of affect

The sustained stability of valence in the absence of the specific experience of the target discrete emotion, reported in the present study, supports the hierarchical organisation of affect, which proposes that valence is a *more* fundamental property of emotional expression, underlying all distinct classes of emotions (Tellegen et al., 1999). Thus, despite the universal, automatic and differentiable character of discrete emotions, they seem to require, over time, more intense forms of emotion elicitation (e.g., detailed episodic recall) than are needed for the re-experience of affective valence. Furthermore, the results also confirmed previous reports (Watson & Clark, 1992) that discrete classes of emotions have in common an either positive or negative valence when they are being experienced (as shown by story *contexts* after 30 minutes), but also that the affective valence is what ultimately is retained and re-experienced from emotional memory when the specificity of discrete emotions has faded (as seen after seven days).

Future research could expand present findings in at least four ways. Firstly, the results of the affective conditioning paradigm employed in the present study could be replicated by participants showing a selective episodic memory impairment (i.e., the amnesic syndrome). Such patients have long been shown to possess a normal ability to retain and re-experience past emotions (Bechara et al., 1995; Feinstein, Duff, & Tranel, 2010; LaBar, LeDoux, Spencer, & Phelps, 1995; Turnbull & Evans, 2006), for considerable periods of time (Damasio, 1994). Thus, it would be possible to examine if specific discrete emotions can even be experienced in the absence of explicit episodic recall, and also, if in such cases emotional memory can retain and retrieve distinct classes of affect.

Secondly, the present study employed momentary self-reports of emotional experiences, as an established way of measuring specific emotions. However, relatively recent neroimaging evidence (Tettamati et al., 2012; Vytal & Hamann, 2010) has invited the possibility of investigating specific cerebral blood-flow patterns as correlates for discrete emotions (anger, fear, sadness, disgust, and happiness). The superior temporal resolution of fMRI techniques over the end-of-story self-reports would allow a live measurement of affective change, which in turn could help identify emotional trigger points during the presentation and recall of narratives, as well as peak and ebb points for the intensity of each discrete emotion.

Thirdly, a further dimension that could be added to the present design refers to the amount of seemingly neutral and emotional details and their association with emotional re-experience; these are sometimes called "peripheral" and "central", respectively (Loftus, 1996). Situations when neutral versus emotional details influence the accuracy and consistency of episodic recall are abundant in the eye-witness literature (see for a review Loftus, Doyle, & Dysert, 2008), but the simultaneous direct investigation of these differences between a wide range of discrete emotions is notably absent. This is surprising since different classes of discrete emotions have long been reported to have a specific effect on other cognitive functions (Lench, Flores, & Bench, 2011).

Fourthly, many studies investigating the difference between positive and negative emotions, in different methodological *contexts*, seemed to reach contradictory findings, especially in relation to the interaction between episodic memory and emotional experience (see for a review Levine & Lench, 2010). Thus, a simultaneous and methodologically controlled investigation of a broader range of discrete classes of emotions could provide more conclusive evidence regarding the effect of distinct emotional experiences on episodic memory.

2.5.2 Implications for core affect and the psychological constructivist view of emotions

The present finding that valence is more stable than the experience of discrete emotions seemingly supports the core affect and psychological constructivist view of emotions. Indeed, the stable re-experience of the correct positive or negative valence of the story *stems* both after 30 minutes and seven days seems to suggest that core affect is a basic process in the experience of emotions. Due to the nature of the self-report measures, only one of the two dimension of core affect were captured in the present study, namely valence (pleasure-displeasure), and not arousal. Nonetheless, the reliable re-experience of the same emotion (viewed as core affect) after the presentation of the story *stems* seems to suggest that intrinsic reaction to the known stories was either one of pleasure or displeasure and, as expected, this remained the same over time.

Notably, one of the fundamental aspects of core affect (Russell, 1999, 2009) is that it changes only in response to consciously processed information. It is without doubt that the participants' core affect changed after the presentation of each of the four stories stems, regardless of the order in which they were presented. However, it remains open to speculation if (or when) participants actually recalled the emotional *endings* of the stories, namely because the only information we have about what the participants were thinking coms from what they told us. One possibility is that, indeed, as instructed, participants listened to the story *stems* and paid attention to them exclusively, after which they reported their momentary emotional experience. A second possibility (less likely for the reason presented below) could be that while listening to the story stems, or immediately afterwards, the participants consciously but silently anticipated (and recounted) the known emotional ending. Therefore the emotional ratings given after the listening to the story stems were in fact referring to the quickly but internally remembered story *endings*. Of course, this artefact would have defeated the purpose of the experimental design. However, such an explanation would not be easily fit the pattern of the results. After 30 minutes from the initial presentation, participants reported specific discrete emotions of reduced intensity after story stems, while after the full (and aloud) recollection of the story *endings* they reported the same discrete emotions with a high specificity and intensity. If the change in core affect was due to conscious processes, then a similar process should have been observed after 7 days. This was not the case. Seven days later, participants' emotional reaction after the story stems was non-specific regarding discrete emotions, but consistent with the positive or negative valence of the story *endings*. It seems unlikely that all participants would have recollected the story *endings* rapidly and silently while listening to the story stems, or shortly afterwards on one occasion, but then a second time nobody or hardly anybody would have done the same thing again.

The present results suggest two novel hypotheses for core affect and psychological construction of emotions. Firstly, the findings seem to indicate that, perhaps, core affect does change in response to unconscious processes. Secondly, the processes broadly defined as psychological construction seem to be recruited differently (1) over time, and (2) in the presence and absence of conscious recollection. It is beyond the purpose of this study to investigate or explain the mechanisms through which this might happen, but indeed, in the absence of detailed recall, over short periods of time processes leading to a very specific categorisation of emotions manifested, while over seven days only those processes that differentiate between pleasure and displeasure were took place. Markedly, after detailed recall, all processes leading to specific emotional experiences were activated both over the short (30 minutes) and longer time frames (seven days).

2.5.3. Active recollection is essential for re-experience

The second aim of the study was to examine the degree to which the presentation of the circumstances *surrounding* an emotional event (i.e., main character, time and location), would produce the re-experience of emotion evoked during the original event. The most surprising finding was the magnitude of the emotional response to the initially neutral stem, when it was known to participants that it would have an emotional ending. At the start of the recall phase, participants' baseline level of *happiness* was high. After complete recall, as expected, participants re-experienced emotional states which were both powerful, and retained the specificity of the original target stories delivered a week earlier. However, surprisingly, emotions were not elicited after cueing, when recall was prompted by the emotionally neutral stem. Notably, the participants subsequently reproduced the story rather well, and in doing so powerfully re-experienced the appropriate emotion. This result suggests that the process of formal *detailed recall* is central for full affective re-experience.

This finding can be linked with the positive psychology literature, which favours an approach usually labelled as "savouring". Here, an individual actively takes time to revisit and systematically re-experience previous events which had been positive (Bryant, 1989; Bryant & Veroff, 2007). This literature suggests several ways in which such positive re-experiencing may benefit *happiness* and overall mental health (Hurley

& Kwon, 2011; Jose, Lim, & Bryant, 2012; Quoidbach, Berry, Hansenne, & Mikolajczak, 2010). The present study offers a clear example of the way in which detailed re-experiencing can map directly onto positive emotional states.

There are further lines of evidence of the obverse aspect of the argument, suggesting that *reducing* re-experience *decreases* the magnitude of negative affect, not only in the encoding stage, but also in later memory. It has long been recognised that re-experiencing a memory directly after a traumatic event disrupts affective control, and leads to an enhancement of disorders such as PTSD (Bisson, Jenkins, Alexander, & Bannister, 1997; Conlon, Fahy, & Conroy, 1999; Mayou, Ehlers, & Hobbs, 2000). There have been various approaches which attempt to regulate the emotional consequences of such re-experiencing, which are relevant to therapy. For example, the work of Emily Holmes suggests that avoiding episodic recall of an event, through visuo-spatial distraction, reduces traumatic re-experience (Krans, Näring, Holmes, Becker, 2010; Stuart, Holmes, & Brewin, 2006). Similar approaches have been adopted in the sport psychology domain where elite athletes are encouraged to actively avoid the recollection of aversive negative experiences in order to maintain adequate levels of concentration (Mahoney, Gabriel, & Perkins, 1987; Thomas & Over, 1994) and improve performance (Jackson, Thomas, Marsh, & Smethurst, 2001). In a different class of therapeutic intervention, attempts are often made to *allow* the patient to re-experience traumatic events, but to *manage* the emotional consequences of these traumatic recollections through reappraisal or reframing (Bryant, 2011; Litz, Gray, Bryant, & Adler, 2002; Nickerson, Bryant, Silove, & Steel, 2010; Williams, Joseph, & Yule, 1994).

Emotional self-report measures remain the most widely used means of investigating the intensity of discrete emotions in experimental psychology. However, as with any subjective ratings they introduce the risk of demand characteristics – an experimental artefact where participants direct their responses away from the intended purpose of the experiment, and towards fulfilling self-serving goals, such as, appearing that the experiment has worked in their case (and thus they fit the expected norm), or on the contrary assuming a negative-participant role, and derail the experimental procedure (see for a detailed discussion Weber & Cook, 1972). To reduce the risk of demand characteristics, the present study dissimulated the true nature of the experimental manipulation until the final debriefing at the end of the last session of the study. Participants were told that this was a pilot study aim to investigate the effect of listening to a set of stories on the ability to perform mental calculations. Emotional measures were also collected in this case to assess the participants' affect. As per usual practice, the memory task was only revealed before participants were asked to recall the stories, so knowledge of the task could not have affected the encoding of the material. However, participants were repeatedly asked to provide self-report measures of their emotional experience. Demand characteristics could have affected the present study if participants had identified and labelled the stories as being specific to each discrete emotion (the nasty/angry story, the scary story, the sad story and the nice/happy story). In turn, this could have affected the experimental results in two ways: (1) after listening to the story *stems/contexts*, participants may have identified the story by the affective label they assigned to it (angry, scary, sad, happy) and provide emotion reports consistent with their labelling (irrespective of their true affective experience), and/or (2) when providing the affective experience ratings after recalling the story *endings/contents*, participants may have remembered that they reported once feeling specifically very "angry" after the angry story and provided emotional ratings consistent with their initial reports. However, the instructions for providing emotional experience ratings specifically mentioned, each time, that participants were expected to report momentary ratings of the four emotions (i.e., how they felt in that moment), rather than emotions associated with the presented/recall story (i.e., how the story made them feel). This is a significant aspect of the orienting task, which directs the focus away from a cognitive assessment of the story and towards an introspective assessment of own affect. Moreover, as argued below, the participant data itself argues against the previous two confounding effects.

Firstly, there are strong reasons to believe that participants followed the instructions faithfully after the presentation of the story *stems*. This is because initially, the story *stems* were rated as neutral, but 30 minutes after the presentation of the associated story *endings*, they reported the specific re-experience of the target emotion, (just as they did after the story *endings*) but at a substantially reduced intensity. Thus, their emotional reports following the story *stems* after 30 minutes are neither consistent with their initial ratings of the story *stems* (which were neutral), nor with their ratings of the emotional *endings* (which were of a considerably higher intensity). Thus, the emotion ratings are not consistent compatible with an attempt to remain consistent with an earlier set of ratings – whichever they may be: after the story *stems* or story *endings*. Moreover, the emotion ratings after 7 days were no longer specifically identifying the target emotion, but all negative stories reported a significant reduction in the baseline levels of *happiness*. Again, such ratings are further removed from any of the previous ratings after the presentation of 30 minute recall phases, either after *stems* or *endings*. In conclusion, it seems that indeed, the emotion ratings showed a successful and specific affective conditioning of the *stem* to the target emotion after 30 minutes and a loss of the specific re-experience and retention only of the correct affective valence (positive or negative).

Secondly, the emotion self-report ratings after the presentation and 30-minutes and 7-day recall phases respectively was markedly consistent over time, with a high degree of specificity and high intensity. This may present the risk of participants potentially having recalled their previous emotional report and choose to provide similar ratings on subsequent occasions. However, the recall accuracy of the story *endings* showed an identical pattern with the emotion ratings, being markedly similar between the 30-minutes and 7-days phases, containing almost the same emotional material every time. If demand characteristics were responsible for this high consistency in emotion ratings over time (instead of the constantly high recall accuracy), it is difficult to explain the different ratings of participants after the story *stems*. The only explanation could be that participants were naive about the story *stems* and thus provided true (and changing over time) ratings of their emotions after them, but treated the story *endings* differently, by always referring to and repeating their initial ratings, time after time and for each of the four discrete emotions. This convoluted possibility is made even more unlikely by the fact that the standard deviations of the emotional ratings after *stems* and *endings* were low and constant over time. This means that all the participants with no noticeable exception should have adopted the same approach in providing emotion ratings differently after story *stem* and *ending*, thus allowing for individual differences in putting into practice this approach. While it is not possible to entirely exclude this possibility for a limited minority of cases, it seems very unlikely that such a highly complex rationale which goes against the direct instructions of the task and its face validity, would have applied to a majority of participants, thus driving the effects reported in the study.

In conclusion, this is the first investigation of the hierarchical classification of basic discrete emotions, using emotional memory. Results showed that stimuli encountered in emotional situations, reflect the discrete emotional specificity of these situations. However, ultimately, over time, they elicit only the core affect, characterised by either a positive or negative valence. These changes over time appear to represent a fundamental structure of affect, suggesting that valence is a *more* basic level at which emotional experiences seem to be encoded and re-experienced. Discrete classes of affect appear to be subordinated to the positive or negative dimension, to be more volatile over time, or to require superior forms of cognitive and emotional processing. Such an organisation of affect invites a dynamic and simultaneous investigation of both discrete emotions and valence, especially to understand the influence of emotions on cognition and vice-versa.

Secondly, the present study provided an important empirical foundation for a psychological process with substantial practical and therapeutic implications. To promote and maximise happiness and good mental health we might seek to encourage a complete recollection of positive experiences, whereas the re-experience of negative emotional experiences is best delayed until managed appropriately. More specifically, it seems that emotions elicited by past events do not appear to transfer to temporally adjacent memories (i.e., story *endings* to story stems), even after repeated recollections. Arguably, one possibility is that episodic memory may have helped to strengthen the dissociation between the neutral *stem* and emotional *ending*. Further studies could investigate this claim by attempting to replicate the present findings in cases of diminished recall of episodic information (e.g., in elderly memory impaired, or amnesic participants).

Chapter 3. The specific re-experience of discrete emotions in amnesic Korsakoff’s syndrome patients

3.1 Abstract

Amnesic patients have long been shown to re-experience emotions elicited by events they no longer remember. The neural structures fundamentally associated with the processing of emotionally arousing stimuli (i.e., the amygdala), although strongly connected to episodic memory structures (e.g., mammillary bodies, fornix, the hippocampal complex, etc.) have been shown to preserve their function in amnesic patients. However, this preserved ability of amnesic patients to re-experience past emotions has only been tested in the *context* of generic emotions (e.g., positive and negative; or arousing vs neutral), and never for a full set of specific classes of basic emotions. Also, recent empirical reports have argued that executive functions play a significant role in the re-experience of emotions. However, evidence of which basic emotions are associated with which executive functions are still missing. The present study reports the first separate and simultaneous investigation of the differences in the intensity of the emotional re-experience of *anger*, *fear*, *sadness*, and *happiness*, between a group of amnesic patients and controls. The relationship between the intensity of the re-experience of four basic emotions (*anger*, *fear*, *sadness*, and *happiness*), and well-established measures of executive function is also assessed. Twenty Korsakoff's syndrome patients and 20 neurologically normal age matched controls listened to four emotional vignettes eliciting discretely one of the four basic emotions, and recalled them later, while providing self-report measures for each of the four emotions. The results showed that after 30 minutes, the recall of each of the four stories was severely impaired for Korsakoff's patients, but the emotional re-experience was not different from that of controls. A separate analysis for both groups revealed that there was no relation between the number of episodic details recalled by participants and the reported intensity of each of the four emotions. Moreover, even those patients who could not remember anything at all from the stories after 30 minutes, reported moderate levels of the correct target emotion – and this finding was consistent for all four emotion classes. The intensities of *fear*, *sadness*, and *happiness* were consistently associated with executive functions, such as, cognitive flexibility, response inhibition and non-verbal fluency, and Processing Speed, and Performance IQ from WAIS. Conversely, the intensity of *anger* was only associated with the Verbal Comprehension task from

WAIS, and not with any significant executive function tests. The findings suggest that discrete classes of emotions can be re-experienced independently of episodic memory. This is also a first attempt to map the relationship between the re-experience of the four discrete emotions and the ability to perform specific executive functions and superior abstract cognitive tasks. Although the statistically significant results are encouraging, the findings are limited by the small sample size and the inability to separate the data from the neurologically impaired and unimpaired participants. Future studies could seek to replicate the findings and possibly to pool the data together for a joint analysis.

Keywords: basic emotions, emotional memory, episodic memory, amnesia, Korsakoff's syndrome.

3.2 Introduction

3.2.1 Emotional re-experience in amnesia

Past emotions have long been shown to be encoded and accurately retrieved in the absence of an episodic memory trace of the eliciting event. Perhaps the earliest report consistently cited in the literature is that of Swiss neurologist Édouard Claparède about an amnesic Korsakoff's syndrome patient intuitively avoiding his handshake after being pricked with a hidden pin (Claparède, 1911/1951). More recent studies have reported that even densely amnesic patients show an improved recognition of emotional stimuli as much as controls (Hamann, Cahill, McGaugh, & Squire, 1997; Phelps, LaBar, & Spencer, 1997) and possess the same ability to access past emotional experiences and to employ them in guiding present decisions (Turnbull & Evans, 2006). The neural mechanisms behind the preserved ability of amnesic patients to accurately re-experience past emotions have been revealed in neurological studies which confirmed the dissociation between the roles of the amygdala and hippocampus (Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995; see also Phelps, 2004).

Past emotions are not only equally relevant to amnesic patients as they are to controls, but it has been suggested that certain negative emotions (e.g., sadness) could be more enduring for amnesic patients than controls, while other emotions (e.g., *happiness*) might not be any different (Feinstein, Duff, & Tranel, 2010). The small sample size prevented Feinstein and colleagues from drawing any generalising conclusions about affective processes, but invited the question of whether negative emotions have a special property of being more stable than *happiness*, in the absence of episodic memory. Such a dissociation would not be surprising, since positive and negative emotions appear to be affected by different biases (Levine, Lench, & Safer, 2009) and emotion regulation processes (Kim & Hamann, 2007). More than *general* positive and negative emotions, discrete basic emotions (e.g., *anger*, *fear*, *sadness*, *happiness*) may differ in the way they are experienced by amnesic patients and controls, since such emotions have already been shown to uniquely activate different neural structures (Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012; Vytal & Hamann, 2010), have been linked with individual autonomic nervous system response patterns (Rainville, Bechara, Naqvi, & Damasio, 2006; Stephens, Christie, & Friedman, 2010), and to elicit specific changes in cognition, judgment, and behaviour (Lench, Flores, & Bench, 2011).

3.2.2. Emotional experience and the executive function

A large body of psychological evidence has traditionally proposed that cognition can influence and be influenced by emotions (Bower, 1981, Isen, Shalke, Clark, & Karp, 1978; Johnson & Tversky, 1983; Ortony, Turner, & Antos, 1983; Schwarz & Clore, 1983). More recent accounts have argued that emotion–cognition interactions are largely agreed to be a major factor influencing the processes that sustain, amplify, or attenuate emotion experience – collectively labelled *emotion regulation* (Izard, Woodburn, Finlon, Krauthamer-Ewing, Grossman, & Seidenfeld, 2011). Moreover, emotion–cognition interactions are also viewed as a fundamental part of our ability to engage attentional, emotional-cognitive, and behavioural capacities in order to solve everyday challenges – generically referred to as executive function. (cf., Nelson, Thomas, & deHaan, 2006; Zelazo, Carter, Reznick, & Frye, 1997).

The neural pathways most strongly argued to underpin the emotion–cognition interactions point in the direction of the anterior cingulate cortex (ACC) due to its strong connections with other brain regions in the limbic system and neocortex. For example, the ACC was found to play a significant role in processing emotional arousal, and in the interaction between emotions and attention (Lane, Reiman, Axelrod, Yun, Holmes, & Schwartz, 1998; Rudrauf et al., 2009) and is strongly involved in the experience of intense emotions (Phan, Wager, Taylor, & Liberzon, 2002), and interpersonal relations and social engagement (Rudebeck, Bannerman, & Rushworth, 2008). At the same time, the ACC is engaged in decision making processes that require executive functioning (Rudrauf et al., 2009), and neuroimaging evidence also suggests that it is associated with the resolution of emotional conflicts (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006). These functions of the ACC are supported by its interconnectivity with discrete areas of the temporal lobe and subcortical circuits that are involved in controlling activity of the autonomic nervous system (Pessoa, 2009). The anterior cingulate cortex interacts with the amygdala and nucleus accumbens, in integrating affectively significant signals with control signals in the prefrontal cortex (Pessoa, 2009).

Generically, the executive function is a collection of interrelated cognitive processes, predominantly located within the frontal lobes, which are responsible for controlling and directing other brain processes, emotional responses, and behaviour (Gioia, Isquith, & Guy, 2001). Although there is presently no definitive and universally accepted list of executive functions, the most widely mentioned processes include the capacity for response inhibition, switching back and forth between tasks, resisting interference from distractors, forming and carrying out an efficient problem-solving strategy, and integration of feedback.

A growing body of literature has recognised the role of executive function in moderating emotional responses and behavioural actions (Garcia-Andres, Huertas-Martinez, Ardura, & Fernandez-Alcaraz, 2010; Gioia, Isquith, Guy, & Kenworthy, 2000Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012). Executive control is often reported to influence the processing and experience of emotions (Cohen, Henik, & Moyal, 2012; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Etkin, Prater, Hoeft, Menon, & Schatzberg, 2010). Furthermore, neuroimaging studies have reported that emotion regulation and re-experience are strictly linked with brain regions involved in executive function (Cohen, Henik, & Mor, 2011; Goldin, McRae, Ramel, & Gross, 2008; Kim & Hamman, 2007; Levesque et al., 2003; Ochsner et al., 2004). Significantly, impaired executive functioning (executive dysfunction) is often associated with maladaptive emotional responses and social behaviour (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Eslinger, Grattan, Damasio, & Damasio, 1992; Grattan & Eslinger, 1991).

However, the explicit influence of cognitive processes on the re-experience of *discrete emotions* has not been explained by previous studies. The question of interest is what, if not episodic memory, can predict the intensity of the re-experience of discrete basic emotions. More specifically, are differences in executive functions associated with a stronger or less intense re-experience of discrete emotions?

The present study firstly investigates the differences between the experience of four basic discrete emotions (i.e., anger, fear, sadness, and happiness) of amnesic patients (Korsakoff's syndrome) and control participants with unimpaired episodic memory. Secondly, the relationship between the episodic recall and the experience of each discrete emotion is also assessed. Thirdly, the relationship between the intensity of the emotional re-experience of *anger*, *fear*, *sadness*, and *happiness*, and executive function abilities is investigated.

3.3 Method

3.3.1 Participants

Twenty Korsakoff's patients (16 recruited from four residential care units, four patients recruited from home care), and twenty control participants recruited from the local community (see Table 4 for basic demographics) took part in the study in return for the usual amount of participant payment (£10/hour). Recruitment was completed on an opportunity sample basis, and all participants completed all four sessions of the study.

Table 4.

The basic demographics of the Korsakoff patients and control participants.

Group	Female	Male	Age		Years of Education	
			M	*SD*	*M*	*SD*
Korsakoff Patients	6	14	53.5	7.8	11.0	1.3
Control Participants	10	10	64.0	7.8	13.1	3.1

3.3.2 Stimuli and Measures

Four emotional vignettes (developed and piloted previously) were used to elicit discretely *anger, fear, sadness*, and *happiness* respectively (see Appendix F). A propositional analysis (Kintsch, 1994; Kintsch & van Dijk, 1978) was performed on all *Endings* and each propositional unit was treated as a discrete recall unit – a detailed description of the protocol is presented elsewhere (Turner & Greene, 1977). Each story had 60 recall units, whose exact recollection was used to calculate the recall accuracy (see Appendix G).

Momentary ratings of emotional experience were collected using the *anger*, *fear*, *happiness*, and *sadness* questionnaires extracted from the Visual Analogue Mood Scales (VAMS; Stern, 1997). The VAMS questionnaires (see Appendix I) required participants to indicate the momentary intensity of each of the four discrete emotions on a 100mm vertical visual analogue scale. Schematic faces representing a neutral expression and the target emotion anchor the analogue scale. The schematic faces at both ends of the scale are accompanied by a word label describing the neutral state and the four target emotions (i.e., Neutral, Angry, Afraid, Happy, and Sad). The VAMS have been reported to have high validity and test-retest reliability (see Stern, 1997), and were also validated for use with various clinical populations (Arruda, Stern, Somerville; 1999). Recall was measured by comparing the transcripts of the audio recordings of participants' recollections of the stories to the original scripts and counting the number of propositional units correctly reproduced.

3.3.3 Design

The study employed a mixed-factorial design, and included two groups: Korsakoff patients and control participants, and four emotions (*anger, fear, sadness*, and *happiness*). The presentation order of the four sets of stories was counterbalanced using a balanced latin-square.

3.3.4 Procedure

The emotion elicitation paradigm will be adapted for amnesic patients (see Schmidt, 1996), to include successive repetitions of the verbal stimuli in order to help fixate the episodic details of the emotional stories. This will allow the Korsakoff patients to process the meaning of the story as a whole, and create associations between the character and *context* of each story and the emotion eliciting actions presented. In line with classical findings of amnesic patients (Butters et al., 1988; Dean, Massman, Butters, Salmon, Vermak, & Kramer, 1991; Janowski, Shimamura, & Squire, 1989; Squire, Haist, & Shimamura, 1989), episodic memory is expected to be disrupted by an interference story. The recall accuracy scores immediately after interference and following a longer delay of 20-30 minutes are expected to illustrate the Korsakoff patients' level of memory impairment (Squire & Shimamura, 1986), and allow the investigation of the emotional re-experience in the absence of episodic memory.

Participants completed the study over four separate sessions, scheduled one week apart. Each session targeted a specific basic emotion, using a different emotional vignette, and following a similar procedure between sessions. Participants listened to the target emotional story in three successive repetitions, after each presentation recalling everything that they could remember, and immediately providing momentary ratings of the four basic emotions, after each recollection. A novel, distracting story was read at the end of the three repetitions, followed by a similar recall task and emotion rating. Next, participants were asked to recall the target story once again, but notably without listening to it first. After a 30 minute delay interval, occupied with various pen-and-paper tasks, participants were asked again to recall from memory the target story and to provide emotion ratings for each of the four basic emotions.

3.3.5 Neuropsychological assessments

The neuropsychological assessment of participants (Korsakoff patients and neurological controls) included two batteries of executive function tests (i.e., the Delis-Kaplan Executive Function Scale, and the Behavioural Assessments of Dysexecutive Function), the Wechsler Adult Intelligence Scale, the Wechsler Abbreviated Scale of Intelligence, and the Wechsler Memory Scale IIIR. Table 5 shows a list of the tests included from each battery and the number of participants who were administered each test. Appendix H shows a detailed list of all the composite scores computed for each test.

Table 5.

List of neuropsychological assessment tests and the number of participants who were administered each test. (DKEFS – Delis-Kaplan Executive Function Scale)

Battery / Name of test	***Korsakoff patients***	***Control participants***	***Total***
DKEFS - Trail Making	19	19	38
DKEFS - Verbal Fluency	19	16	35
DKEFS - Design Fluency	14	5	19

DKEFS - Colour-Word Interference	14	5	19
DKEFS - Sorting Test	14	5	19
DKEFS - Twenty Questions Test	14	4	18
DKEFS - Word Context Test	14	4	18
DKEFS - Tower Test	14	4	18
DKEFS - Proverb Test	14	4	18

Battery / Name of test (continued)	***Korsakoff patients***	***Control participants***	***Total***
Behavioural Assessment of the Dysexecutive Syndrome	14	5	19
Wechsler Memory Scale III-R – Auditory Immediate	20	16	36
Wechsler Memory Scale III-R – Auditory Delayed	20	16	36
Wechsler Memory Scale III-R – Auditory Recognition Delayed	19	5	24
Wechsler Memory Scale III-R – Working Memory	14	5	19
Wechsler Abbreviated Scale of Intelligence – Verbal IQ	14	5	19
Wechsler Abbreviated Scale of Intelligence – Performance IQ	14	5	19
Wechsler Abbreviated Scale of Intelligence – Full Scale IQ	14	5	19
Wechsler Adult Intelligence Scale – Verbal IQ	13	4	17
Wechsler Adult Intelligence Scale – Performance IQ	13	4	17

Wechsler Adult Intelligence Scale – Full Scale IQ	13	4	17
Wechsler Adult Intelligence Scale – Verbal Comprehension	13	4	17
Wechsler Adult Intelligence Scale – Perceptual Organisation	13	4	17
Wechsler Adult Intelligence Scale – Working Memory	13	4	17
Wechsler Adult Intelligence Scale – Processing Speed	13	4	17

3.3.6 Data analysis

All participants completed all four sessions of the study. Participant's recall transcripts were scored independently by two blind raters against the initially identified recall units to produce the recall accuracy score with an almost perfect inter-rater agreement (*Kappa*=0.93, p<.001, 95% CI [0.928, 0.932]). The final recall score was computed as the average of the two ratings. Emotional experience ratings from the visual analogue scales were converted into numeric values ranging from 0-10 (using one decimal place). Mixed-factorial ANOVAs followed-up by planned contrasts were used to compare the intensity and recall accuracy scores of the four sets of emotional stories. Simple Bonferroni corrections were applied to the family-wise alpha rate (α=.05) for planned contrasts. A series of independent-samples one-way ANOVAs confirmed that there were no order effects for the recall accuracy scores (*anger*, $F(3,36)=.04$, $p=.988$., $\eta_p^2=.004$.; *fear*, $F(3,36)=.04$, $p=.991$, $\eta_p^2=.003$; *sadness*, $F(3,36)=.15$, $p=.927$, $\eta_p^2=.013$; *happiness*, $F(3,36)=.07$, $p=.975$, $\eta_p^2=.006$), the overall intensity of emotion ratings (*anger*, $F(3,36)=1.32$, $p=.284$, $\eta_p^2=.099$; *fear*, $F(3,36)=2.02$, $p=.129$, $\eta_p^2=.144$; *sadness*, $F(3,36)=.84$, $p=.480$, $\eta_p^2=.066$; *happiness*, $F(3,36)=2.06$, $p=.123$, $\eta_p^2=.146$), or the intensity of target emotions (*anger*, $F(3,36)=.97$, $p=.417$, $\eta_p^2=.075$; *fear*, $F(3,36)=2.0$, $p=.132$, $\eta_p^2=.142$; *sadness*, $F(3,36)=1.02$, $p=.394$, $\eta_p^2=.078$; *happiness*, $F(3,36)=1.88$, $p=.151$, $\eta_p^2=.135$).

3.4 Results

3.4.1 Neuropsychological assessments of amnesic Korsakoff's syndrome patients

3.4.1.1 Mini Mental State Examination (MMSE)

All 20 Korsakoff's syndrome patients were administered the Mini Mental State Examinations. The results are shown in Figure 7.

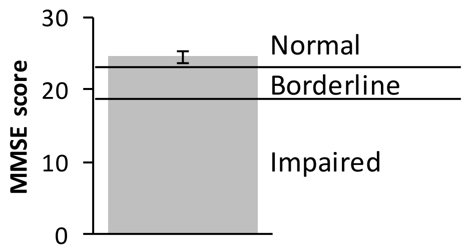

Figure 7. The Mini Mental State Examination (MMSE) score (Korsakoff patients). The Korsakoff's syndrome patients scored in the normal range of the MMSE, with a minimal variation in scores. Error bars represent +/– 1 SE.

3.4.1.2 The Beck's Depression Inventory

The Beck Depression Inventory (BDI) is a questionnaire developed to measure the intensity, severity, and depth of depression in patients with psychiatric diagnoses. It is also used to detect depressive symptoms in a primary care setting as part of a psychological or medical examination. Fourteen Korsakoff's syndrome patients were administered the Beck Depression Inventory (see Figure 8).

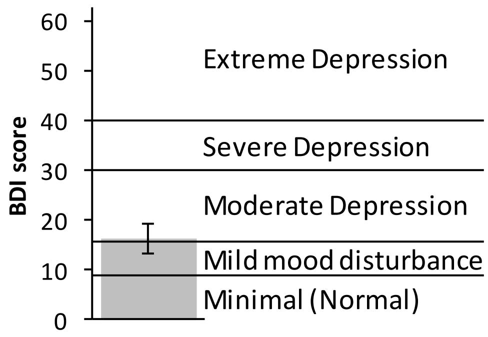

Figure 8. Beck Depression Inventory (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients scored in the mild-moderate depression range of the BDI test. Error bars represent +/– 1 SE.

3.4.1.3 Emotion Regulation Questionnaire (ERQ)

The Emotion Regulation Questionnaire (ERQ) is designed to measure respondents' tendency to regulate their emotions in two ways: (1) Cognitive Reappraisal and (2) Expressive Suppression. Cognitive reappraisal is a form of cognitive change that involves construing a potentially emotion-eliciting situation in a way that changes its emotional impact. Expressive suppression is a form of response modulation that involves inhibiting on-going emotion-expressive behaviour. Reappraisal is an antecedent-focused strategy: it occurs early, and intervenes before the emotion response tendencies have been fully generated. This means that reappraisal can efficiently alter the entire subsequent emotion trajectory. More specifically, when used to down-regulate negative emotion, reappraisal should successfully reduce the experiential and behavioural components of negative emotion. By contrast, suppression is a response-focused strategy: it comes relatively late in the emotion-generative process, and primarily modifies the behavioural aspect of the emotion response tendencies. Suppression should thus be effective in decreasing the behavioural expression of negative emotion, but might have the unintended side effect of also clamping down on the expression of positive emotion. At the same time, suppression will not be helpful in reducing the experience of negative emotion, which is not directly targeted by suppression and may thus continue to linger and accumulate unresolved. In addition, because suppression comes late in the emotion-generative process, it requires the individual to wilfully manage emotion response tendencies as they continually arise. All scores range from zero to seven. Fourteen Korsakoff's syndrome patients were administered the test (see Figure 9).

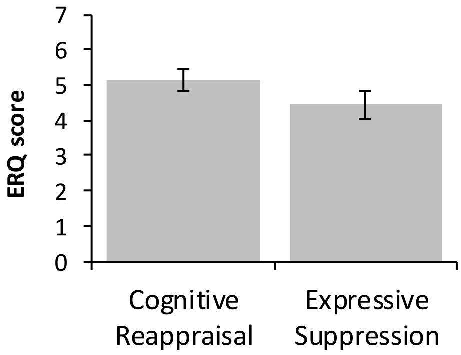

Figure 9. Emotion Regulation Questionnaire (Korsakoff's syndrome patients). The Korsakoff's syndrome patients scored marginally but significantly higher on the *cognitive reappraisal* scale than on the *expressive suppression* scale, showing an adaptive/positive emotion regulation functioning. Error bars represent +/– 1 SE.

3.4.1.4 D-KEFS Trail Making Test

Nineteen Korsakoff's syndrome patients were administered the D-KEFS Trail Making Test. The results are illustrated in Figure 10.

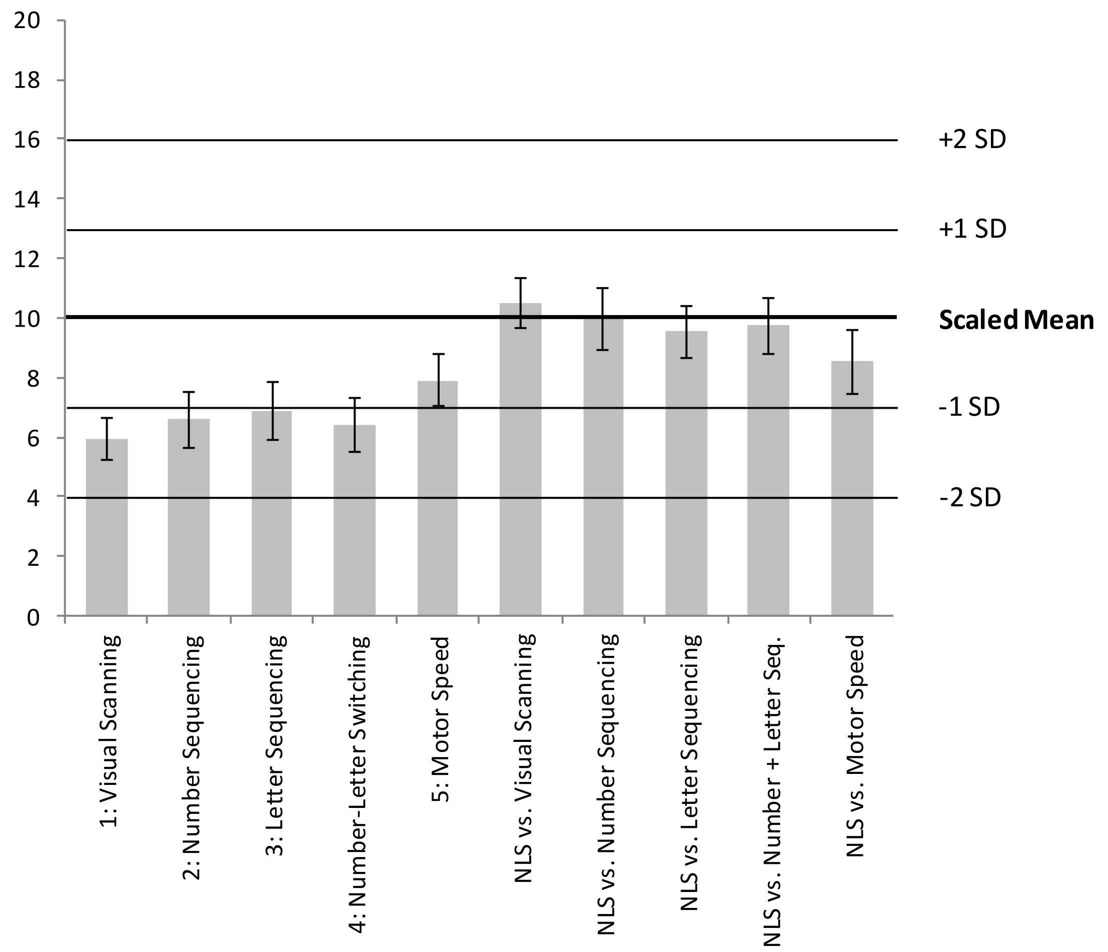

Figure 100. D-KEFS Trail Making Test (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients recorded a below-average score on the Trail Making Test, most importantly on Condition 4 (task switching). Error bars represent +/– 1 SE.

3.4.1.5 D-KEFS Verbal Fluency Test

Nineteen Korsakoff's syndrome patients were tested with the D-KEFS Verbal Fluency Test. The results are shown in Figure 11.

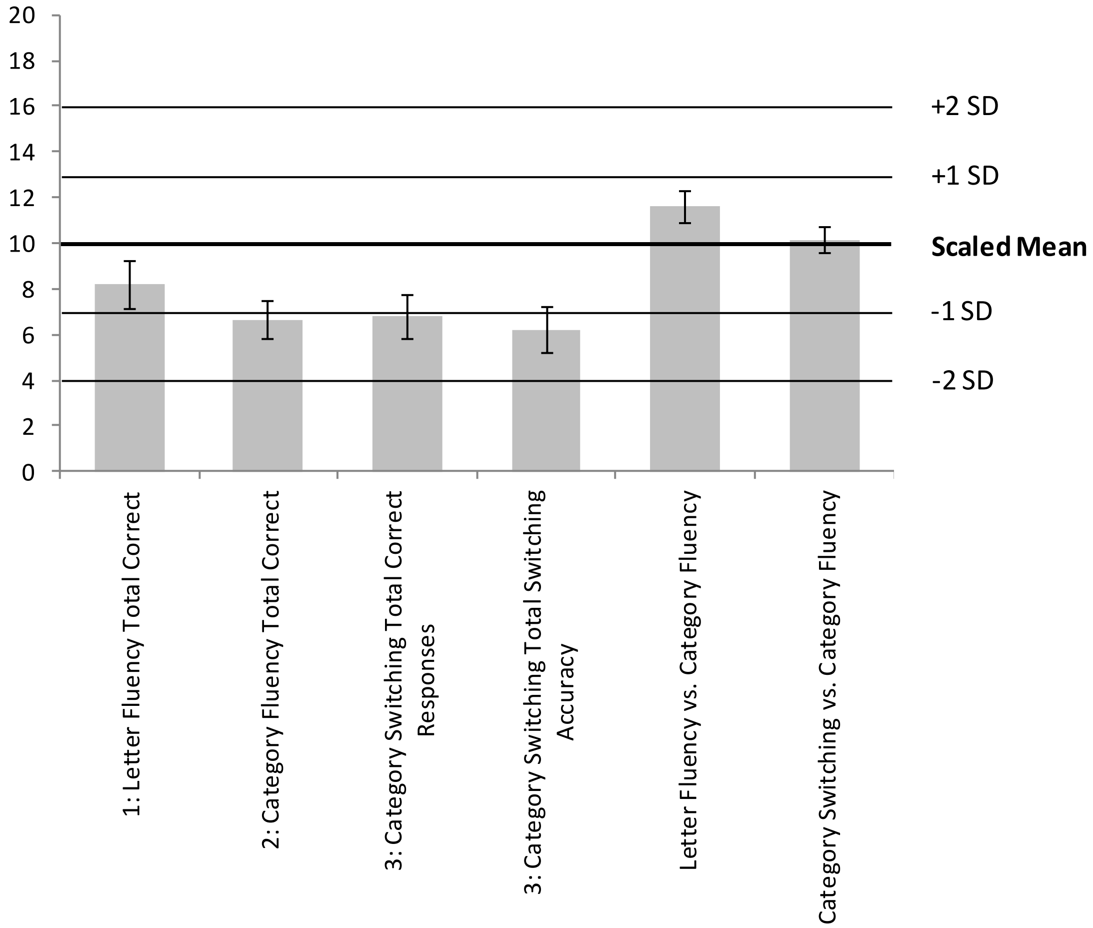

Figure 111. D-KEFS Verbal Fluency Test (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients scored significantly lower the age corrected mean (scaled mean) on the D-KEFS Verbal Fluency Test, especially on the two primary measures (task switching) during Condition 3. Error bars represent +/– 1 SE.

3.4.1.6 D-KEFS Design Fluency Test

The D-KEFS Design Fluency Test assesses motor planning, cognitive flexibility, and fluency in generation of visual patterns, above and beyond contributions from motor speed. Condition 1 provides a basic test of design fluency, Condition 2 measures both design fluency and response inhibition, and Condition 3 measures both design fluency and cognitive flexibility. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Design Fluency Test. The results are illustrated in Figure 12.

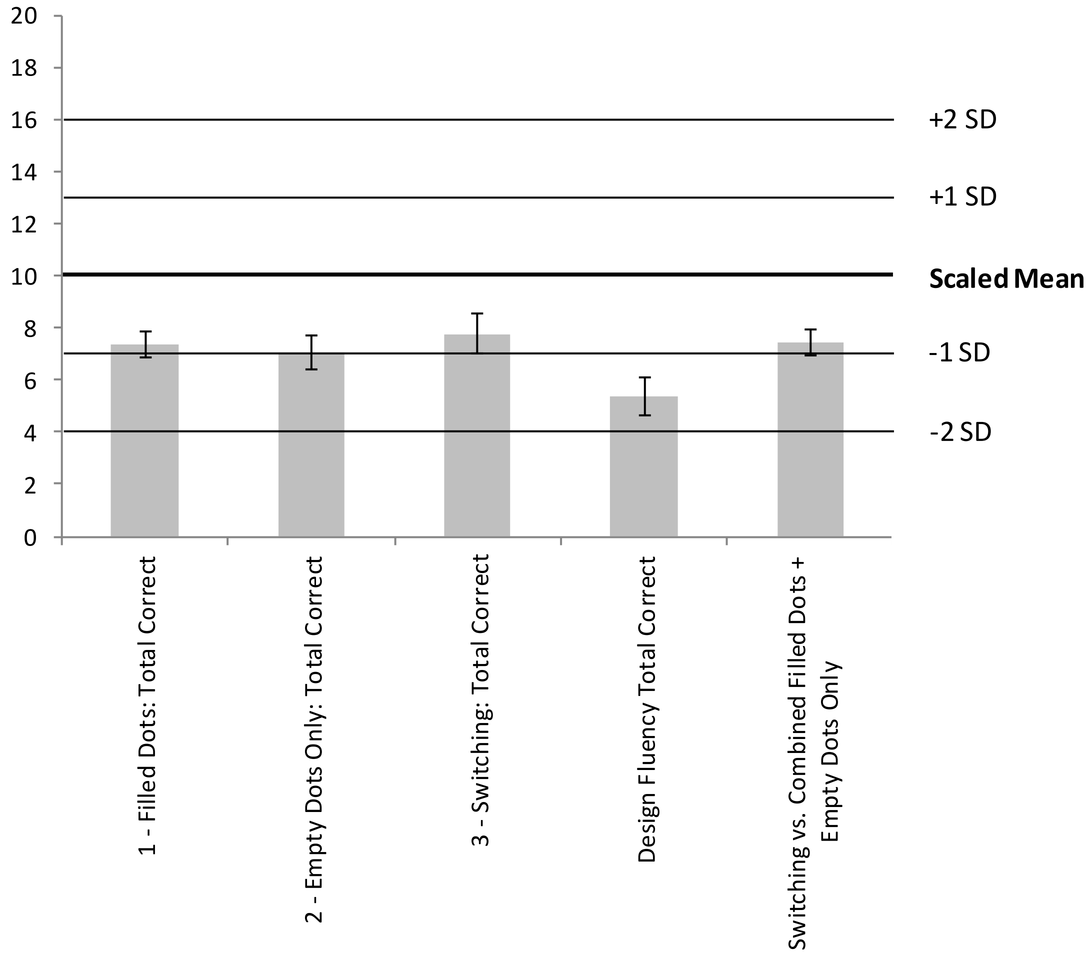

Figure 12. D-KEFS Design Fluency Test (Korsakoff's syndrome patients).
The Korsakoff's syndrome patients scored below the age corrected average of the Design Fluency Test on all measures, most importantly, on Condition 3 (task switching). The error bars represent +/– 1 SE.

3.4.1.7 D-KEFS Colour-Word Interference Test

The D-KEFS Colour-Word Interference Test is modelled on the Stroop task. The primary executive functions measured are verbal inhibition, simultaneous processing, and cognitive flexibility. Condition 3: Inhibition is the traditional Stroop task which measures verbal inhibition. Condition 4: Inhibition/Switching is a means of evaluating both inhibition and cognitive flexibility. Fourteen Korsakoff's syndrome participants took the D-KEFS Colour-Word Interference Test. The results are shown in Figure 13.

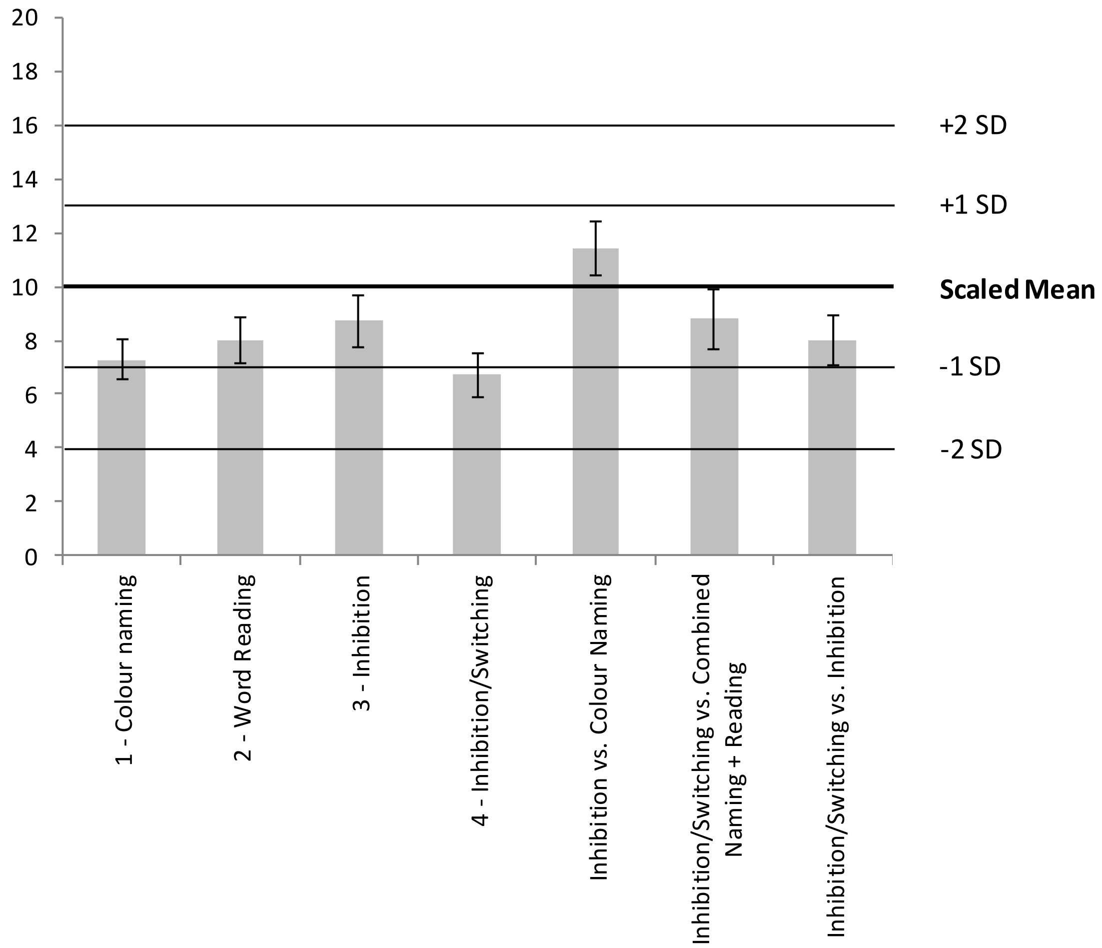

Figure 13. D-KEFS Colour-Word Interference Test (Korsakoff's syndrome patients). The Korsakoff's syndrome patients performed marginally but significantly below the age corrected average for the Condition 3 (inhibition) and lower still on Condition 4 (inhibition/switching) of the D-KEFS Colour-Word Interference Test. The error bars represent +/– 1 SE.

3.4.1.8 D-KEFS Sorting Test

The D-KEFS Sorting Test evaluates primarily the examinee's abilities of problem solving and concept formation. Secondly, the test also involves the executive functions of initiation of problem-solving behaviour concept formation skills, modality-specific problem-solving skills (verbal versus nonverbal), creativity in forming responses, transfer of conceptual knowledge into goal-directed behaviour, and the ability to inhibit previous responses in order to allow behavioural and cognitive flexibility. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Sorting Test. The results are depicted in Figure 14.

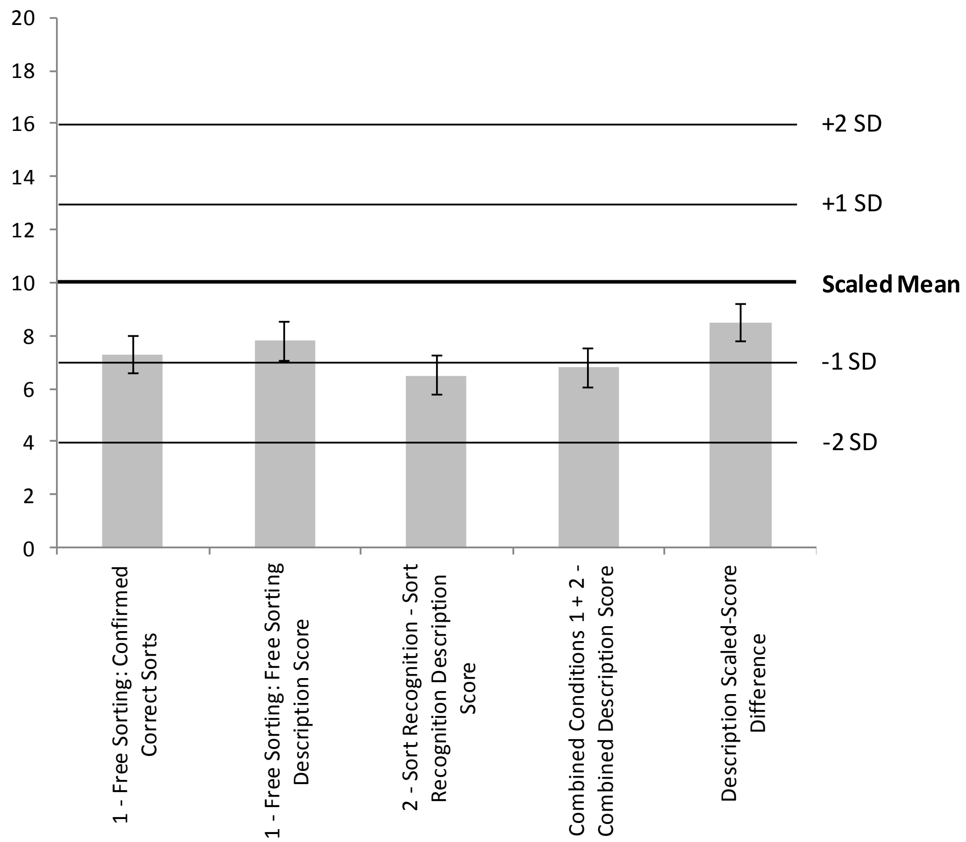

Figure 14. D-KEFS Sorting Test (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients performed below the age corrected average on all the measures of the D-KEFS Sorting Test. The error bars represent +/– 1 SE.

3.4.1.9 D-KEFS Twenty Questions Test

The D-KEFS Twenty Questions Test measures the examinee's logical thinking, hypothesis testing, and deduction. The test assesses the ability to organise visual elements into categories and subcategories, formulate abstract questions, and incorporate the examiner's feedback. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Twenty Questions Test. The results are shown in Figure 15.

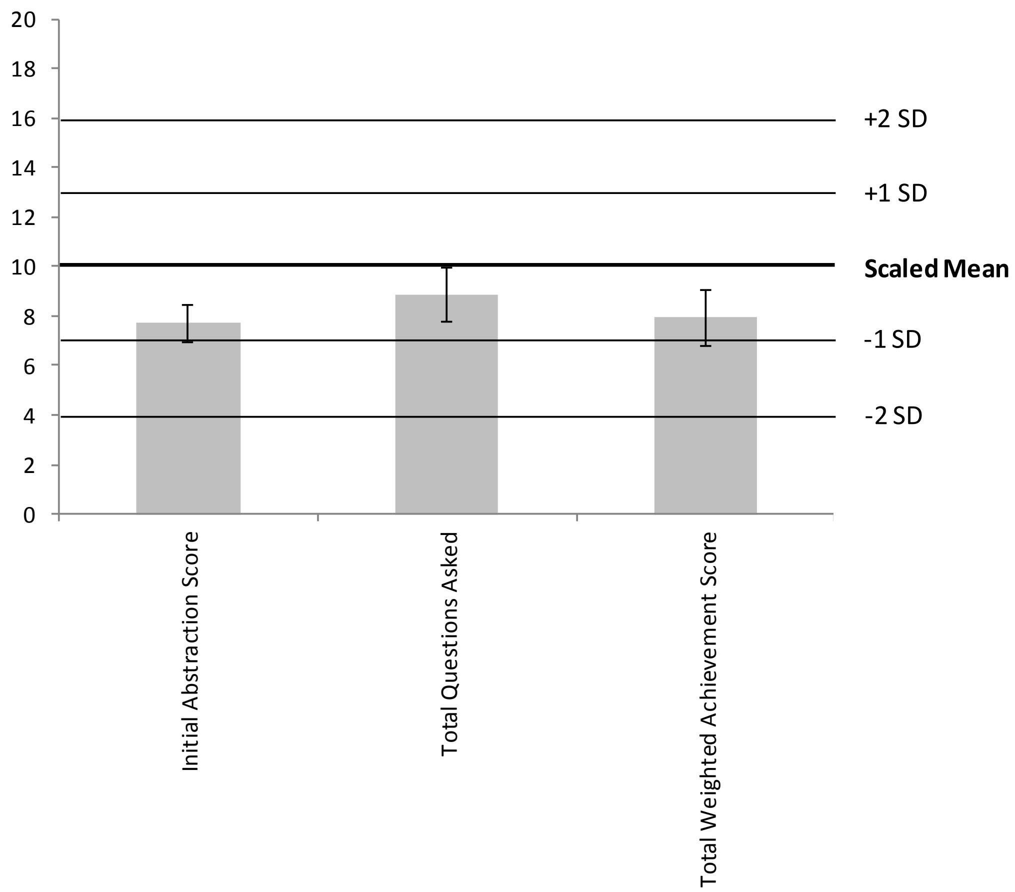

Figure 15. D-KEFS Twenty Questions Test (Korsakoff's syndrome patients). The Korsakoff's syndrome patients scored marginally but significantly below average on the D-KEFS Twenty Questions Test. The error bars represent +/– 1 SE.

3.4.1.10 D-KEFS Word Context Test

The D-KEFS Word Context Test is a means of evaluating executive functioning in the verbal modality and assessing skills such as deductive reasoning, integration of multiple bits of information, hypothesis testing, and flexibility of thinking. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Word Context Test. The results are shown in Figure 16.

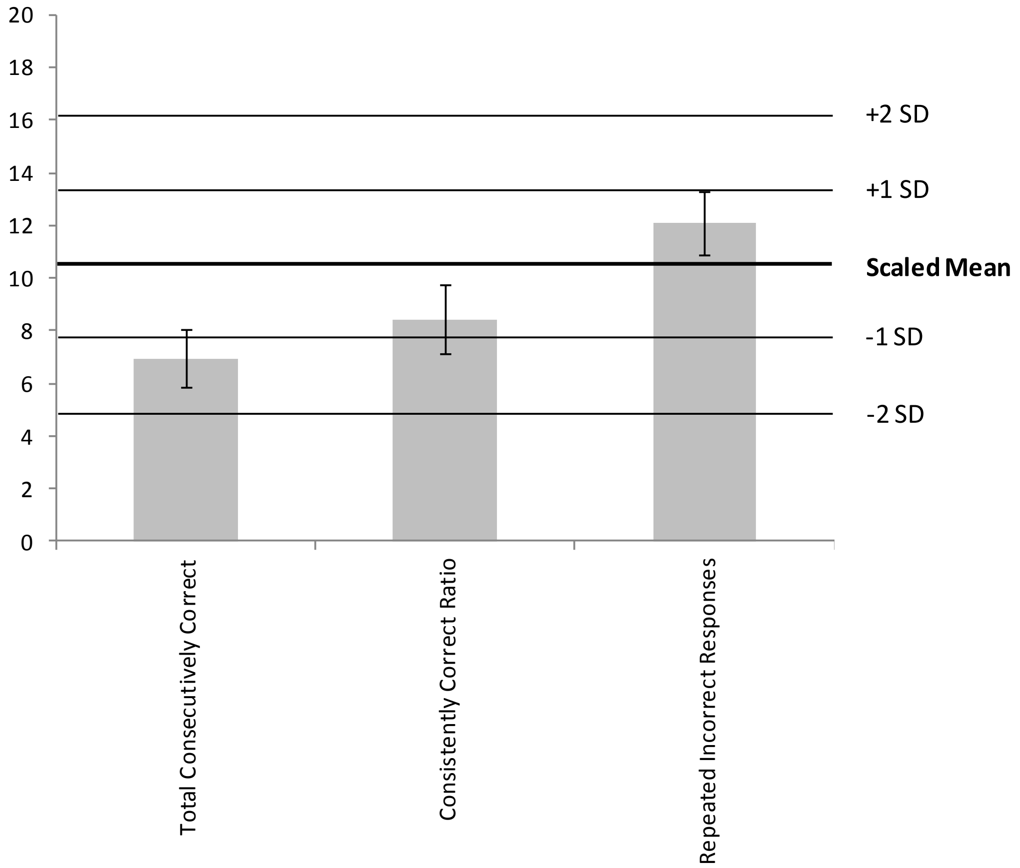

Figure 16. D-KEFS Word Context Test (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients performed below the average age corrected level of the D-KEFS Word Context Test. The error bars represent +/– 1 SE.

3.4.1.11 D-KEFS Tower Test

The D-KEFS Tower Test is a measure of visual attention, spatial planning, rule learning, inhibition of impulsive and perseverative responding, and the ability to establish and maintain a cognitive (instructional) set. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Tower Test. The results are illustrated in Figure 17.

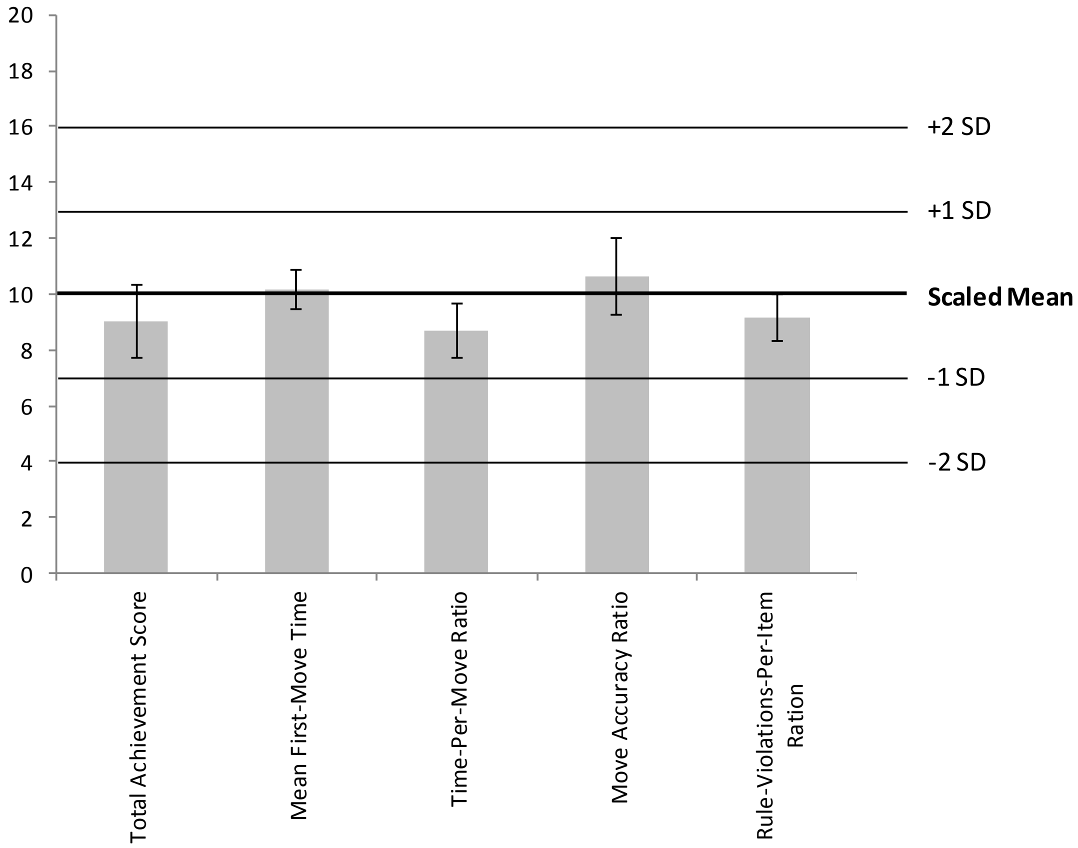

Figure 17. D-KEFS Tower Test (Korsakoff's syndrome patients).

Unlike all previous D-KEFS tests, the Korsakoff's syndrome patients showed a normal (age corrected average) performance on the D-KEFS Tower Test. The error bars represent +/– 1 SE.

3.4.1.12 D-KEFS Proverb Test

The D-KEFS Proverb Test assesses the examinee's ability to interpret brief, concrete phrases that convey deeper, abstract meaning. The test requires high level executive functions of verbal abstract thinking, semantic integration of the individual words into coherent, abstract principles or concepts, and generalisation to many situations beyond the concrete, literal interpretation. Fourteen Korsakoff's syndrome patients were administered the D-KEFS Proverb Test. The results are shown in Figure 18.

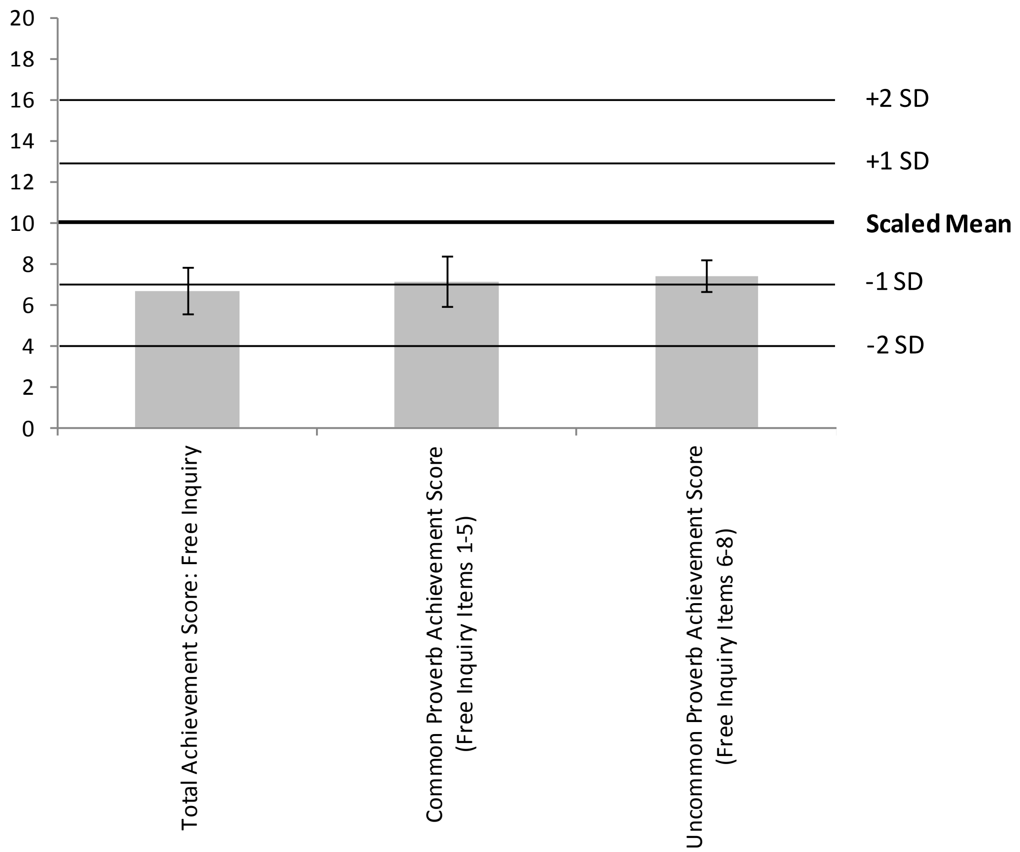

Figure 1818. D-KEFS Proverb Test (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients performed below the age corrected average on the D-KEFS Proverb Test. The error bars represent +/– 1 SE.

3.4.1.13 Behavioural Assessment of the Dysexecutive Syndrome

The Behavioural Assessment of the Dysexecutive Syndrome (BADS) is a battery of six tests which require participants to plan, initiate, monitor and adjust behaviour in response to the explicit and implicit demands of a series of tasks. (1) Rule Shift Cards (RS) – This test purports to identify perseverative tendencies and its obverse, mental flexibility (perseveration refers to a difficulty in adjusting behaviour to meet the demands of a changing situation). (2) Action Programme (AP) – This test assesses the ability to devise and implement a solution to a practical problem (getting a cork out of a narrow plastic tube) while not contravening a set of rules. (3) Key Search (KS) – was influenced by one of the task in the Stanford-Binet Intelligence Scale, and it assesses ability to plan a strategy to solve a problem (finding a key lost in a field). (4) Temporal Judgement (TJ) – This test involves judgement and abstract thinking based on common knowledge, as the respondent is required to estimate times for everyday events. (5) Zoo Map (ZM) – This is a test to assess the ability to formulate and implement a plan while following an instructional set (spontaneous planning ability) and to follow a pre-formulated plan while observing the original set of instructions. (6) Modified Six Elements (6E) – This test assesses the ability to time-manage, while making demands on the examinee's ability to plan, organise and monitor behaviour, and also to remember to carry out an intention at a future time (prospective memory). It involves dividing the available time between a number of simple tasks (picture naming, arithmetic and dictation) while not contravening a set of rules. The results of the six tests are reported as an aggregate score, standardised and age corrected. Fourteen Korsakoff’s syndrome patients took the BADS. The results are shown in Figure 19.

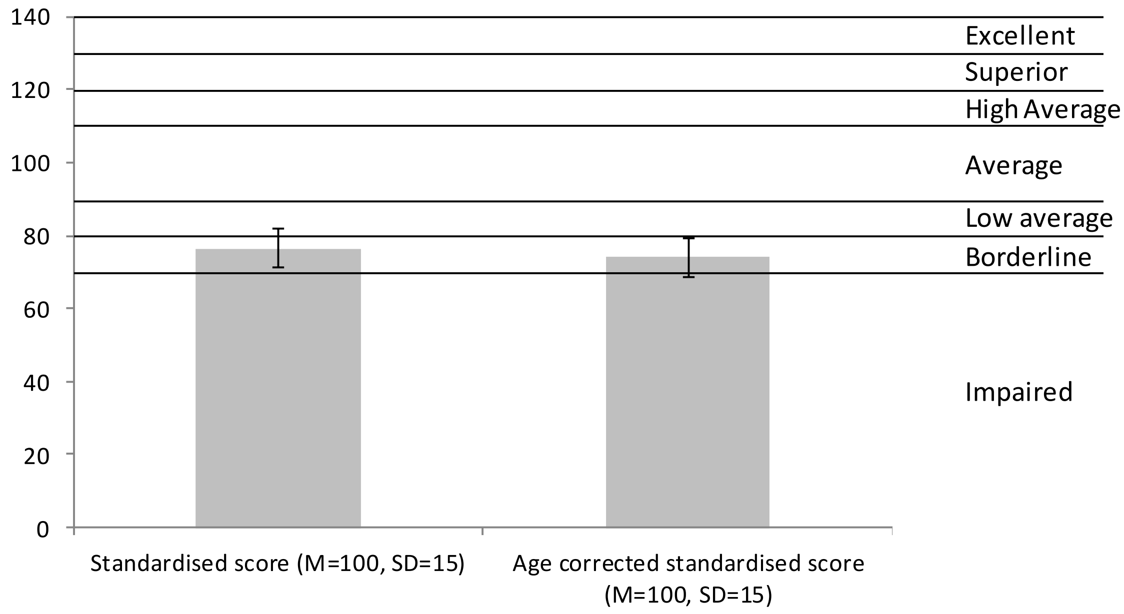

Figure 19. Behavioural Assessment of the Dysexecutive Syndrome (Korsakoff patients).

The Korsakoff's syndrome patients performed in the borderline-low average range of the BADS. The error bars represent +/– 1 SE.

3.4.1.14 Wechsler Memory Scale III-R

All 20 Korsakoff's syndrome patients were administered the Wechsler Memory Scale (III-R). As for the neurologically normal participants, only the Auditory Immediate, Auditory Delayed, Auditory Recognition Delayed and Working Memory indices are reported. The results are shown in Figure 20.

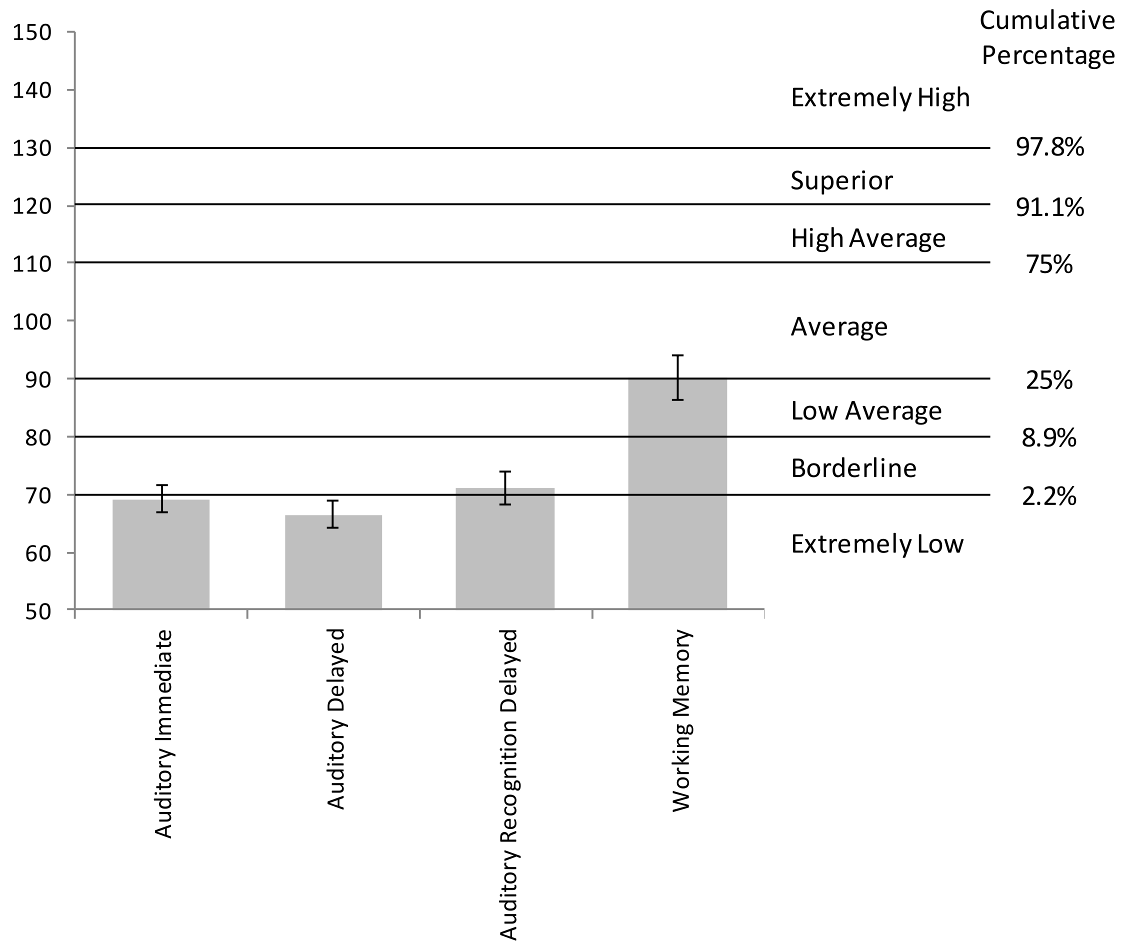

Figure 20. Wechsler Memory Scale III-R (Korsakoff's syndrome patients).

The Korsakoff's syndrome patients scored in the borderline-extremely low range of the WMS III-R for the three memory indices (Auditory Immediate, Delayed and Auditory Recognition Delayed). The Working Memory scores were close to the normal age corrected range, between the average and low average intervals. The error bars represent +/– 1 SE.

3.4.1.15 Wechsler Adult Intelligence Scale

The primary composite measures of the Wechsler Adult Intelligence Scale (WAIS) are the Verbal IQ, the Performance IQ, and the overall Full Scale IQ indices.

Scores for the secondary Verbal Comprehension, Perceptual Organisation, Working Memory, and Processing Speed indices are also presented.

The Verbal IQ is derived from scores on seven of the subtests: information, digit span, vocabulary, arithmetic, comprehension, similarities, and letter-number sequencing. The information subtest is a test of general knowledge, including questions about geography and literature. The digit span subtest requires test takers to repeat strings of digits. The vocabulary and arithmetic subtests are general measures of a person's vocabulary and arithmetic skills. The comprehension subtest requires test takers to solve practical problems and explain the meaning of proverbs. The similarities subtest requires test takers to indicate the similarities between pairs of things. The letter-number sequencing subtest involves ordering numbers and letters presented in an unordered sequence. Scores on the verbal subtests are based primarily on correct answers.

The Performance IQ is derived from scores on the picture completion, picture arrangement, block design, digit symbol, matrix reasoning, and symbol search. In the picture completion subtest, the test taker is required to complete pictures with missing elements. The picture arrangement subtest entails arranging pictures in order to tell a story. The block design subtest requires test takers to use blocks to make specific designs. In the digit symbol subtest, digits and symbols are presented as pairs and test takers then must pair additional digits and symbols. The matrix reasoning subtest requires test takers to identify geometric shapes. The symbol search subtest requires examinees to match symbols appearing in different groups. Scores on the performance subtests are based on both response speed and correct answers.

Thirteen Korsakoff's syndrome patients were administered the WAIS. The results are shown in Figure 21.

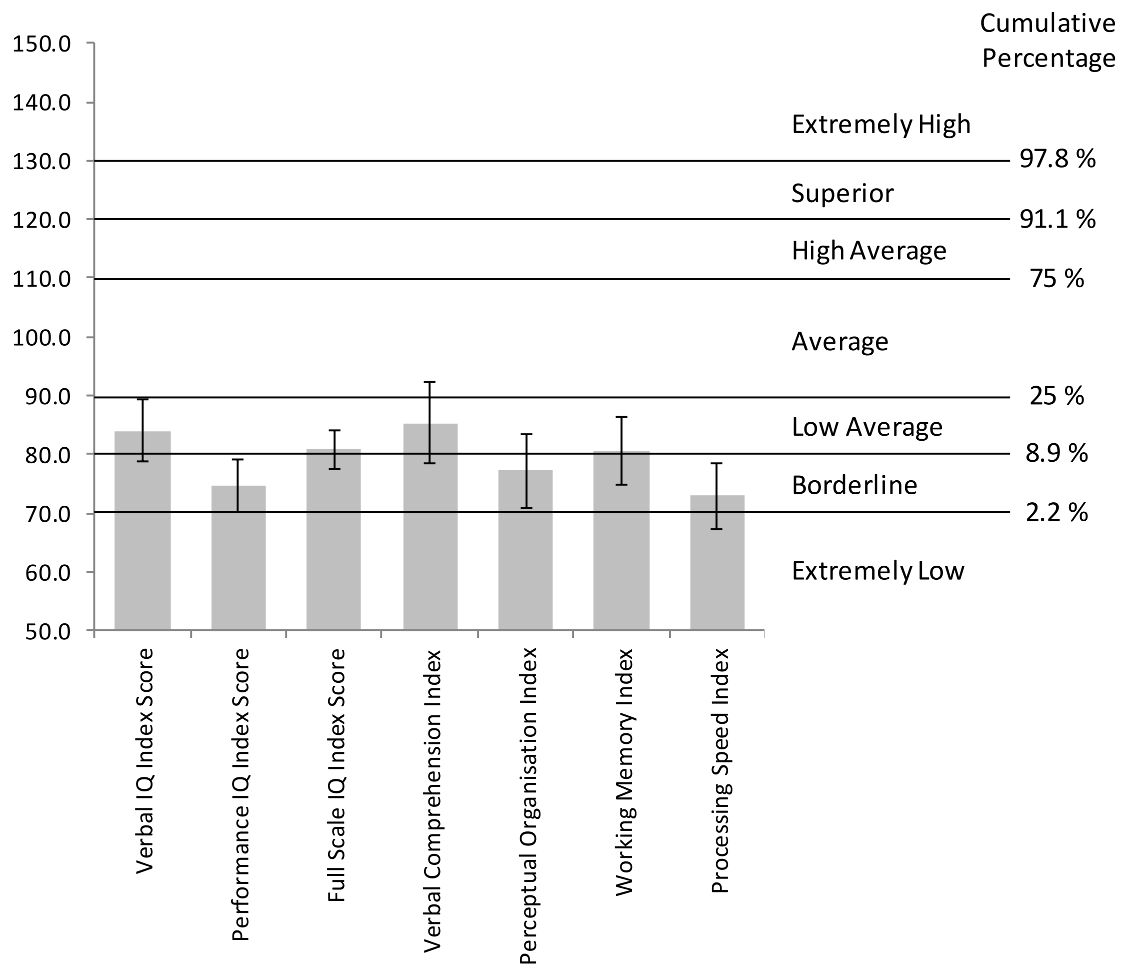

Figure 21. Wechsler Adult Intelligence Scale (Korsakoff's syndrome patients). The Korsakoff's syndrome patients scored between the low average and borderline low ranges of the WAIS, most importantly for the Full Scale IQ. The error bars represent +/– 1 SE.

3.4.1.16 Wechsler Abbreviated Scale of Intelligence

The Wechsler Abbreviated Scale of Intelligence (WASI) is a shortened version of the Wechsler Adults Intelligence Scale, which produces three primary composite scores: the Verbal IQ, the Performance IQ, and the overall Full Scale IQ indices. Although the scores on the WASI and WAIS are shown to be highly correlated, the fact that WASI can be administered in a shorter period of time, means that patients can potentially perform better. Fourteen Korsakoff's syndrome patients were administered the WASI. The results are shown in Figure 22.

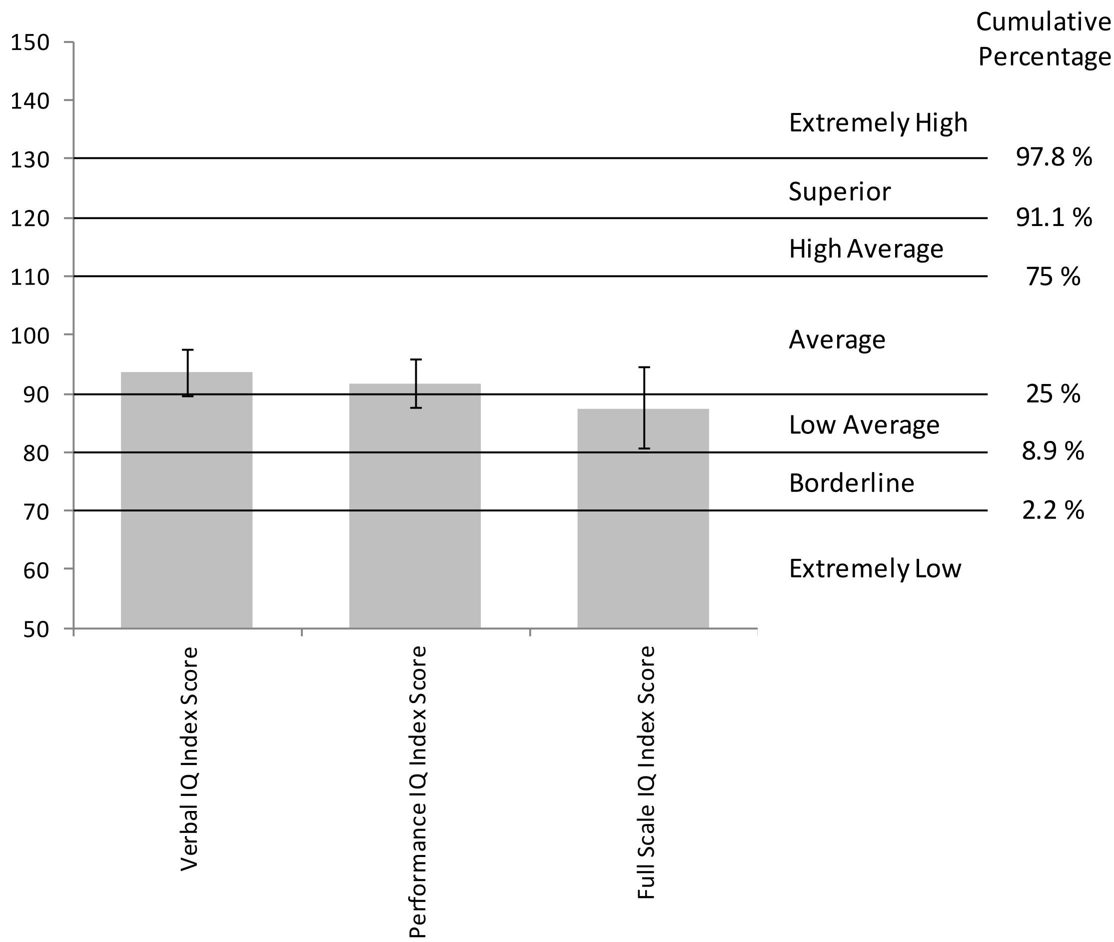

Figure 22. Wechsler Abbreviated Scale of Intelligence (Korsakoff's syndrome patients). The Korsakoff's syndrome patients performed close to the normal age corrected range of the WASI, between the average and low average intervals. The error bars represent +/– 1 SE.

3.4.2 Neuropsychological assessments of neurologically intact elderly controls

3.4.2.1 Mini Mental State Examination (MMSE)

The Mini Mental State Examination (MMSE) is the most commonly used test to screen for cognitive impairment. It can be used by clinicians to help diagnose dementia and to help assess its progression and severity. All 20 participants in the sample were administered this test, and the results are presented in Figure 23.

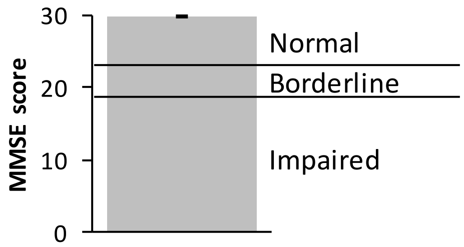

Figure 23. The Mini Mental State Examination (MMSE) score (elderly controls). Neurologically normal participants scored in the upper part of the normal range, with a minimal variation in scores. Error bars represent +/– 1 SE.

3.4.2.2 D-KEFS Trail Making Test

The primary executive function task is Condition 4: Number-Letter Switching, which assesses cognitive flexibility on a visual-motor sequencing task. The other four conditions allow the examiner to determine if a deficient score on the switching condition is related to a deficit in cognitive flexibility and/or to an impairment in one or more underlying skills. Nineteen participants were administered the Trail Making Test (see Figure 24).

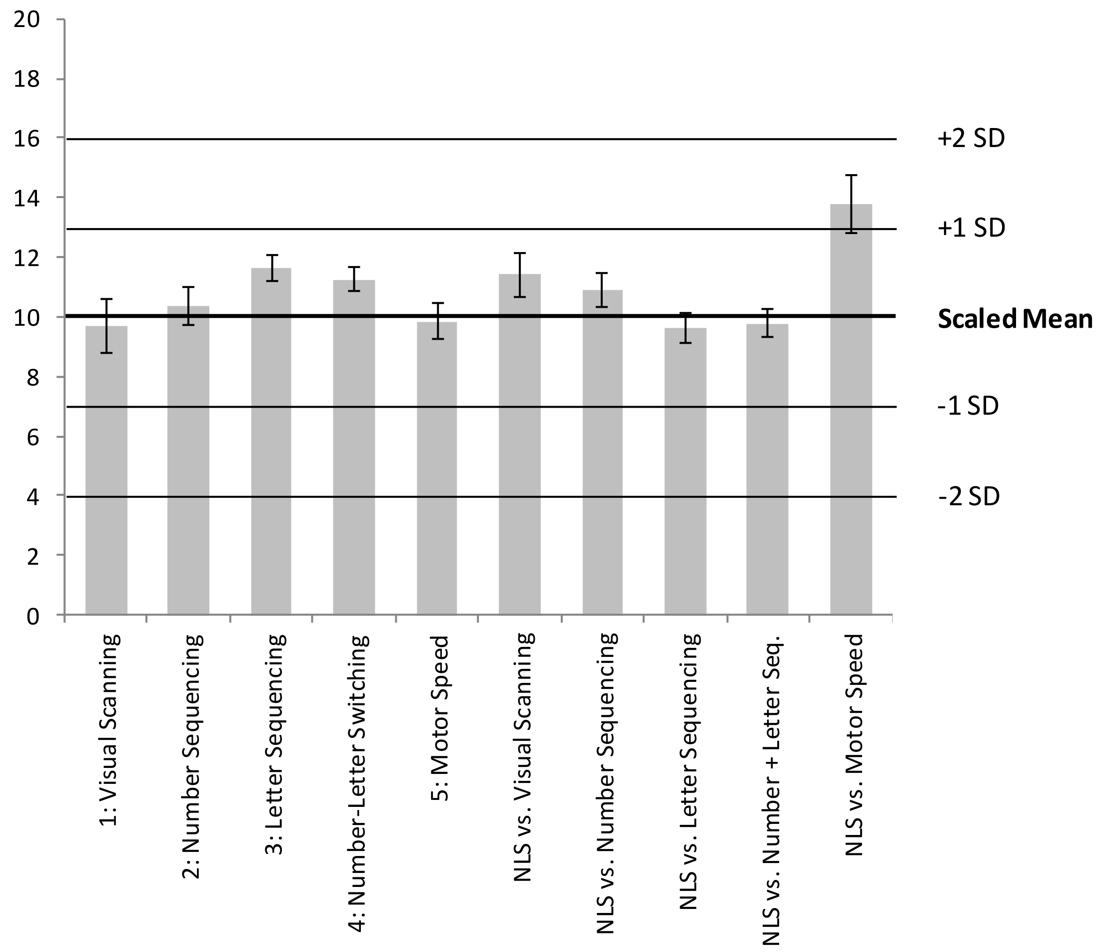

Figure 24. D-KEFS Trail Making Test (neurologically normal elderly controls)
The age corrected scores (scaled scores) showed participants performed above average on the key measures of the test, especially Condition 4 (task switching). Error bars represent +/– 1 SE.

3.4.2.3 D-KEFS Verbal Fluency Test

The Verbal Fluency Test measures the examinee's ability to generate words fluently in an effortful, phonemic format (Letter Fluency), from overlearned concepts (Category Fluency), and while simultaneously shifting between overlearned concepts

(Category Switching). The key measures of the test are Condition 3: total correct responses and the second measure during Condition 3: total switching accuracy. Sixteen participants were administered the Verbal Fluency Test (see Figure 25).

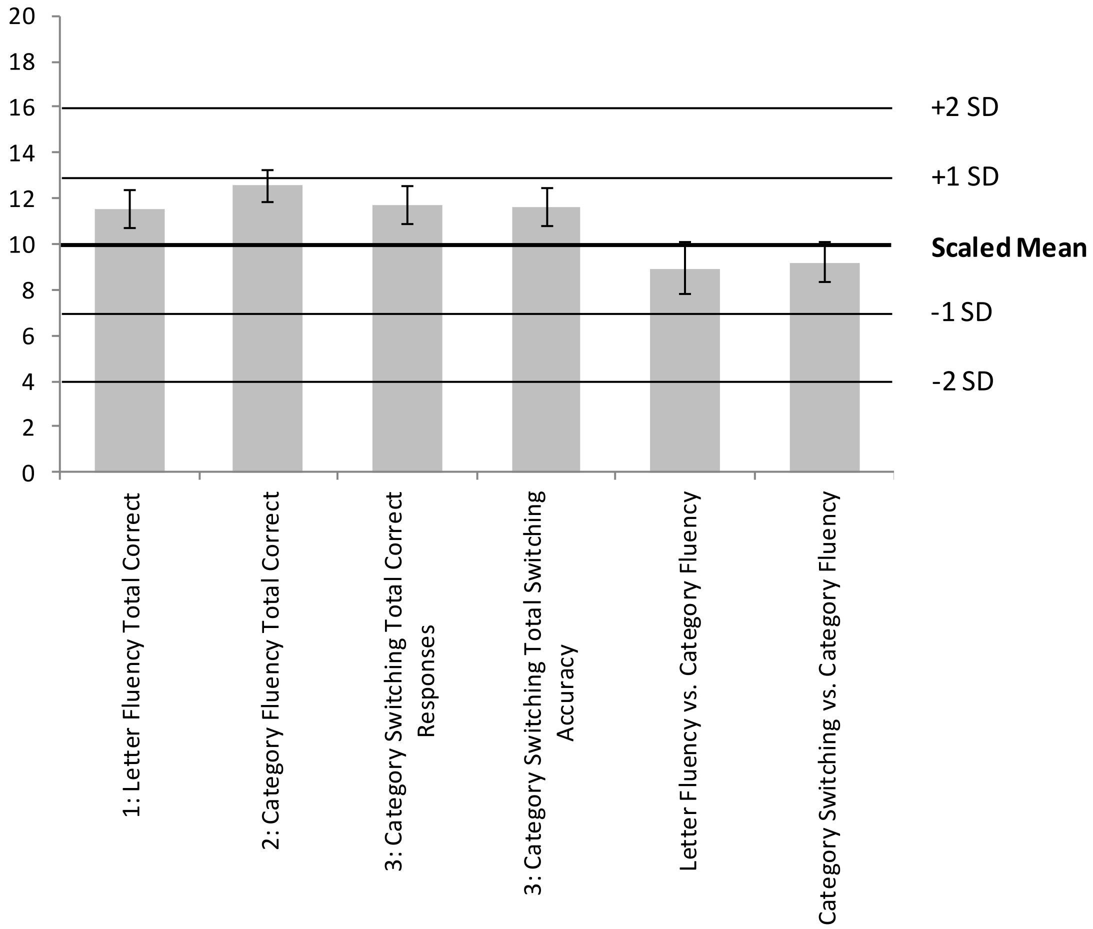

Figure 25. D-KEFS Verbal Fluency Test (neurologically normal elderly controls). Participants performed above average (age corrected performance), especially on the two primary measures of the test in Condition 3 (category switching). Error bars represent +/– 1 SE.

3.4.2.4 Wechsler Memory Scale IIIR

The Wechsler Memory Scale involves a number of classical memory tests whose scores are used to compute aggregate index scores. For the purposes of the present study four such index scores were computed: Auditory Immediate, Auditory Delayed, Auditory Recognition Delayed, and Working Memory.

The Auditory Immediate index reflects the examinee's ability to remember information immediately after it is orally presented. Scores from Logical Memory I and verbal Paired Associates I contribute to this index.

The Auditory Delayed index reflects the examinee's ability to remember orally presented information after a 25-30 minute delay. Scores from Logical Memory II and Verbal Paired Associates II are used to calculate this index.

The Auditory Recognition Delayed index reports the examinee's ability to remember (via recognition, not free recall) auditory information after a delay of 25-30 minutes. Recognition scores from Logical Memory II and Verbal Paired Associates II contribute to this index.

The Working Memory index reflects the examinee's capacity to remember and manipulate both visually and orally presented information in the short-term (working) memory. Scores from Spatial Span and Letter-Number Sequencing are used to compute this index.

For the purposes of the present study, the key measure from the Wechsler Memory Scale IIIR is the Auditory Delayed Index. Sixteen participants completed this assessment, and the results are shown in Figure 26.

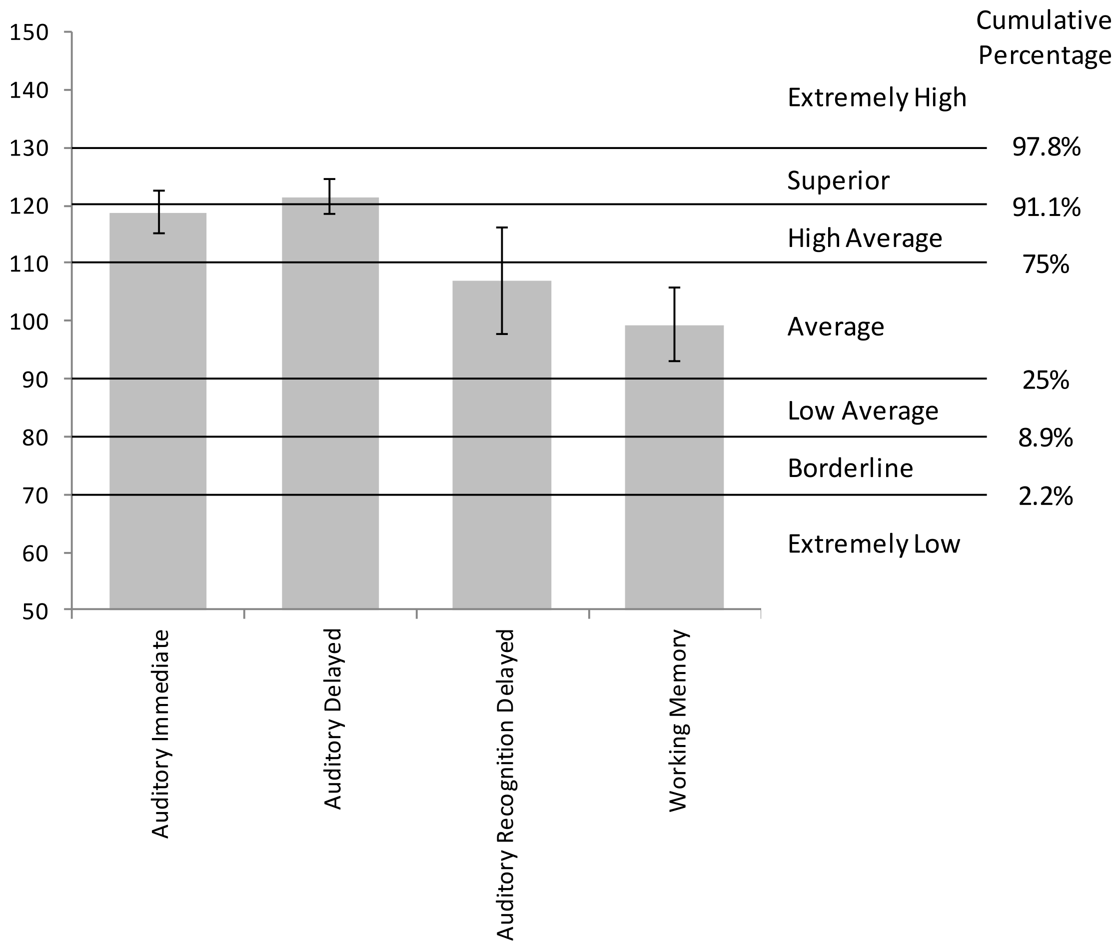

Figure 26. Wechsler Memory Scale IIIR (neurologically normal elderly controls). Participants scored in the high-average range of the WMS test, especially for the key measure (Auditory Delayed Index). Error bars represent +/– 1 SE.

3.4.3 The specific re-experience of discrete emotions is unimpaired for amnesic Korsakoff's syndrome patients

The present study investigated the differences in the emotional experience of four basic discrete emotions (anger, fear, sadness, and happiness) between a group of 20 Korsakoff patients and 20 control participants, following the recollection of four emotional vignettes aimed at eliciting the target emotion discretely. Firstly, we sought to establish the difference in the recall accuracy between the two groups. Secondly, we compared the emotional experience for each discrete emotion after the story recall. Finally, a set of correlational analyses was carried out between the intensity of the target emotion and the amount of episodic details recalled from each story.

3.4.3.1 Differences in recall accuracy

The Korsakoff patients were expected to show a substantial level of memory impairment compared to controls, across all four emotions. As shown in Figure 27, the patients' lowest recall accuracy was recorded for the *sadness* stories (*M*=9.65%, *SD*=1.41%), followed by *fear* (*M*=14.62%, *SD*=2.51%), and *happiness* (*M*=14.71%, *SD*=2.40%), while the recall of *anger* stories was highest (*M*=20.92%, *SD*=2.24%). The control participants scored the lowest recall accuracy for the *fear* stories (*M*=57.99%, *SD*=2.58%), followed by *anger* (*M*=68.84%, *SD*=2.53%), *happiness* (*M*=70.33%, *SD*=1.95%), and *sadness* (*M*=71.22%, *SD*=2.15%). A sample of the free recall transcripts of a Control participant and Korsakoff's syndrome patient are included in Appendices J and K, respectively.

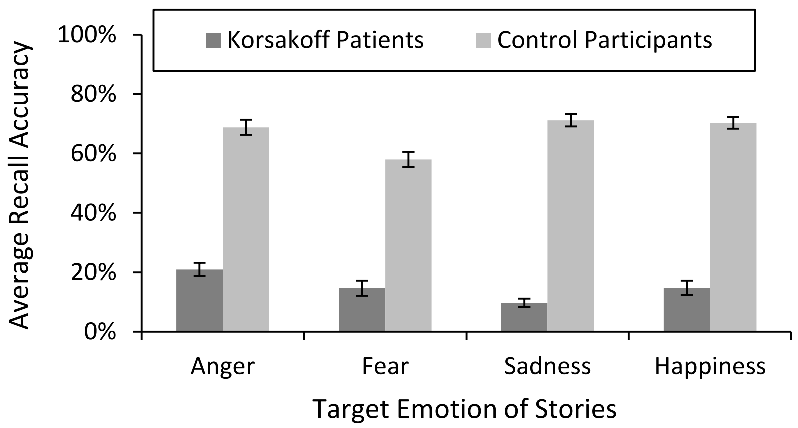

Figure 27. Episodic recall of emotion stories for Korsakoff patients and controls. Korsakoff patients recalled substantially fewer story details compared to healthy controls. Error bars show +/– 1 SE.

Paired sample t-tests confirmed the predicted differences for the *anger* stories ($t(38)=14.20$, $p<.001$, $d=4.49$), *fear* ($t(38)=12.06$, $p<.001$, $d=3.81$), *sadness* ($t(38)=23.96$, $p<.001$, $d=7.58$), and *happiness* stories ($t(38)=17.98$, $p<.001$, $d=5.69$). Thus, the Korsakoff patients presented a substantial episodic memory impairment compared to control participants. This result allowed the investigation of the differences in the re-experience of discrete emotions, in the presence and absence of episodic information about the original events.

3.4.3.2 Emotional experiences after the recall of emotional stories

The average ratings for each discrete emotion after each of the four stories (see Figure 28) showed a specific elicitation of the target emotion. However, despite the large difference between the amount of episodic information recalled by the two groups, emotional experience was surprisingly similar for Korsakoff patients and controls.

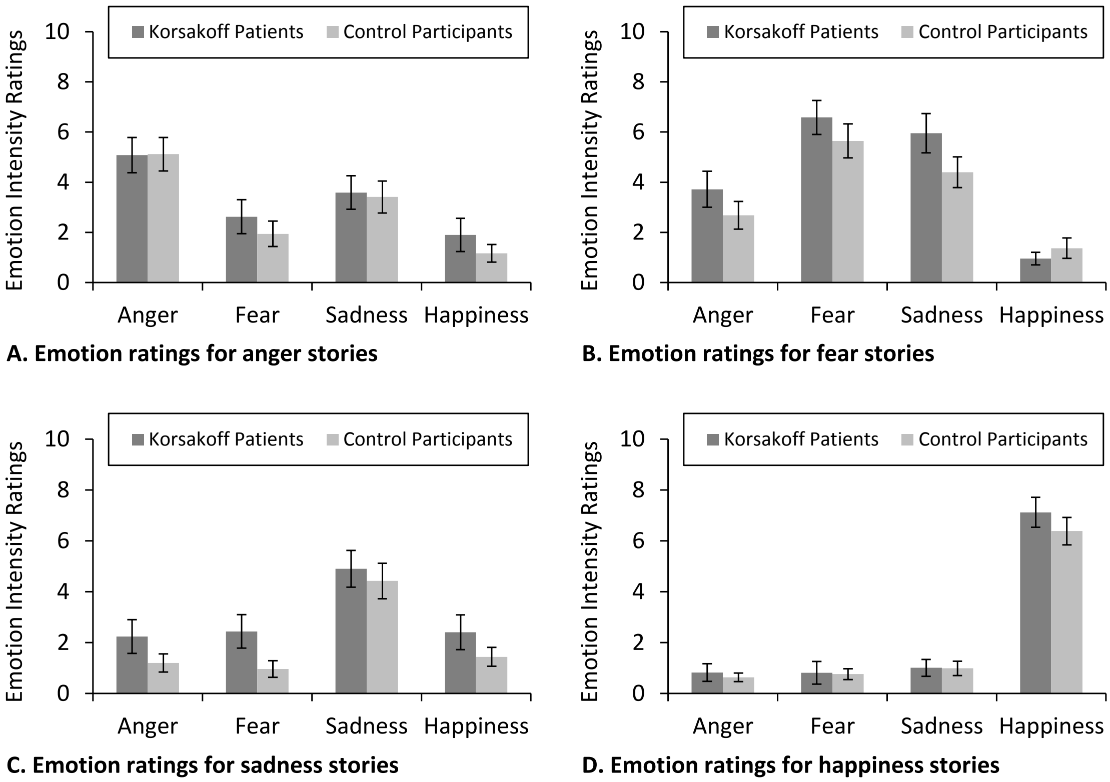

Figure 28. Ratings of discrete emotions for Korsakoff patients and control participants. Each story showed a specific elicitation of the target emotion, and Korsakoff patients showed a similar emotional experience to healthy controls. Error bars show +/– 1 SE.

The results were confirmed by four mixed factorial ANOVAs and planned contrasts, analysing the emotion ratings after each story (see Table 6). Ratings of target emotions were significantly higher than all non-target emotions, with no significant differences between control participants and patients. This seems to suggest that a substantially impaired episodic recall of an emotional event can still produce a similarly distinct experience of each of the four basic emotions as a normal detailed recollection.

Table 6.

The difference between the ratings of discrete emotions after story recall showed a specific elicitation of the target emotions (compared to non-target emotions), with no significant differences between the two groups (Korsakoff patients and control participants). Effect sizes are expressed as partial eta-squared.

Target Emotion	Analysis	Non-Target Emotion	Main Effect of Emotion			Emotion*Group Interaction		
			F	p	η^2	F	p	η^2
Anger	Overall ANOVA	-	16.09 *	<.001	.298	1.89	.816	.006
	Planned contrasts	Fear	29.55 *	<.001	.437	0.49	.490	.013
		Sadness	10.26 *	.003	.213	0.05	.828	.001
		Happiness	25.99 *	<.001	.406	0.31	.577	.008
Fear	Overall ANOVA	-	37.66 *	<.001	.498	1.40	.246	.036
	Planned contrasts	Anger	29.91 *	<.001	.440	0.01	.933	<.001
		Sadness	5.95 *	.019	.135	0.65	.425	.017
		Happiness	83.1 *	<.001	.686	1.59	.215	.040
Sadness	Overall ANOVA	-	17.05 *	<.001	.310	0.35	.720	.009
	Planned contrasts	Anger	42.67 *	<.001	.529	0.39	.536	.010
		Fear	34.49 *	<.001	.476	0.99	.325	.025
		Happiness	15.36 *	<.001	.288	0.13	.722	.003
Happiness	Overall ANOVA	-	139.06 *	<.001	.785	1.10	.728	.011
	Planned contrasts	Anger	167.51 *	<.001	.815	0.35	.559	.009
		Fear	149.61 *	<.001	.797	0.49	.487	.013
		Sadness	136.21 *	<.001	.782	0.52	.476	.013

3.4.3.3 The relationship between recall accuracy and intensity of target emotions

To confirm the previous surprising finding that despite the sizable difference in the amount of information recalled, both groups of participants experienced the target emotion of each story at significantly higher levels than any of the non-target emotions, the relationship between the intensity of the target emotion and the amount of information remembered from each story was investigated directly. As shown in Figure 29, the data failed to indicate a relationship between recall accuracy and intensity of target emotion.

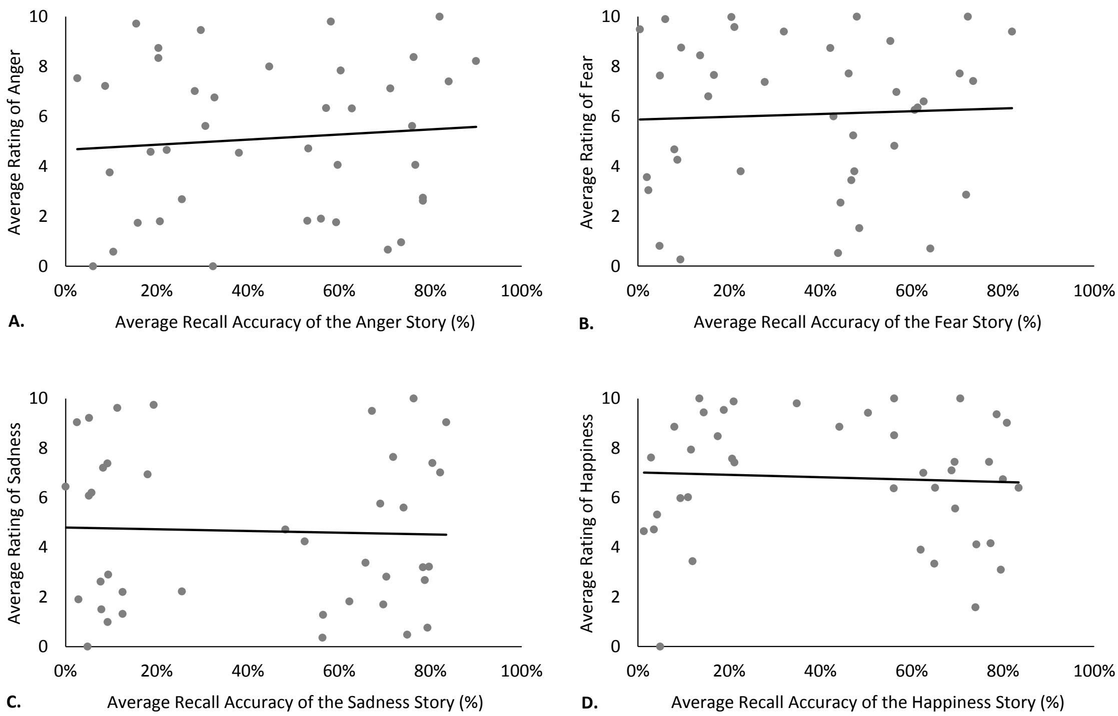

Figure 29. The relation between recall accuracy and the intensity of the target emotion. The correlations between the recall accuracy and the ratings of each of the four discrete emotions were not significant. Korsakoff patients' and control participants' scores are analysed together.

A Spearman correlation failed to reach significance for any of the target emotions (*anger* stories, $r(40)=0.10$, $p=.522$; *fear* stories, $r(40)=0.06$, $p=.698$; *sadness* stories, $r(40)=0.07$, $p=.651$; *happiness* stories, $r(40)=-0.04$, $p=.788$). Surprisingly, the data showed that even those patients whose recall accuracy was close to zero (4-5%) specifically reported high levels of the basic target emotions (80-90%). The nil correlations between emotional intensity and recall accuracy seemed to be explained by equal spread in emotion intensity scores for participants with massively different recall scores. Specifically, some of amnesic patients with floor levels of recall accuracy scores reported moderate-to-high levels of the target emotions for all classes of emotions (e.g., *anger*, 7.2; *fear*, 9.9; *sadness*, 6.5; *happiness*, 4.7). The results suggest that the amount of episodic information retained and actively recalled is not related to the intensity of basic emotions re-experience.

3.4.4 The re-experience of discrete emotions is positively correlated with the executive functions of cognitive flexibility and response inhibition

The second aim of the present study was to investigate the relationship between the four discrete classes of emotions, basic demographics, executive function, memory, and intelligence. At first, an analysis of the relationship between the intensity of each discrete emotion and basic demographics (age and years of education) was carried out to rule out these variables as possible covariates. Secondly, the relationship between the intensity of the re-experience of the four basic emotions and measures of the executive function is carried out controlling for the difference in recall accuracy of the appropriate stimulus/story corresponding to each emotion. Thirdly, the relationship between the performance on more complex abstract reasoning tasks, part of popular IQ tests are compared against emotion intensity ratings. Lastly, the relationship between the emotion intensities and overall measures of episodic memory are analysed and presented. On each occasion, the relationships are presented first cumulatively (Korsakoff patients and neurologically normal controls together), and the separately for patients and controls. The cumulative analysis benefits from the larger sample size (patients + controls), which carries a great weight in identifying a relationship using Pearson's *r*. However, given the marked cognitive (specifically declarative memory) and neurological differences between the two groups, correlational analysis were also carried out separately for the separate samples of Korsakoff patients and control participants. The Korsakoff patients were administered distinctly more neuropsychological tests (see Table 6 above, in section 3.3.5). When fewer than 12 participants contributed with scores for an analysis, results were not reported.

3.4.4.1 The relationship between the intensity of discrete emotions and basic demographic variables

A Pearson correlation analysis was conducted for each of the four discrete emotions to investigate the relationship between the intensity of basic emotions and two basic demographics variables (age, and years of education). A second analysis was performed separately (but reported together in Table 7), in which the same variables were partially correlated, controlling for the recall accuracy scores for the stories of each discrete emotion.

Table 7.

Age of participants showed a moderate negative relation with the intensity of fear. The relationship between age and the intensities of all other discrete emotions (anger, sadness and happiness) was not significant. The numbers of years of education showed no relationship with the intensity of any basic emotions.

Discrete emotions	**Demographic variables**	**Pearson Correlation**			**Partial Pearson Correlation (Covariate: Free Recall)**		
		r	***p***	***N***	***r***	***p***	***df***
Anger	Age	-0.23	.151	40	-0.27	.094	37
Anger	Education	-0.01	.971	40	-0.04	.820	37
Fear	Age	-0.33	.036 *	40	-0.38	.016 *	37
Fear	Education	-0.24	.143	40	-0.27	.097	37
Sadness	Age	-0.08	.619	40	-0.08	.631	37
Sadness	Education	-0.03	.858	40	-0.02	.900	37
Happiness	Age	-0.24	.135	40	-0.25	.131	37
Happiness	Education	-0.06	.731	40	-0.04	.797	37

As shown in Table 7, the age of participants had a moderate negative relationship only with the intensity of fear, and not with any other discrete emotions. The number of years of education was not related with the intensity of any of the four basic emotions.

3.4.4.1a The relationship between the intensity of discrete emotions and the age of the Korsakoff patients

The relationship between the intensity of the discrete target emotions and the Korsakoff patients' age was tested using the Pearson's correlation test, and the data are shown in a scatterplot in Figure 30. The correlations failed to reach significance for any of target emotions: *anger* ($r(20)=-0.36$, $p=.122$), *fear* ($r(20)=-0.36$, $p=.114$), *sadness* ($r(20)=0.69$, $p=.773$), and *happiness* ($r(20)=-0.375$, $p=.103$).

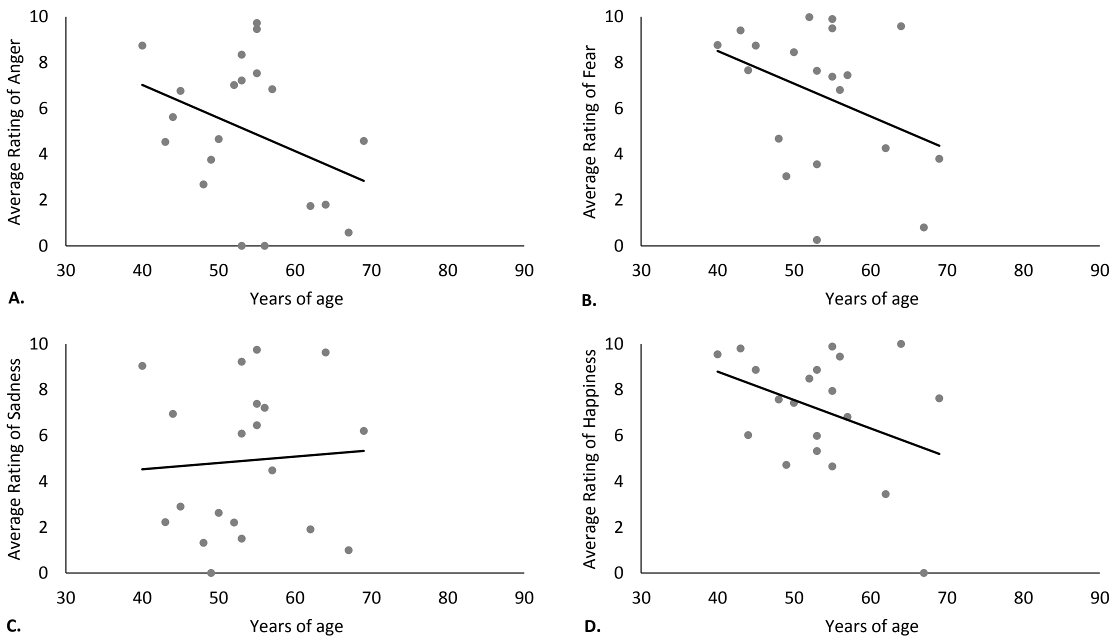

Figure 30. The relation between Korsakoff patients' age and emotion ratings. The correlations between the intensity of the target emotions and the age of the Korsakoff patients were non-significant.

Thus, despite the wide range of ages of the Korsakoff patients group (40-69 y.o.) differences in the intensity of emotional experience were not related to their age. A similar analysis was carried out for the control participants (see below).

3.4.4.1b The relationship between the intensity of discrete emotions and the age of the control participants

A similar Pearson correlation test as above was carried out between the intensity of the discrete target emotions of the control participants and their age (see Figure 31 below). Notably, the intensity of *anger* ($r(20)=-0.55$, $p=.012$) and *fear* ($r(20)=-0.50$, $p=.026$) were negatively correlated with age, indicating that the more elderly control participants reported lower levels of the two emotions. Although both effects sizes are large (Cohen, 1992, 2013), when a Bonferroni correction for multiple comparisons is applied, only the *anger* correlation remains significant. The relationships for sadness ($r(20)=-0.29$, $p=.773$) and *happiness* ($r(20)=-0.35$, $p=.129$) failed to reach significance.

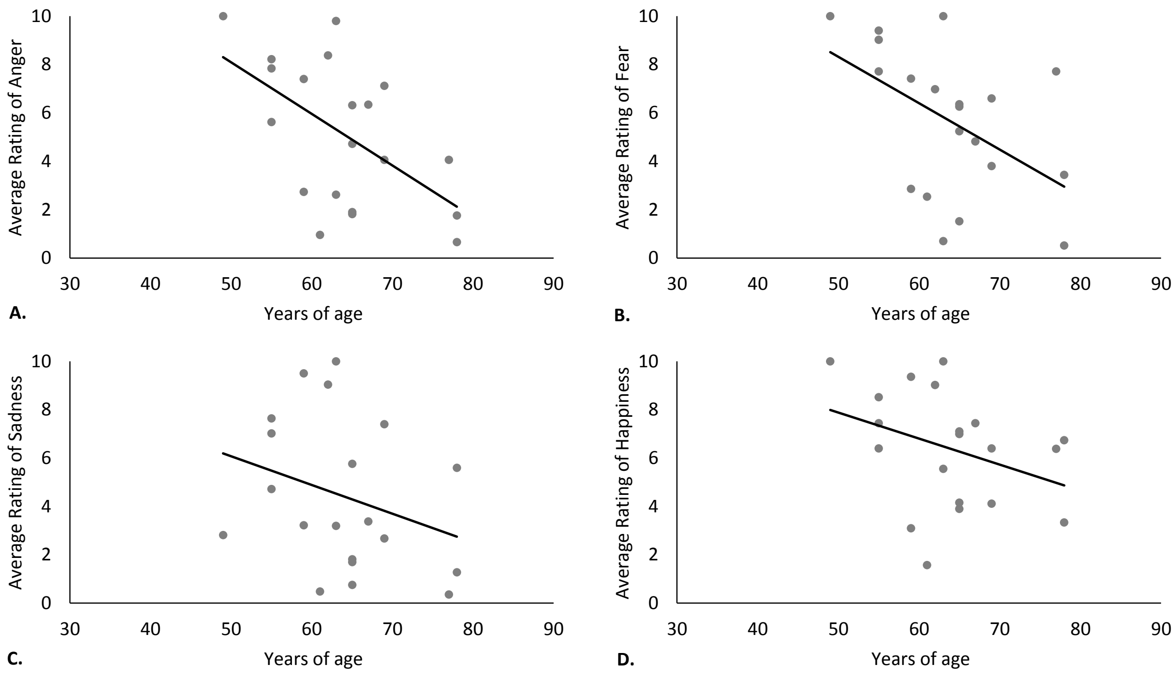

Figure 31. The relation between control participants' age and emotion ratings.
The correlations between the intensity of the target emotions and the age of the control participants show that the re-experience of *anger* (A.) and *fear* (B.) were significantly and negatively correlated with age.

Despite the small sample size, the two significant correlations were not affected by moderate or extreme outliers. Results suggest that the two high arousal negative emotions (anger and fear) were experienced at a lower intensity by the more elderly control participants.

3.4.4.2 The relationship between the intensity of discrete emotions and measures of the executive function

The second research question addressed the possible relationship between the intensity of the re-experience of basic emotions and the executive function. The scores on two commonly used batteries of executive functions tests: the Delis Kaplan

Executive Function Scale (DKEFS) and the Behavioural Assessment of the Dysexecutive Syndrome (BADS) were compared to the intensity of basic emotions.

As presented in Table 8 below, only the DKEFS tests reached significance, especially for the re-experience of *happiness* and after controlling for recall accuracy. Key measures from the Design Fluency test, joining the empty dots only (DKEFS DF 2) and switching between joining filled and empty dots (DKEFS DF 3) showed a moderate positive relationship with the intensity of *happiness*, when controlling for recall accuracy. Both tests require participants to ignore the previously learned rule of joining the filled dots, practiced in the first part of the test. This relationship has further transferred into the combined scores for both parts of the test (DKEFS DF Comb) and the total score for the Design Fluency test (DKEFS DF Total). The intensity of *happiness* also showed a moderate positive relationship with the initial abstraction score of the Twenty Question Test (DKEFS TQT Abs), which examines logical thinking, hypothesis testing, and deduction.

The intensity of sadness showed a moderate positive correlation with the first task of the Design Fluency test (filled dots; DKEFS DF 1), while the intensity of fear was moderately correlated with the set-shifting task of the same test (DKEFS DF 3). The intensity of anger reported a small negative correlation with the motor speed task of the Trail Making Test (DKEFS TMT 5).

Table 8.

The relationship between the intensity of discrete emotions and measures of executive function. Only the significant values are shown, for either the simple or partial correlation, beginning with the negative emotions in alphabetical order, and followed by happiness.

Discrete emotions	Measures of executive function	Pearson Correlation			Partial Pearson Correlation (Covariate: Free Recall)		
		r	***p***	***N***	***r***	***p***	***df***
Anger	DKEFS TM 5	-0.36	.046	32	-0.39	.029 *	29
Fear	DKEFS DF 3	0.45	.054	19	0.50	.034 *	16
Sadness	DKEFS DF 1	0.46	.047	19	0.51	.029 *	16
Happiness	DKEFS DF 2	0.56	.013 *	19	0.64	.004 *	16
Happiness	DKEFS DF 3	0.45	.055	19	0.62	.006 *	16
Happiness	DKEFS DF Comb	0.54	.017 *	19	0.68	.002 *	16
Happiness	DKEFS DF Total	0.51	.024 *	19	0.68	.002 *	16
Happiness	DKEFS TQT Abs	0.59	.009 *	18	0.67	.003 *	15

3.4.4.2a The relationship between the intensity of discrete emotions and measures of the executive function for the Korsakoff patients

The relationship between the intensity of the discrete target emotions and the Korsakoff patients' performance on the DKEFS battery of executive function tests was examined individually, for each test, using a series of Pearson's correlations. The data for the Trail-Making test are shown in a scatterplot in Figure 32. The correlations failed to reach significance for any of target emotions: *anger* (r(19)=-0.21, p=.382), *fear*

(r(19)=0.07, p=.786), *sadness* (r(19)=0.04, p=.876), and *happiness* (r(19)=0.13, p=.606).

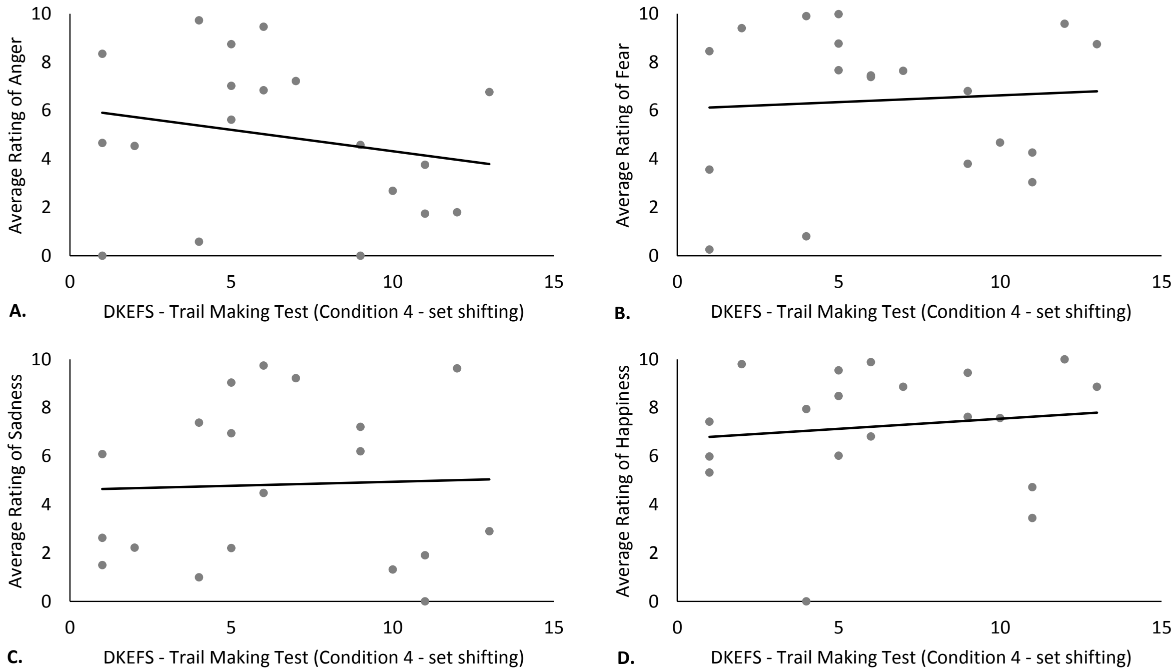

Figure 32. The relation between Korsakoff patients' DKEFS-TM scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Trail-Making Test for the Korsakoff patients were non-significant.

A similar Pearson correlation test was carried using the scores on the DKEFS Verbal Fluency test (see Figure 33). Similarly with before, no relationship was identified for any of target emotions: *anger* (r(19)=-0.09, p=.706), *fear* (r(19)=0.08, p=.749), *sadness* (r(19)=-0.28, p=.245), and *happiness* (r(19)=-0.26, p=.275).

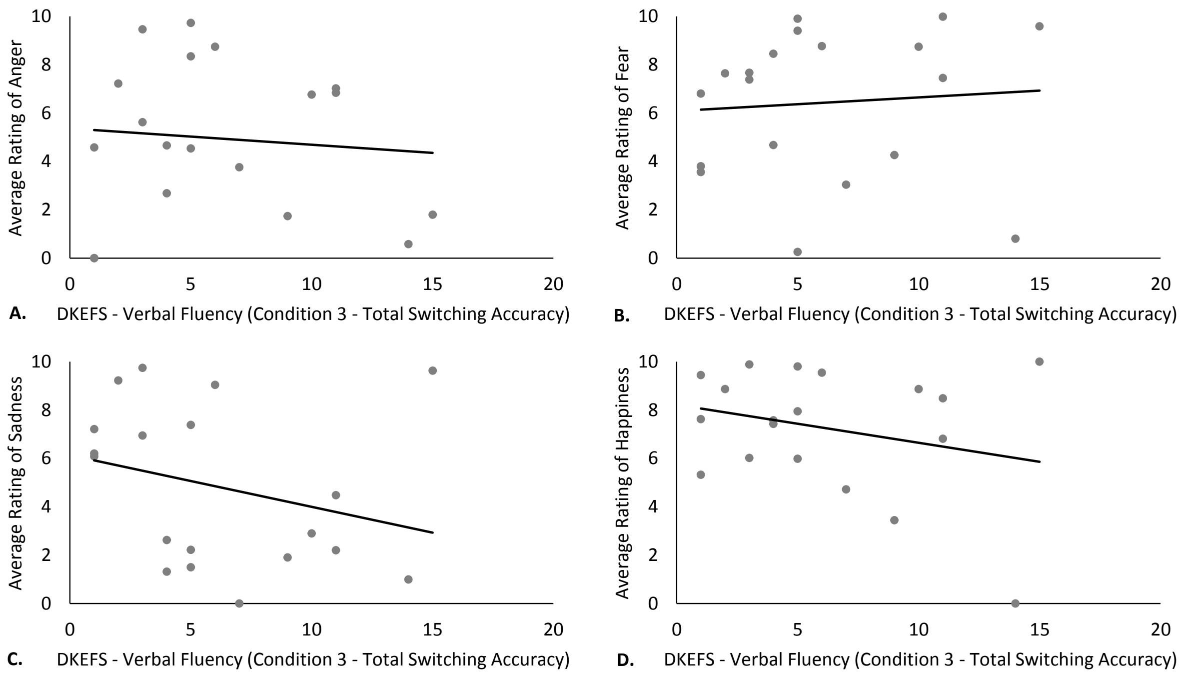

Figure 33. The relation between Korsakoff patients' DKEFS-VF Total Switching Accuracy scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Verbal Fluency Test for the Korsakoff patients were non-significant.

Two separate sets of correlation analyses were carried out for the DKEFS Design Fluency Test, one for the Condition 2 – response inhibition scores (see Figure 34) and the second for Condition 3 - cognitive flexibility (see Figure 35). The correlations with the response inhibition measure failed to reach significance for any of target emotions: *anger* ($r(14)=0.12$, $p=.689$), *fear* ($r(14)=0.29$, $p=.307$), *sadness* ($r(14)=0.07$, $p=.825$), and *happiness* ($r(14)=0.51$, $p=.062$).

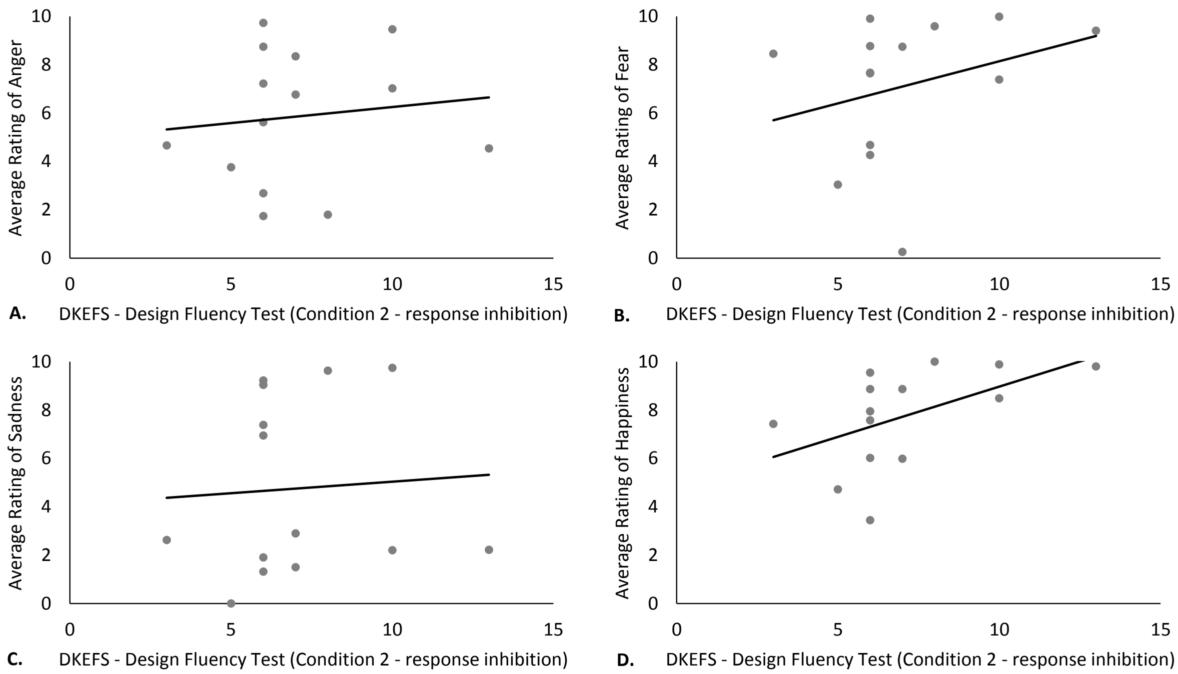

Figure 34. The relation between Korsakoff patients' DKEFS-DF Response Inhibition scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Design Fluency Test (response inhibition) for the Korsakoff patients were not significant.

Similarly with above, the correlations with the cognitive flexibility measure of the DKEFS – Design Fluency Test (see Figure 35) failed to reach significance for any of target emotions: *anger* ($r(14)=-0.36$, $p=.209$), *fear* ($r(14)=0.49$, $p=.075$), *sadness* ($r(14)=-0.13$, $p=.667$), and *happiness* ($r(14)=0.44$, $p=.113$). Results of the correlations with both primary measures of the Design Fluency Test may have been substantially affected by the small sample size ($N=14$). In particular for *fear* and *happiness* the data show a trend towards a large positive correlation, but that cannot be interpreted in the context of the limited data available.

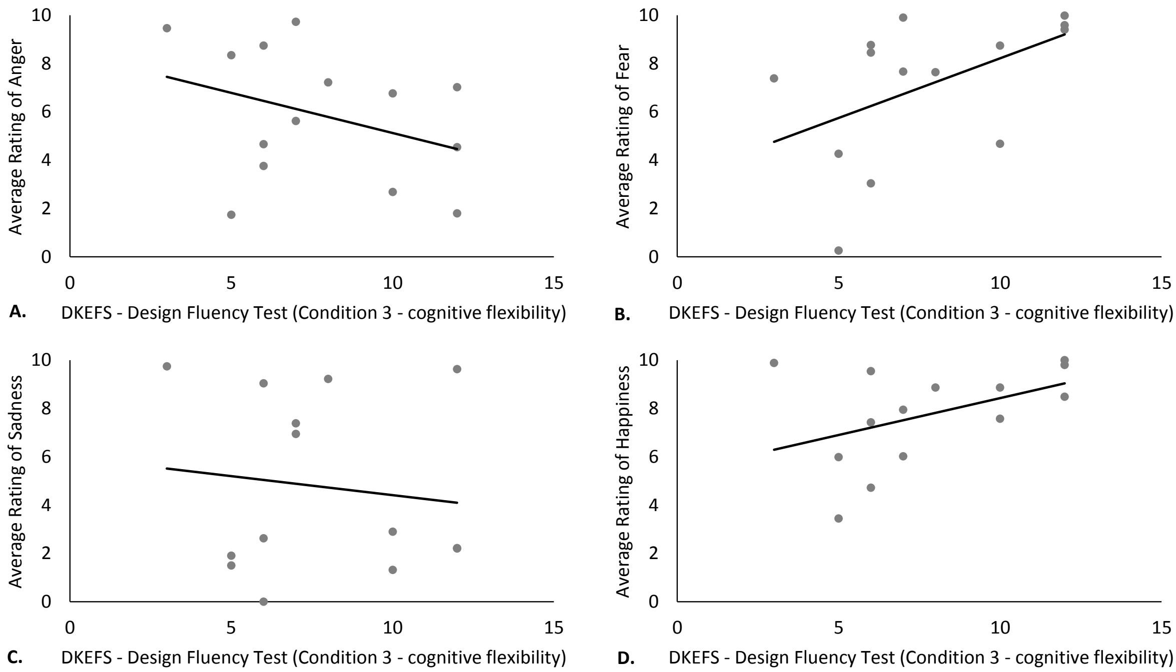

Figure 35. The relation between Korsakoff patients' DKEFS-DF Cognitive Flexibility scores and emotion ratings.
The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Design Fluency Test (cognitive flexibility) for the Korsakoff patients were not significant.

Two separate sets of correlation analyses were also carried out for the DKEFS Colour-Word Interference Test (a variant of the common Stroop task). The first set of analyses was done for the measure of inhibition during Condition 3 (see Figure 36). None of the correlations reached significance: *anger* (*r*(14)=-0.46, *p*=.095), *fear* (*r*(14)=0.06, *p*=.840), *sadness* (*r*(14)=-0.29, *p*=.313), and *happiness* (*r*(14)=0.09, *p*=.768).

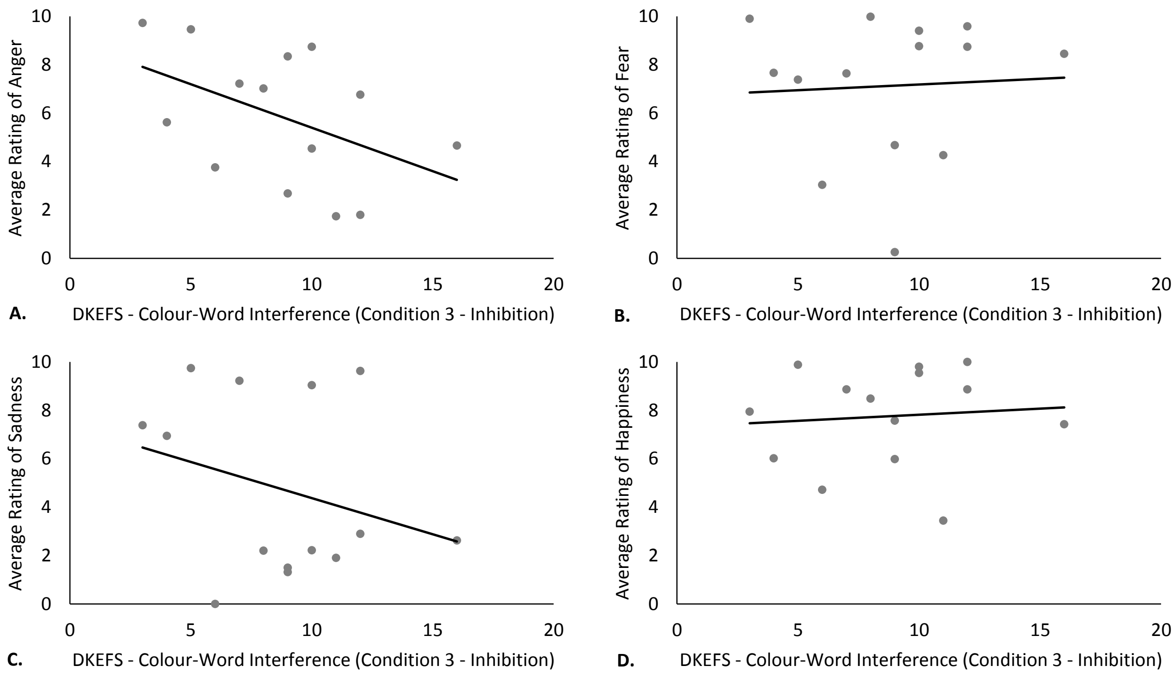

Figure 36. The relation between Korsakoff patients' DKEFS-CWI Inhibition scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Colour-Word Interference Test (inhibition) for the Korsakoff patients were not significant.

The second set of correlations involved the measures on Condition 4 (inhibition/switching) of the DKEFS – Colour-Word Interference Test (see Figure 37). Again, none of the correlations reached significance: *anger* ($r(14)=-0.11$, $p=.714$), *fear* ($r(14)=0.03$, $p=.929$), *sadness* ($r(14)=-0.49$, $p=.075$), and *happiness* ($r(14)=-0.20$, $p=.492$).

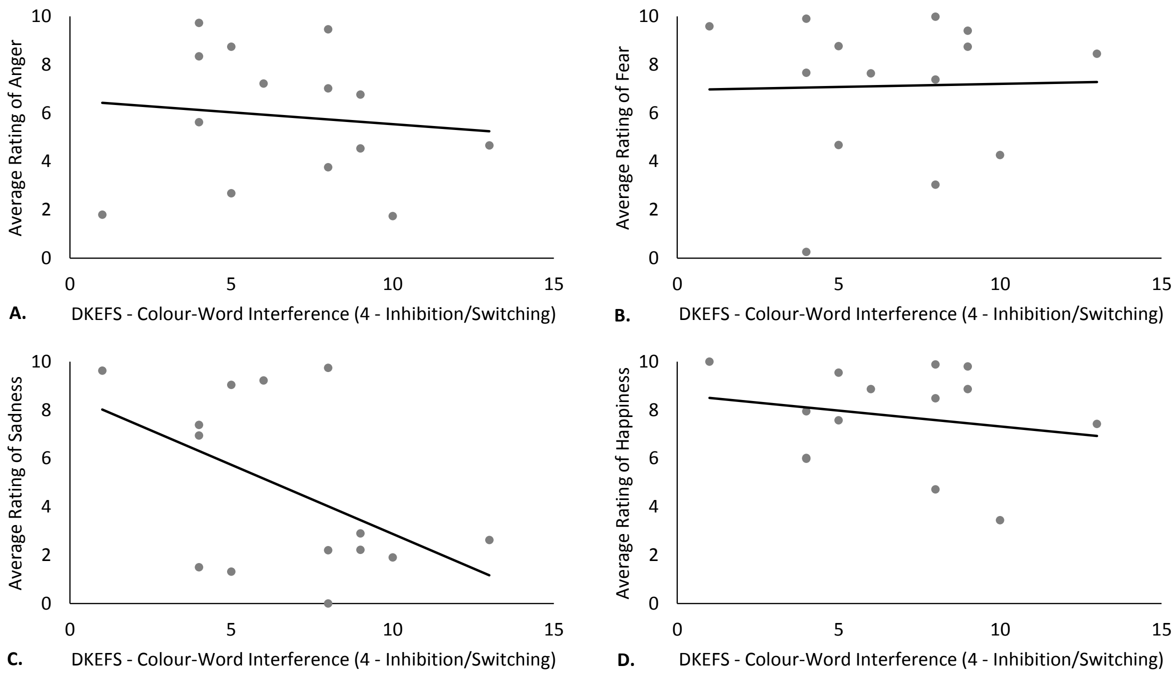

Figure 37. The relation between Korsakoff patients' DKEFS-CWI Inhibition/Switching scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Colour-Word Interference Test (inhibition/switching) for the Korsakoff patients were not significant.

Next, the relationship between the intensity of the discrete target emotions and the Korsakoff patients’ performance on the DKEFS Sorting Test was investigated. As shown in Figure 38, the correlations failed to reach significance for any of target emotions: *anger* ($r(14)=-0.46$, $p=.098$), *fear* ($r(14)=0.26$, $p=.366$), *sadness* ($r(14)=0.01$, $p=.978$), and *happiness* ($r(14)=0.17$, $p=.568$).

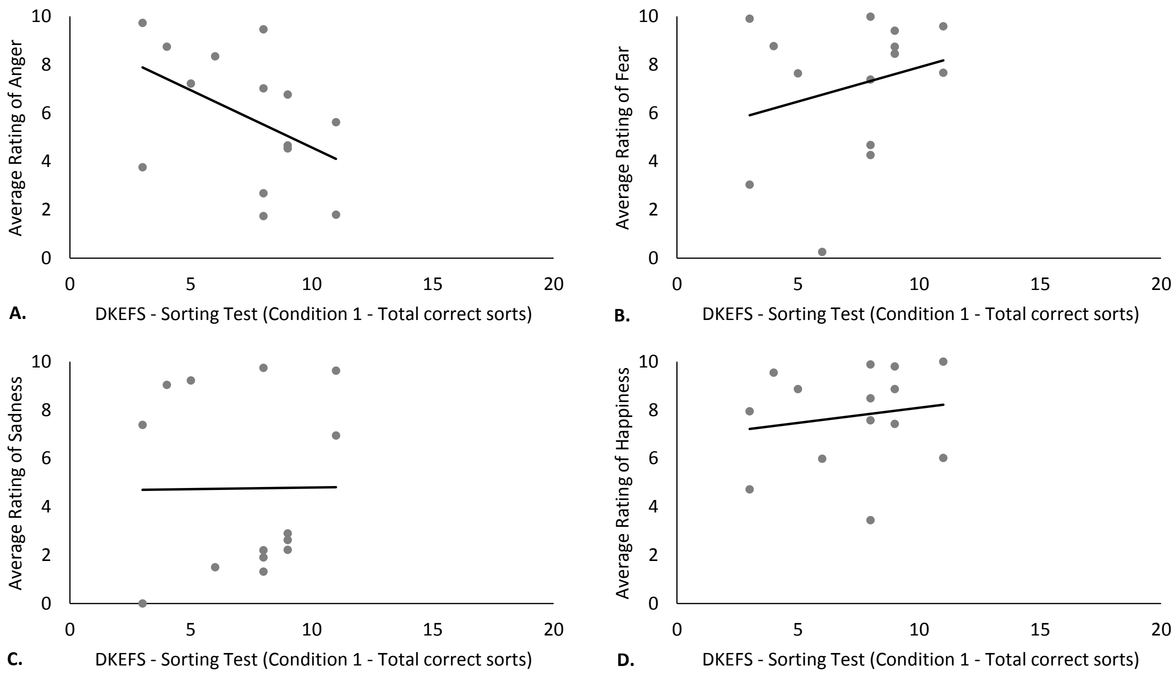

Figure 38. The relation between Korsakoff patients' DKEFS-S scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Sorting Test for the Korsakoff patients were not significant.

The relationship between the intensity of the discrete target emotions and the performance on the DKEFS – Twenty Questions Test and the intensity of the discrete target emotions for the Korsakoff patients' was analysed next (see Figure 39). The Pearson's correlations failed to reach significance for any of target emotions: *anger* (r(14)=-0.29, p=.311), *fear* (r(14)=0.36, p=.205), *sadness* (r(14)=0.10, p=.727), and *happiness* (r(14)=0.34, p=.242).

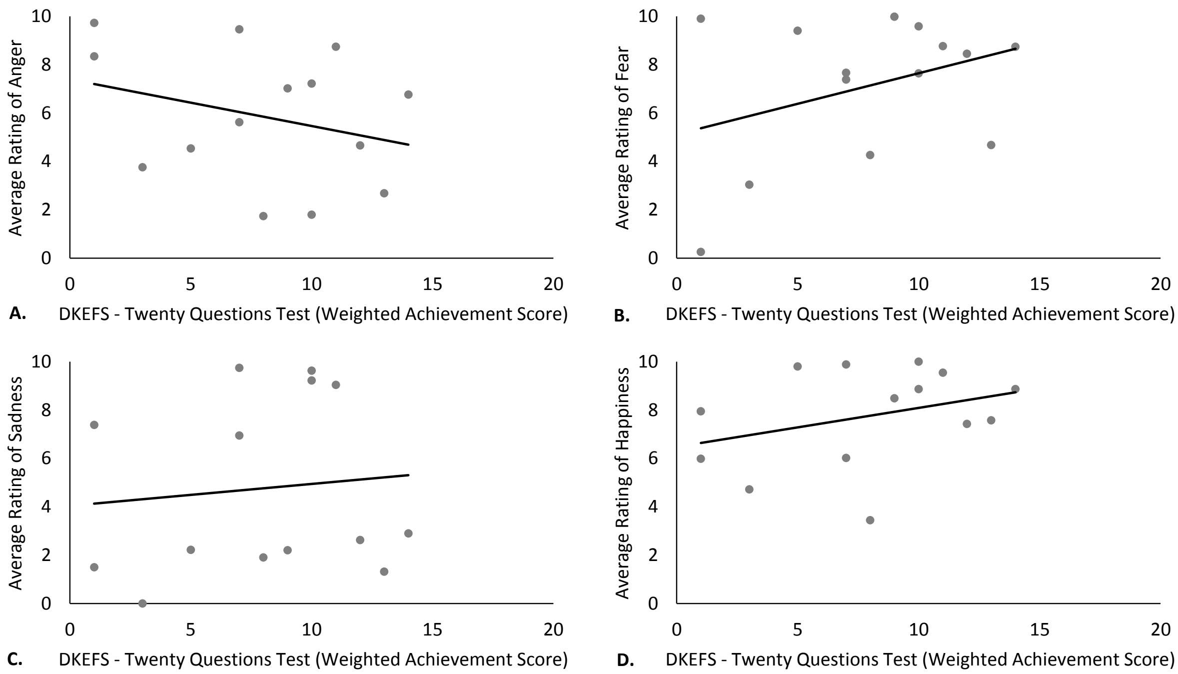

Figure 39. The relation between Korsakoff patients' DKEFS-TQ scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Twenty Questions Test for the Korsakoff patients were not significant.

The relationship between the intensity of the discrete target emotions and the Korsakoff patients’ performance on the DKEFS – Word Context Test was analysed using a series of Pearson’s correlations (see Figure 40). All correlations failed to reach significance: *anger* ($r(14)=-0.10$, $p=.739$), *fear* ($r(14)=-0.15$, $p=.612$), *sadness* ($r(14)=-0.38$, $p=.185$), and *happiness* ($r(14)=-0.38$, $p=.897$).

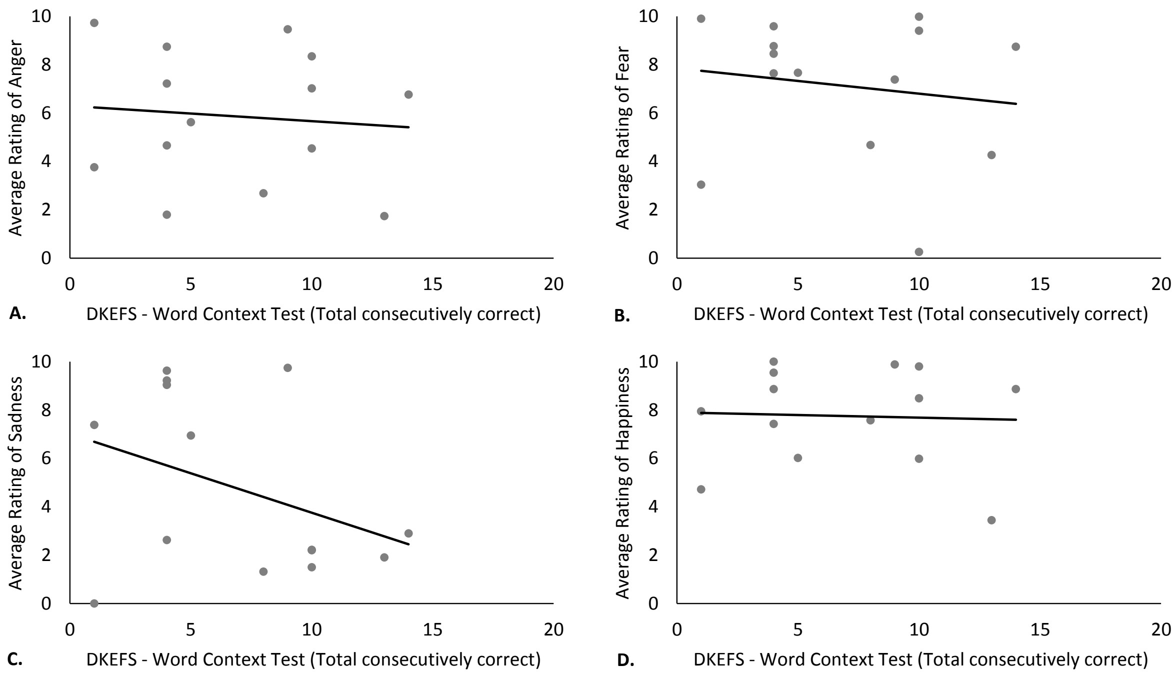

Figure 40. The relation between Korsakoff patients' DKEFS-WC scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Word Context Test for the Korsakoff patients were not significant.

The relationship between the intensity of the discrete target emotions and the Korsakoff patients' performance on the DKEFS – Tower Test was examined using a series of Pearson's correlations. The data are shown in a scatterplot in Figure 41. The correlations failed to reach significance for any of target emotions: *anger* ($r(14)=-0.21$, $p=.483$), *fear* ($r(14)=0.28$, $p=.328$), *sadness* ($r(14)=0.01$, $p=.992$), and *happiness* ($r(14)=0.39$, $p=.173$).

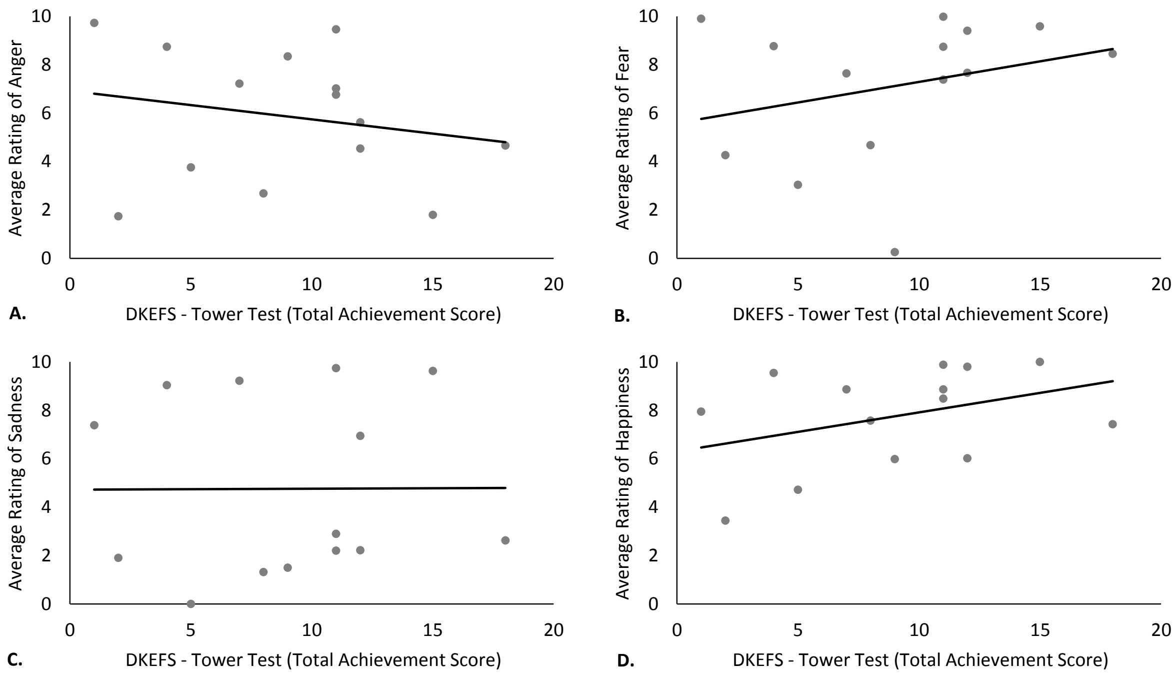

Figure 41. The relation between Korsakoff patients' DKEFS-T scores and emotion ratings.

The correlation between the intensity of the target emotions and the standardised scores on the DKEFS – Tower Test for the Korsakoff patients were not significant.

The relationship between the Korsakoff patients' performance on the DKEFS – Proverb Test and the intensity of the discrete target emotions was analysed next, using a series of Pearson's correlations. The correlations (see Figure 42) failed to reach significance for any of target emotions: *anger* ($r(14)=-0.14$, $p=.641$), *fear* ($r(14)=0.06$, $p=.828$), *sadness* ($r(14)=-0.03$, $p=.910$), and *happiness* ($r(14)=0.17$, $p=.556$).

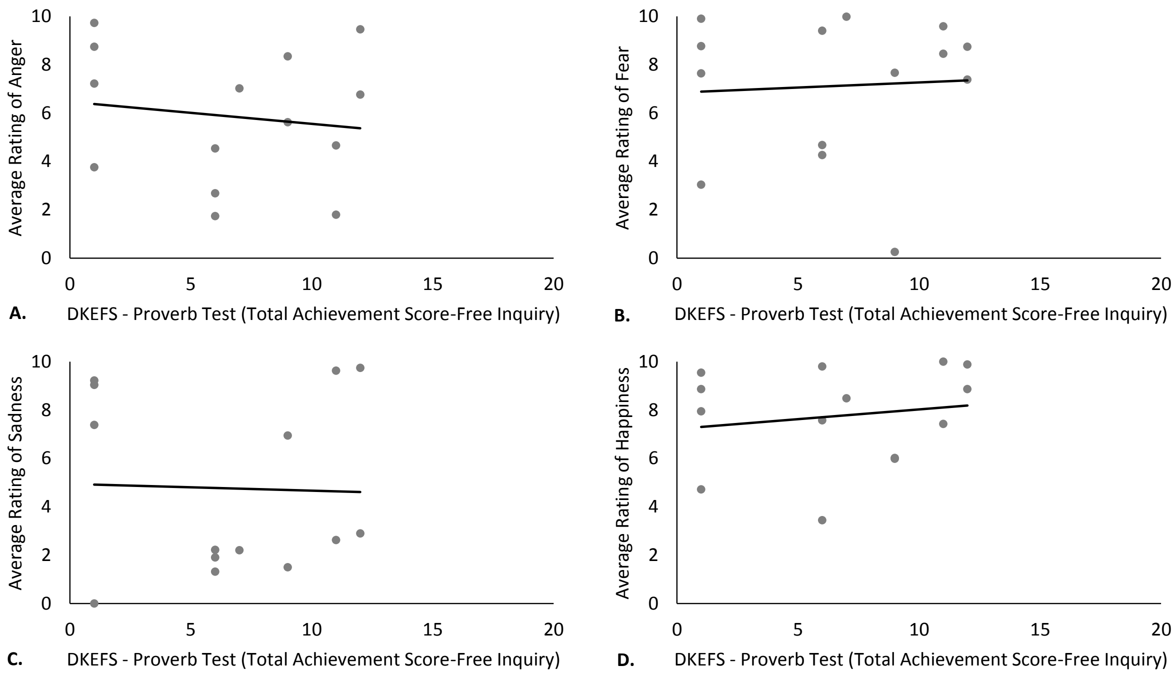

Figure 42. The relation between Korsakoff patients' DKEFS-P scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Proverb Test for the Korsakoff patients were not significant.

Finally, the relationship between the intensity of the discrete target emotions and the Korsakoff patients’ performance on the Behavioural Assessment of the Dysexecutive Syndrome test was investigated using a series of Pearson’s correlations. The data are shown in a scatterplot in Figure 43. The correlations failed to reach significance for any of target emotions: *anger* ($r(14)=-0.19$, $p=.518$), *fear* ($r(14)=-0.28$, $p=.341$), *sadness* ($r(14)=-0.31$, $p=.277$), and *happiness* ($r(14)=0.17$, $p=.565$).

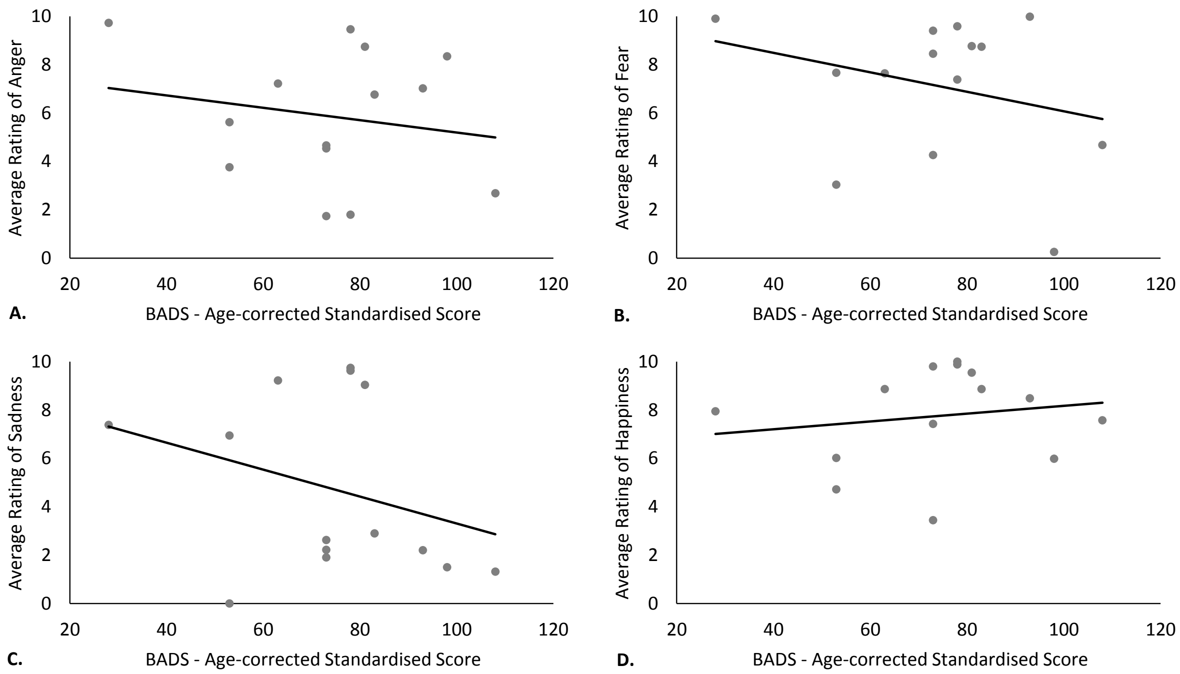

Figure 43. The relation between Korsakoff patients' BADS scores and emotion ratings. The correlations between the intensity of the target emotions and the standardised scores on the Behavioural Assessment of the Dysexecutive Syndrome for the Korsakoff patients were not significant.

In conclusion, the executive function measures were largely not correlated with the intensity of the discrete target emotions reported by the Korsakoff patients. Although on occasions, the data seemed to indicate an either positive of negative trend, it failed to reach the significance level. The small sample size, usually unsuitable for correlational analyses may have been a major cause for the lack of significance. However, in a current study design (involving four separate discrete emotions) a sufficiently large sample size would have been of a different order of magnitude (*N*>100), considering necessary corrections of the significance level to allow for multiple simultaneous comparisons.

3.4.4.2b The relationship between the intensity of discrete emotions and measures of the executive function for the control participants

Similarly with the analyses for the Korsakoff patients, the relationship between the intensity of the discrete target emotions and the control participants' performance on key tests from the DKEFS battery were performed using a series of Pearson's correlations. The data for the Trail-Making test are shown in a scatterplot in Figure 44. The correlations failed to reach significance for any of target emotions: *anger* ($r(19)=-0.06$, $p=.797$), *fear* ($r(19)=-0.04$, $p=.888$), *sadness* ($r(19)=-0.10$, $p=.689$), and *happiness* ($r(19)=-0.14$, $p=.560$).

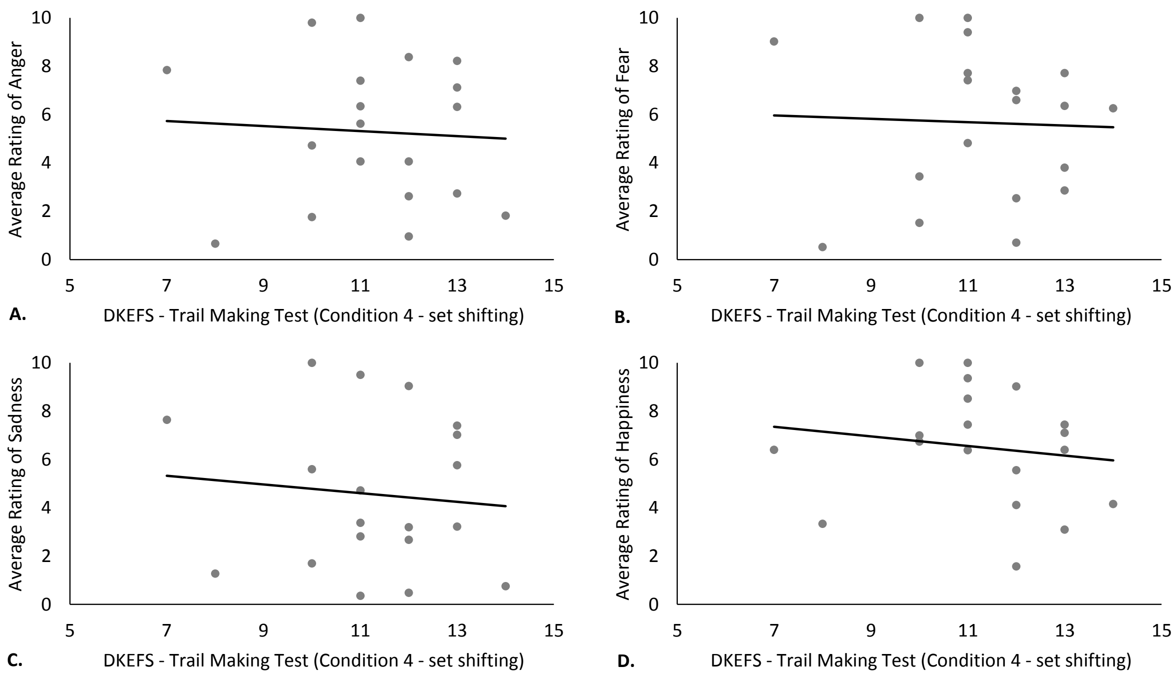

Figure 44. The relation between control participants' DKEFS-TM scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Trail-Making Test for the control participants were non-significant.

Next, the relationship between the intensity of the discrete target emotions and the control participants' performance on the DKEFS – Verbal Fluency Test was investigated. The data are shown in Figure 45. The correlations failed to reach significance for any of target emotions: *anger* ($r(16)=-0.01$, $p=.990$), *fear* ($r(16)=-0.23$, $p=.389$), *sadness* ($r(16)=0.03$, $p=.905$), and *happiness* ($r(16)=0.16$, $p=.545$).

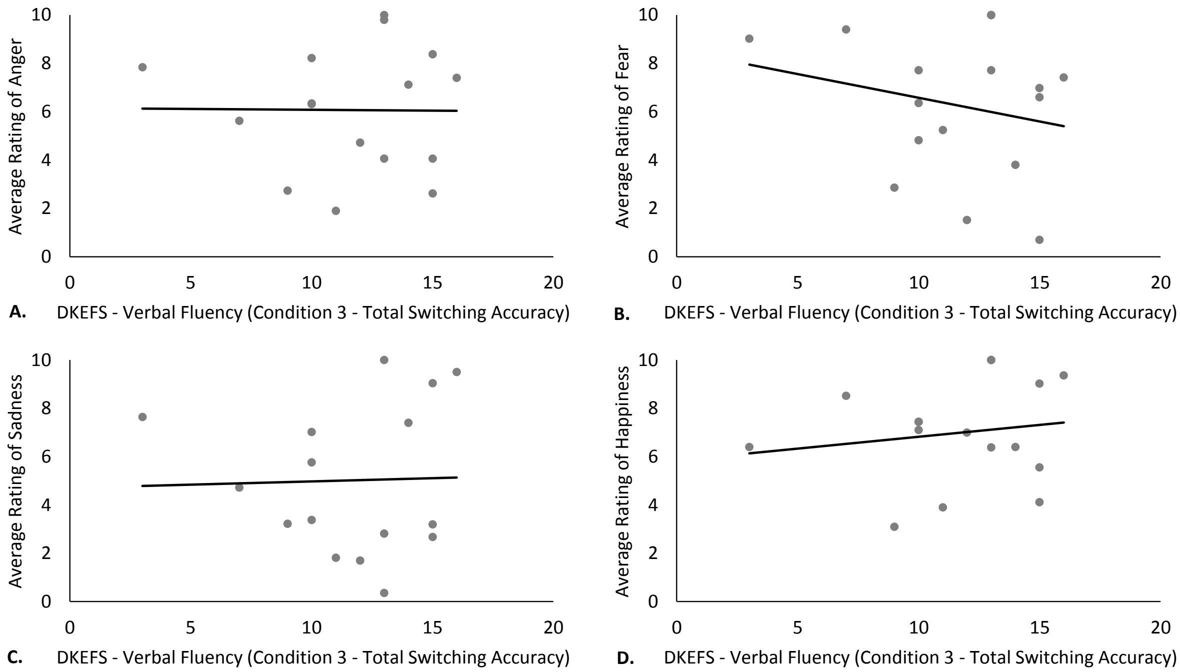

Figure 45. The relation between control participants' DKEFS-VF scores and emotion ratings.

The correlations between the intensity of the target emotions and the standardised scores on the DKEFS – Verbal Fluency Test for the control participants were not significant.

In conclusion, the executive function measures failed to show a significant correlation with any of the four discrete target emotions (*anger, fear, sadness*, and *happiness*) for the control participants. The results are in line with those of the Korsakoff syndrome patients, and could largely be attributed to the small sample size of both groups.

3.4.4.3 The relationship between the intensity of discrete emotions and the scores on the Wechsler Adult Intelligence Scale

The third research questioned examined the relationship between more complex forms of abstract thinking, tested by the Wechsler Adult Intelligence Scale (WAIS) and the intensity of the re-experience of basic emotions. Similarly with before, the emotion intensities were correlated with the WAIS scores both with and without controlling for recall accuracy (see Table 9).

Table 9.

The relationship between the intensity of discrete emotions and the scores on the Wechsler Adult Intelligence Scale. Only the significant values are shown, for either the simple or partial correlation. Negative emotions are shown at the top in alphabetical order, and happiness, as above, is shown last.

Discrete emotions	**Wechsler Adult Intelligence Scale**	**Pearson Correlation**			**Partial Pearson Correlation (Covariate: Free Recall)**		
		r	***p***	***N***	***r***	***p***	***df***
Anger	WAIS Ver Comp Perc.	-0.56	.020 *	17	-0.58	.018 *	14
Fear	WAIS P Speed Index	.47	.059	17	.70	.002 *	14
Sadness	WAIS P Speed Index	.45	.070	17	.78	< .001 *	14
Sadness	WAIS PIQ Index	.36	.150	17	.50	.049 *	14
Happiness	WAIS P Speed Index	.54	.024 *	17	1.00	< .001 *	14
Happiness	WAIS PIQ Index	.38	.137	17	.60	.014 *	14
Happiness	WASI FSIQ Index	.43	.064	19	.51	.031 *	16

The intensity of *fear*, *sadness,* and *happiness* showed a small to moderate positive correlation with the Processing Speed Index, which in the case of *happiness* and *sadness* translated into a relationship with the Performance IQ index, and further for *happiness* only, into a relationship with the Full Scale IQ index. The intensity of *anger* showed a moderate but negative correlation with Verbal Comprehension.

3.4.4.3a The relationship between the intensity of discrete emotions and the scores on the Wechsler Adult Intelligence Scale for the Korsakoff patients

The relationships between key indices of the Wechsler Adult Intelligence Scale and the intensity of the discrete target emotions for the Korsakoff patients were analysed using Pearson's correlation. The data are shown in Figure 46. The correlations failed to reach significance for any of target emotions: *anger* ($r(13)=-0.12$, $p=.697$), *fear* ($r(13)=0.19$, $p=.534$), *sadness* ($r(13)=0.16$, $p=.605$), and *happiness* ($r(13)=0.37$, $p=.208$).

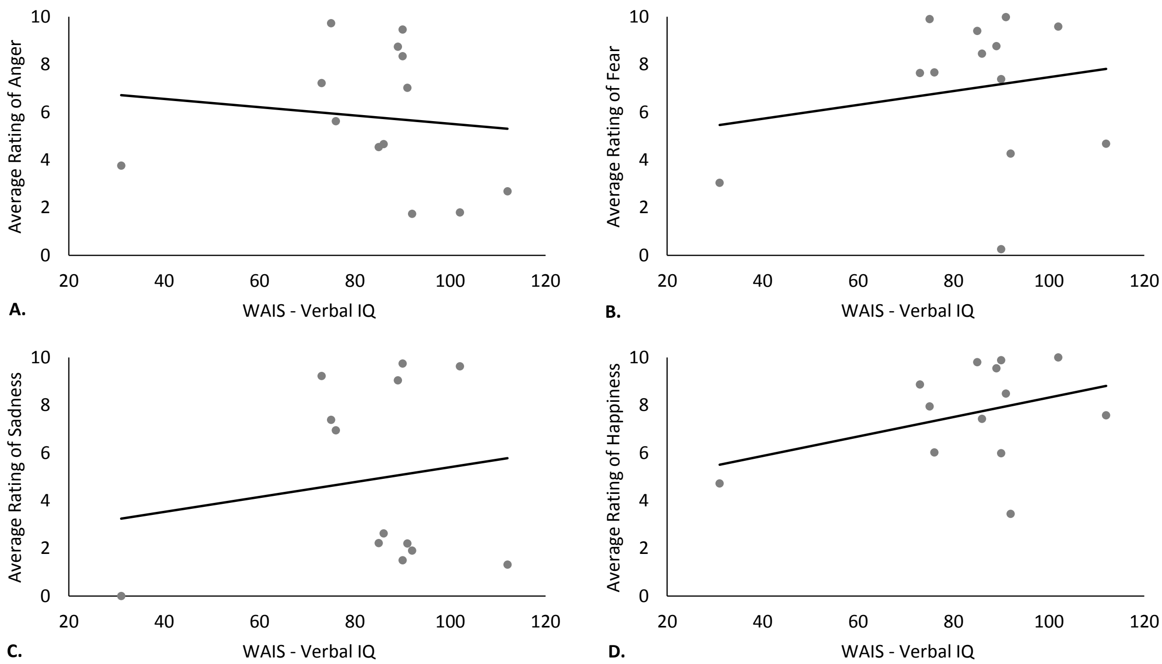

Figure 46. The relation between Korsakoff patients' WAIS Verbal IQ scores and emotion ratings.

The correlations between the intensity of the target emotions and the WAIS – Verbal IQ for the Korsakoff patients were not significant.

Next, the relationship between the intensity of the discrete target emotions and the Korsakoff patients' WAIS – Verbal IQ was investigated. As shown in Figure 47, the correlations were all non-significant for all the target emotions: *anger* ($r(13)=-0.12$, $p=.709$), *fear* ($r(13)=0.05$, $p=.876$), *sadness* ($r(13)=0.24$, $p=.436$), and *happiness* ($r(13)=0.29$, $p=.335$).

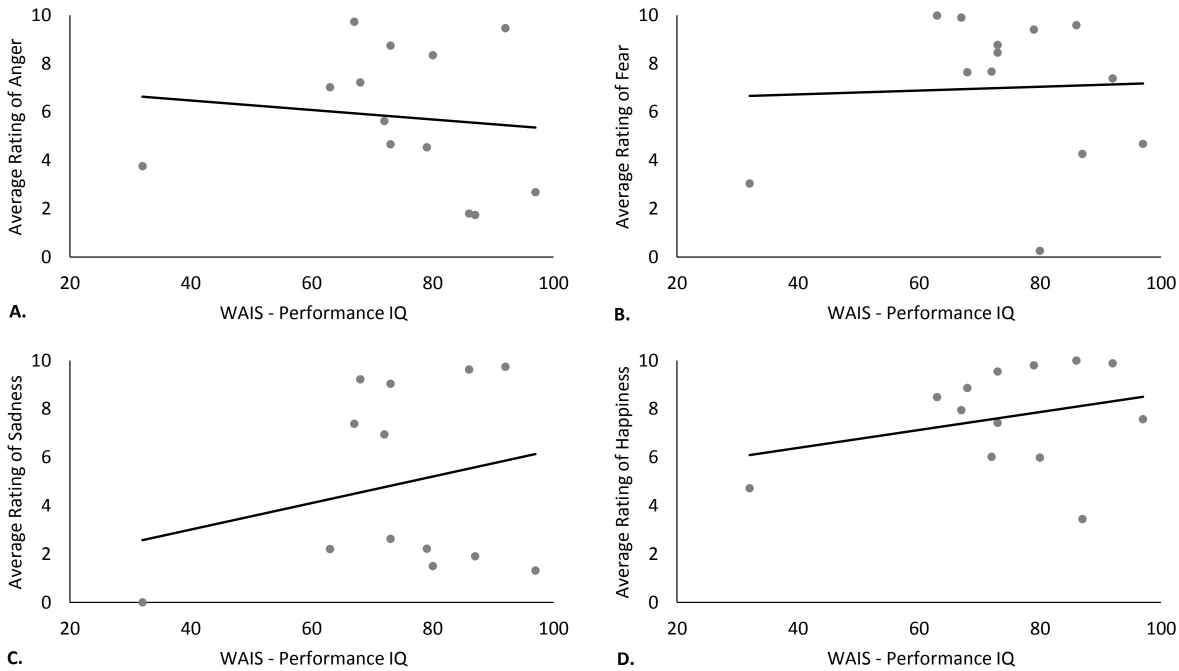

Figure 47. The relation between Korsakoff patients' WAIS Performance IQ scores and emotion ratings.
The correlations between the intensity of the target emotions and the WAIS – Performance IQ for the Korsakoff patients were not significant.

The correlations between the intensity of the discrete target emotions and the Korsakoff patients' WAIS Full Scale IQ are shown in Figure 48. All relationships are non-significant: *anger* ($r(13)=-0.39$, $p=.189$), *fear* ($r(13)=-0.15$, $p=.620$), *sadness* ($r(13)=-0.04$, $p=.896$), and *happiness* ($r(13)=0.16$, $p=.608$).

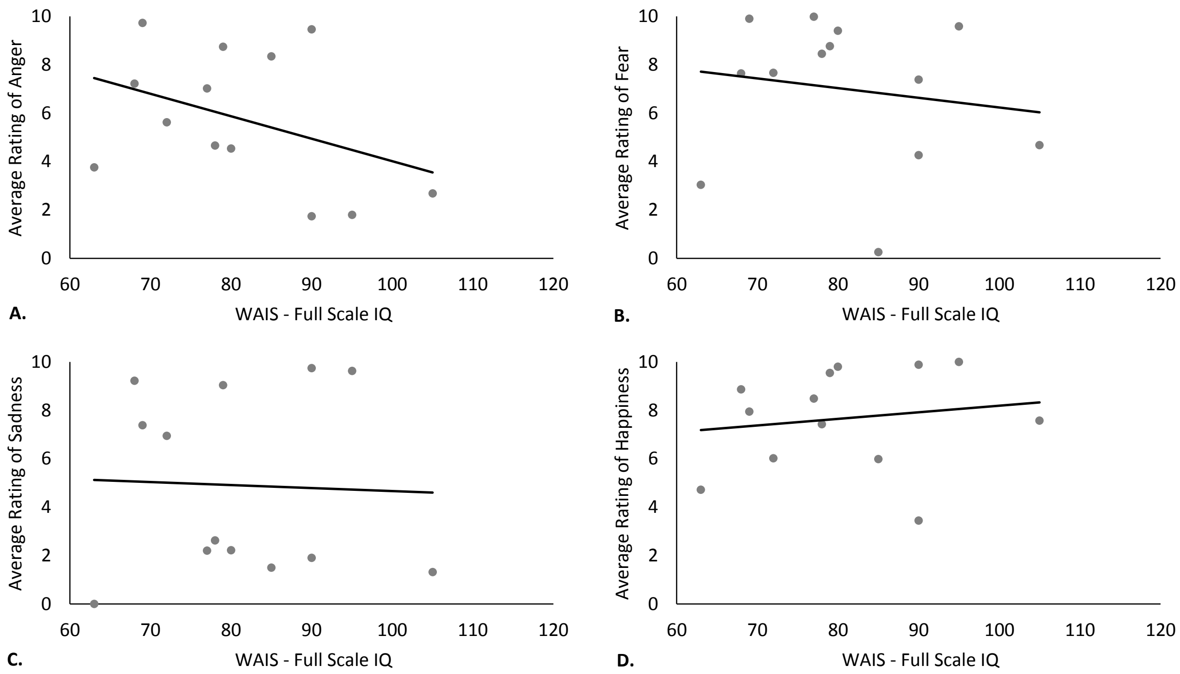

Figure 48. The relation between Korsakoff patients' WAIS Full Scale IQ scores and emotion ratings.
The correlations between the intensity of the target emotions and the WAIS – Full Scale IQ for the Korsakoff patients were not significant.

The composite scores of the WAIS battery were also analysed in relation to the intensity of the discrete target emotions. The data for the WAIS – Verbal Comprehension indices for the Korsakoff patients are shown in Figure 49. All the correlations failed to reach significance for any of target emotions: *anger* (r(13)=-0.16, p=.602), *fear* (r(13)=0.17, p=.571), *sadness* (r(13)=0.17, p=.573), and *happiness* (r(13)=0.35, p=.238).

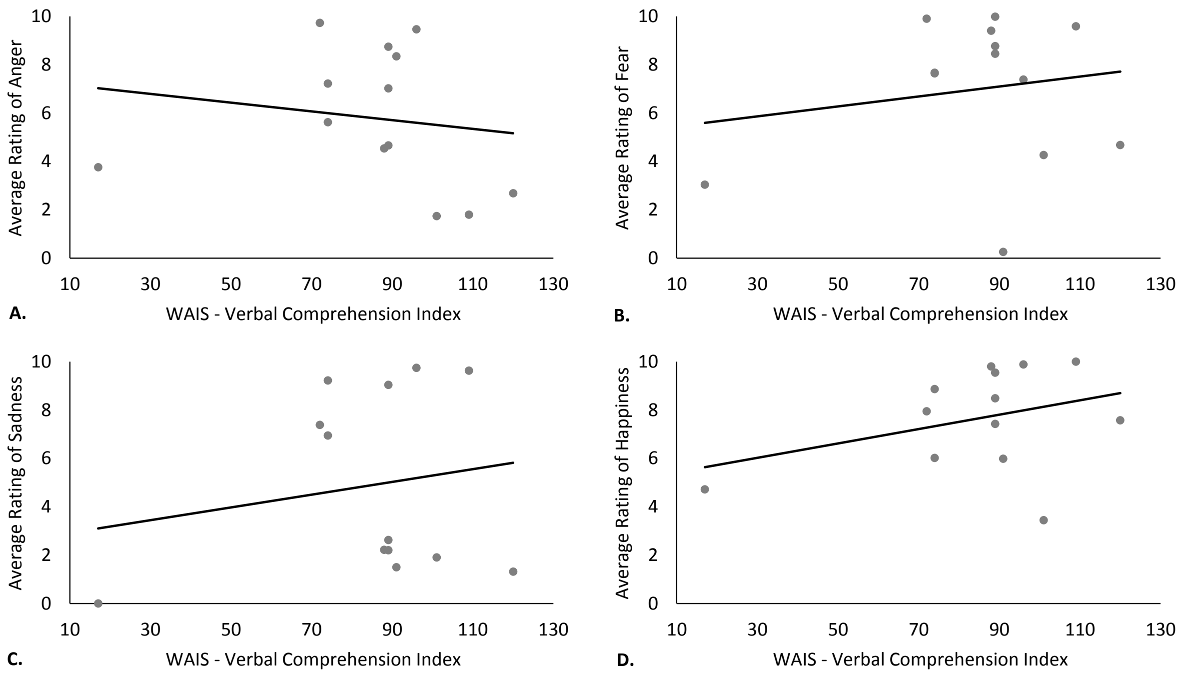

Figure 49. The relation between Korsakoff patients' WAIS Verbal Comprehension Index scores and emotion ratings.

The correlations between the intensity of the target emotions and the WAIS – Verbal Comprehension Index for the Korsakoff patients were not significant.

Next, the relationships between the intensity of the discrete target emotions and the Korsakoff patients' WAIS – Perceptual Organisation indices were investigated. The data are shown in Figure 50. The analyses reported non-significant relationships with any of target emotions: *anger* (*r*(13)=-0.08, *p*=.786), *fear* (*r*(13)=0.07, *p*=.821), *sadness* (*r*(13)=0.28, *p*=.357), and *happiness* (*r*(13)=0.26, *p*=.397).

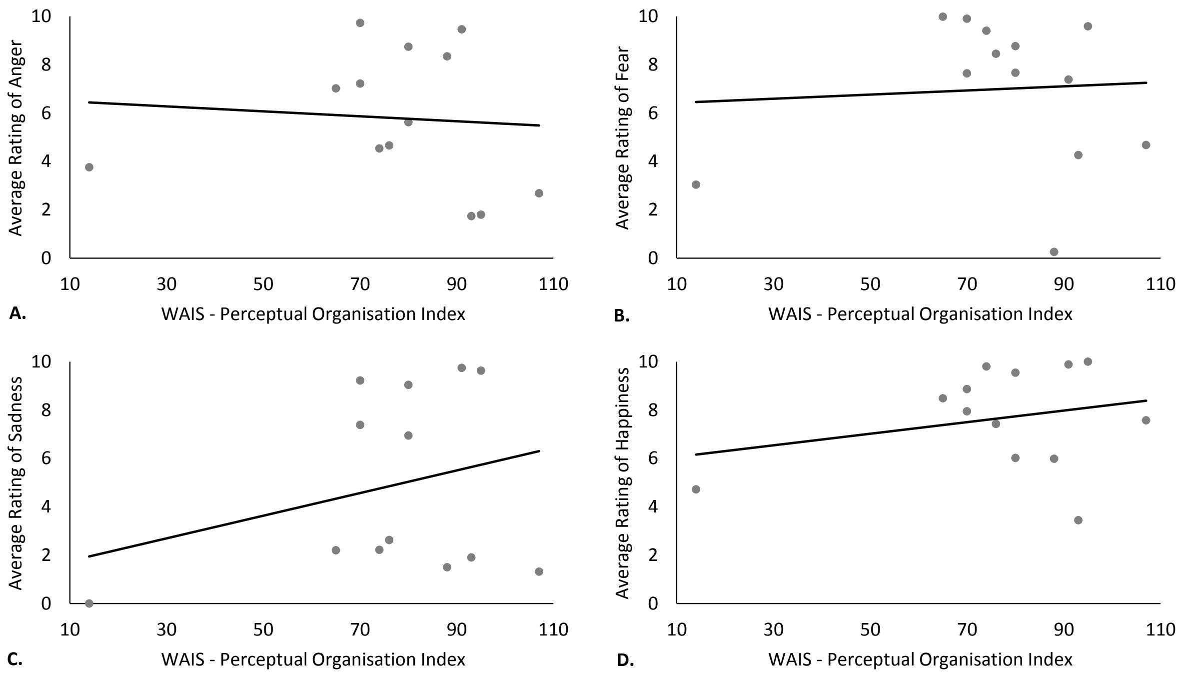

Figure 50. The relation between Korsakoff patients' WAIS Perceptual Organisation Index scores and emotion ratings.

The correlations between the intensity of the target emotions and the WAIS – Perceptual Organisation Index for the Korsakoff patients were not significant.

The relationships between the intensity of the discrete target emotions and the Korsakoff patients' WAIS – Working Memory indices were investigated next. The data are shown in Figure 51. All correlations failed to reach significance: *anger* ($r(13)=0.07$, $p=.814$), *fear* ($r(13)=0.30$, $p=.312$), *sadness* ($r(13)=0.22$, $p=.469$), and *happiness* ($r(13)=0.37$, $p=.212$).

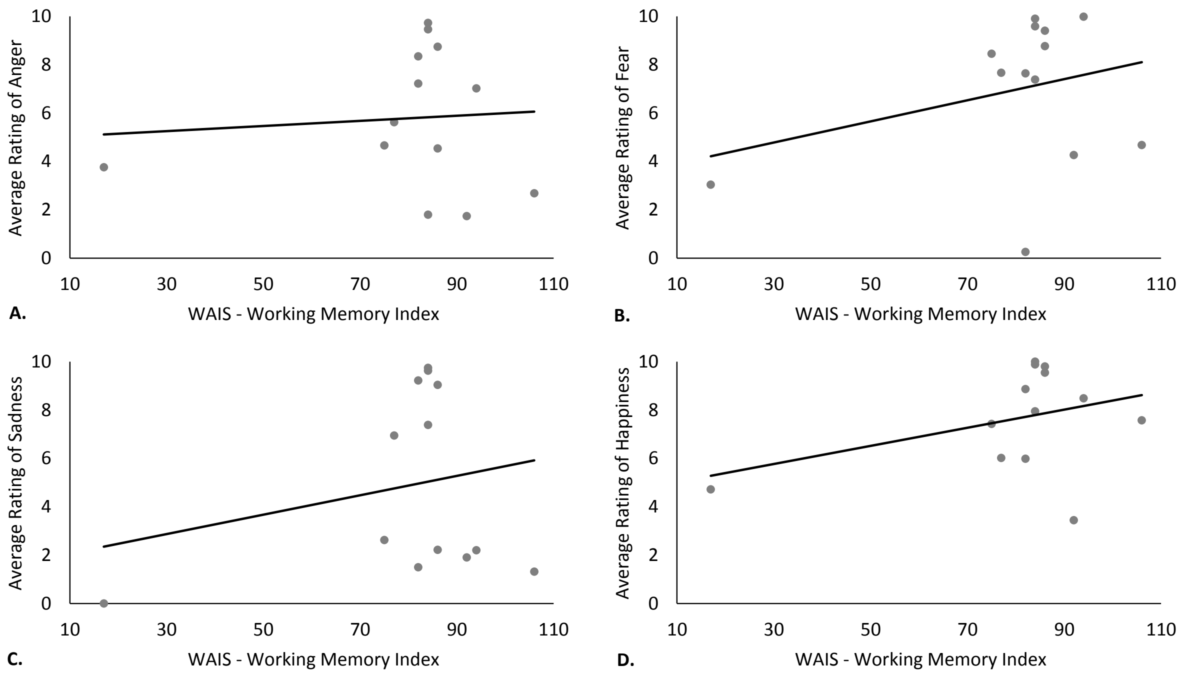

Figure 51. The relation between Korsakoff patients' WAIS Working Memory Index scores and emotion ratings.

The correlations between the intensity of the target emotions and the WAIS – Working Memory Index for the Korsakoff patients were not significant.

Finally, the relationship between the intensity of the discrete target emotions and the Korsakoff patients’ WAIS – Processing Speed indices were analysed using a series of Pearson’s correlations. As shown in Figure 52, only the correlations correlation with the intensity of *happiness* (following the recall of happy stories) was significant ($r(13)=0.56$, $p=.049$), and all other emotions failed to reach significance: *anger* ($r(13)=0.08$, $p=.799$), *fear* ($r(13)=0.44$, $p=.128$), *sadness* ($r(13)=0.29$, $p=.336$). However, when correcting the α (Type I error) level to account for multiple corrections (Bonferroni corrected $\alpha=.0125$), none of the correlations reach significance. Notably, the analysis was substantially underpowered (due to the small sample size), hence a definitive answer cannot be extracted from the data.

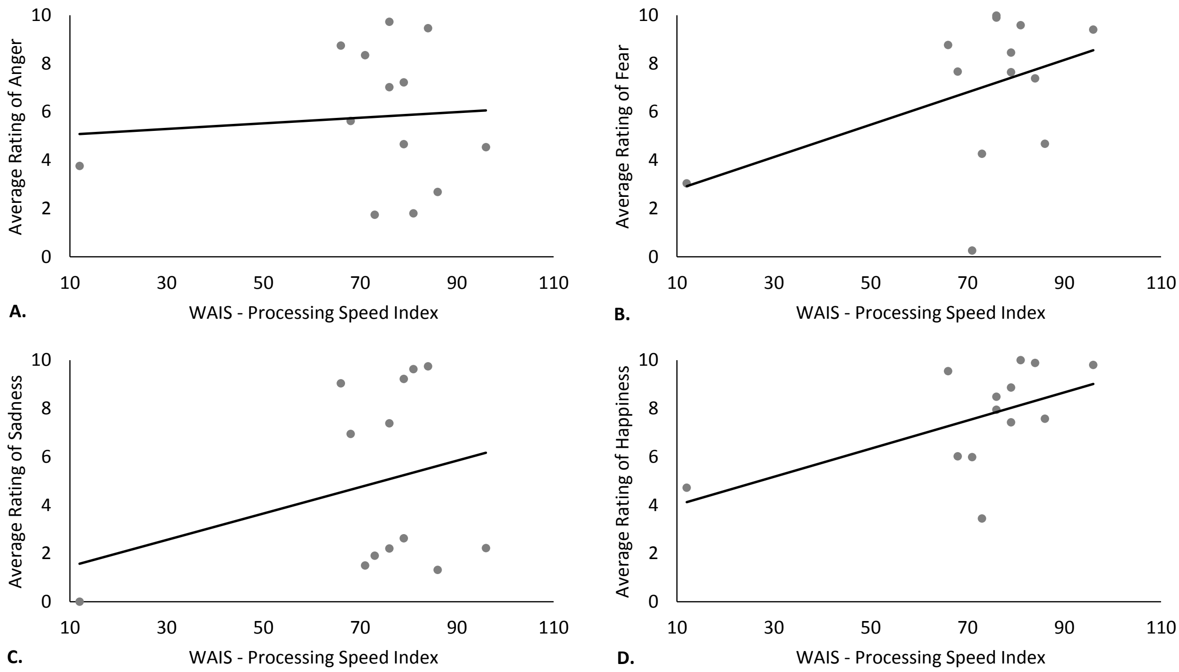

Figure 52. The relation between Korsakoff patients' WAIS Processing Speed Index scores and emotion ratings.
The correlations between the intensity of the target emotions and the WAIS – Processing Speed Index for the Korsakoff patients were not significant.

In conclusion, the Wechsler Adult Intelligence Scale indices failed to show a significant correlation with the intensity of the discrete target emotions for the Korsakoff syndrome patients. The only notable exception was the intensity of *happiness* and the WAIS – Perceptual Speed index, which showed a significant correlation initially, but failed to retain significance when accounting for the number of simultaneous comparisons being done.

3.4.4.4 The relationship between the intensity of discrete emotions and the scores on the Wechsler Memory Scale – IIIR

The last research question sought to establish if there was any relationship between the intensity of discrete emotions and general episodic memory ability, measured using the Wechsler Memory Scale – IIIR (WMS3). As before, the correlation between emotion intensity and WMS scores was analysed both before and after controlling for the recall accuracy of the emotional stories. As shown in Table 10 *anger* and *happiness* showed a moderate positive relationship with the Auditory Recognition Delayed percentile score (WMS3 ARD Perc), while the intensity of sadness showed a moderate negative relationship with the retrieval composite score, which contrasts memory retrieval for recall versus recognition memory.

Table 10.

The relationship between the intensity of discrete emotions and the scores on the Wechsler Memory Scale – IIIR. Only the significant values are shown, for either the simple or partial correlation. At the top of the table, the negative emotions are listed in alphabetical order, followed by happiness.

Discrete emotions	**Wechsler Adult Memory Scale IIIR**	**Pearson Correlation**			**Partial Pearson Correlation (Covariate: Free Recall)**		
		r	***p***	***N***	***r***	***p***	***df***
Anger	WMS3 ARD Perc	0.37	.074	24	0.44	.037 *	21
Sadness	WMS3 Retrieval Perc	-0.51	.011 *	24	-0.51	.013 *	21
Happiness	WMS3 ARD Perc	0.32	.126	24	0.44	.037 *	21

In conclusion, the intensity of the target discrete emotions was only partly negatively associated with age (i.e., *anger*), but showed a more consistent moderate positive relation with the flexibility and set-shifting tasks of the executive function battery tests for all basic emotions with the exception of *anger*. From the battery of intelligence scale tests, only processing speed showed a consistent moderate positive relationship with the intensity of *fear*, *sadness*, and *happiness*.

3.4.4.4a The relationship between the intensity of discrete emotions and measures of episodic memory (Wechsler Memory Scale III-R) for the Korsakoff patients

The relationship between the intensity of the discrete target emotions and the Korsakoff patients' performance on the Wechsler Memory Scale III-R was investigated. The data for the Auditory Immediate index are shown in Figure 53. The correlations failed to reach significance for any of target emotions: *anger* ($r(20)=0.01$, $p=.8$), *fear* ($r(20)=-0.16$, $p=.499$), *sadness* ($r(20)=-0.25$, $p=.286$), and *happiness* ($r(20)=-0.01$, $p=.986$).

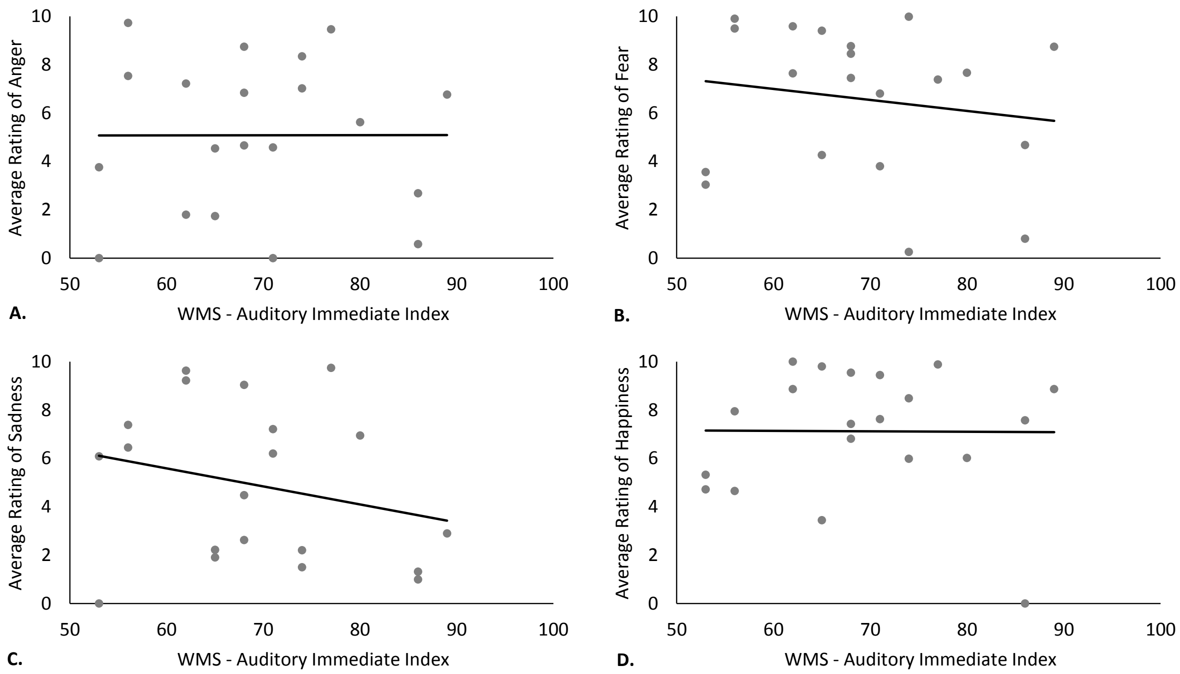

Figure 53. The relation between Korsakoff patients' WMS-III R Auditory Immediate Index scores and emotion ratings.
The correlations between the intensity of the target emotions and the Wechsler memory Scale III-R – Auditory Immediate Index for the Korsakoff patients were not significant.

Next, the relationship between the intensity of the discrete target emotions and the Korsakoff patients' WMS III-R Auditory Delayed index was examined. As shown in Figure 54, all correlations failed to reach significance for any of target emotions: *anger* ($r(20)=0.23$, $p=.323$), *fear* ($r(20)=0.01$, $p=.962$), *sadness* ($r(20)=0.20$, $p=.393$), and *happiness* ($r(20)=0.21$, $p=.381$).

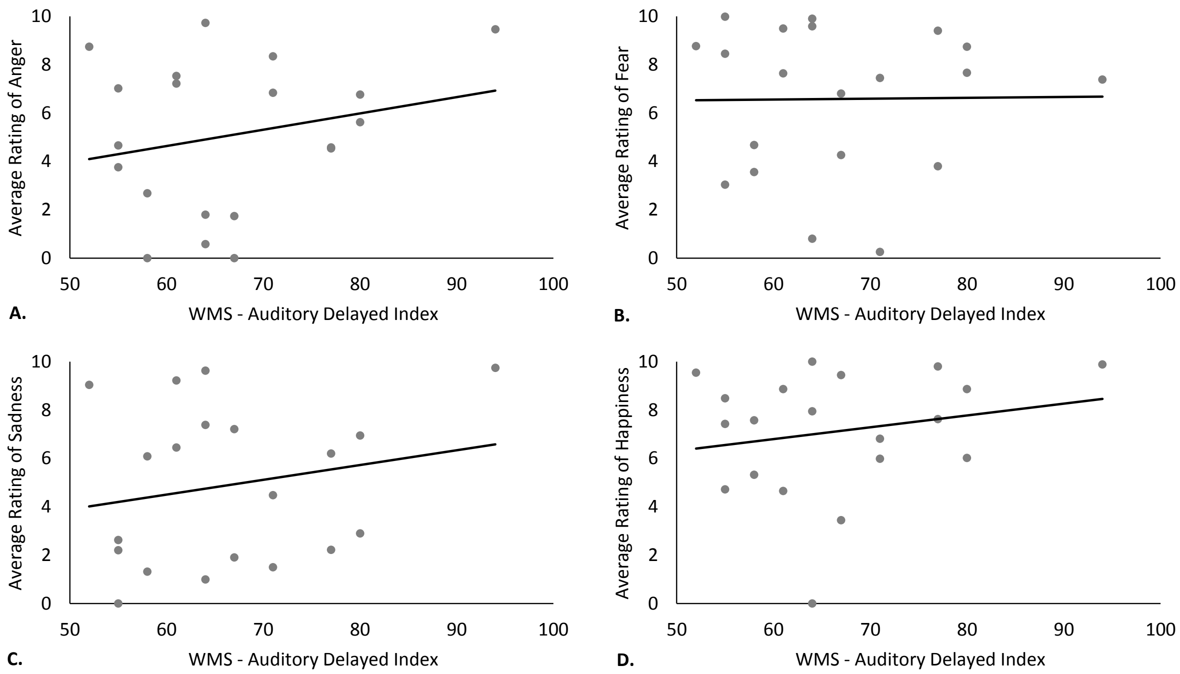

Figure 54. The relation between Korsakoff patients' WMS-III R Auditory Delayed Index scores and emotion ratings.
The correlations between the intensity of the target emotions and the Wechsler memory Scale III-R – Auditory Delayed Index for the Korsakoff patients were not significant.

The correlation between the intensity of sadness and the Korsakoff patients' WMS III-R Auditory Delayed Recognition (see Figure 55) revealed a statistically significant strong negative relationship ($r(19)=-0.63$, $p=.004$). The higher the delayed recognition scores on the WMS III-R scale, the lower the intensity of target emotion after the sad story. The correlation remained significant even after applying the Bonferroni correction for multiple comparisons ($\alpha=.0125$) between the four target emotions. However, the Korsakoff patients' intensity of sadness was correlated in total with 24 measures of neuropsychological assessment, and the correlation fails to reach the significance level ($\alpha=.002$) Bonferroni corrected for the larger number of comparisons. All other correlations were non-significant: *anger* ($r(19)=0.02$, $p=.938$), *fear* ($r(19)=-0.31$, $p=.200$), and *happiness* ($r(19)=-0.03$, $p=.907$).

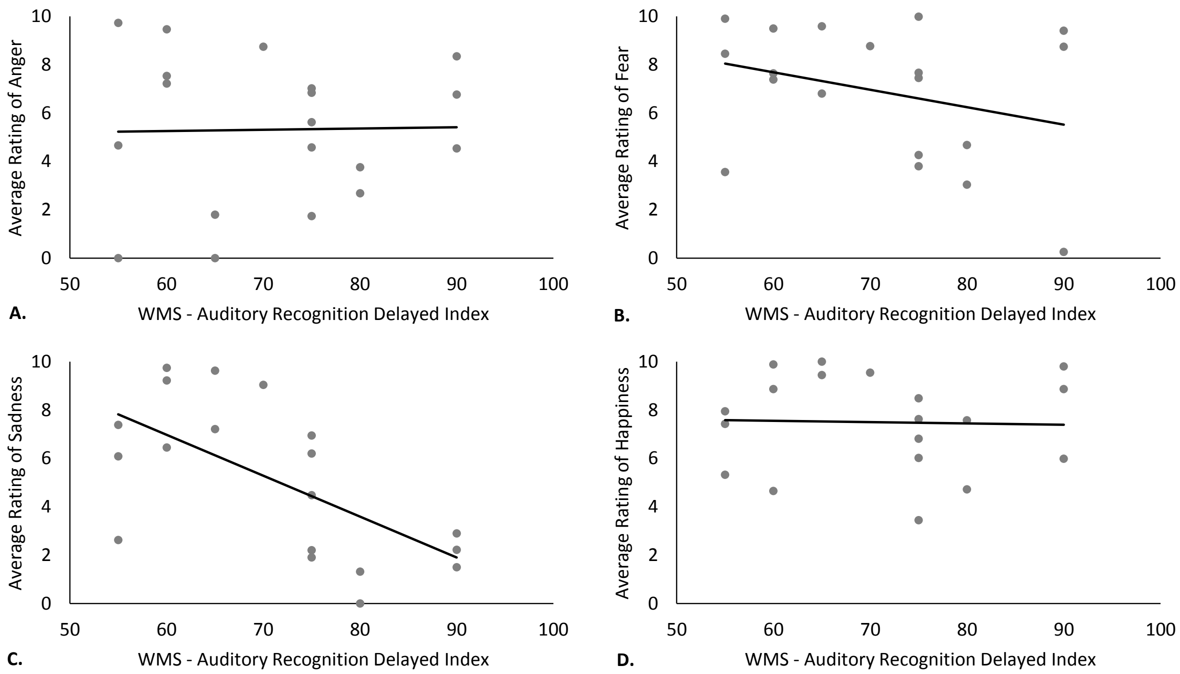

Figure 55. The relation between Korsakoff patients' WMS-III R Auditory Delayed Recognition scores and emotion ratings.

There was a strong negative correlation between the intensity of sadness and the Wechsler memory Scale III-R – Auditory Recognition Delayed Index for the Korsakoff patients, but it failed to reach significance when the α level was corrected for multiple comparisons using the traditional Bonferroni method (α=.002). All other correlations were not significant.

Finally, the relationship between the intensity of the discrete target emotions and the Korsakoff patients' Working Memory indices on the WMS III-R were also analysed (see Figure 56). Similarly with the WAIS Working Memory scores, all correlations failed to reach significance for any of target emotions: *anger* (r(14)=-0.27, p=.348), fear (r(14)=-0.09, p=.754), *sadness* (r(14)=-0.41, p=.151), and *happiness* (r(14)=0.03, p=.927).

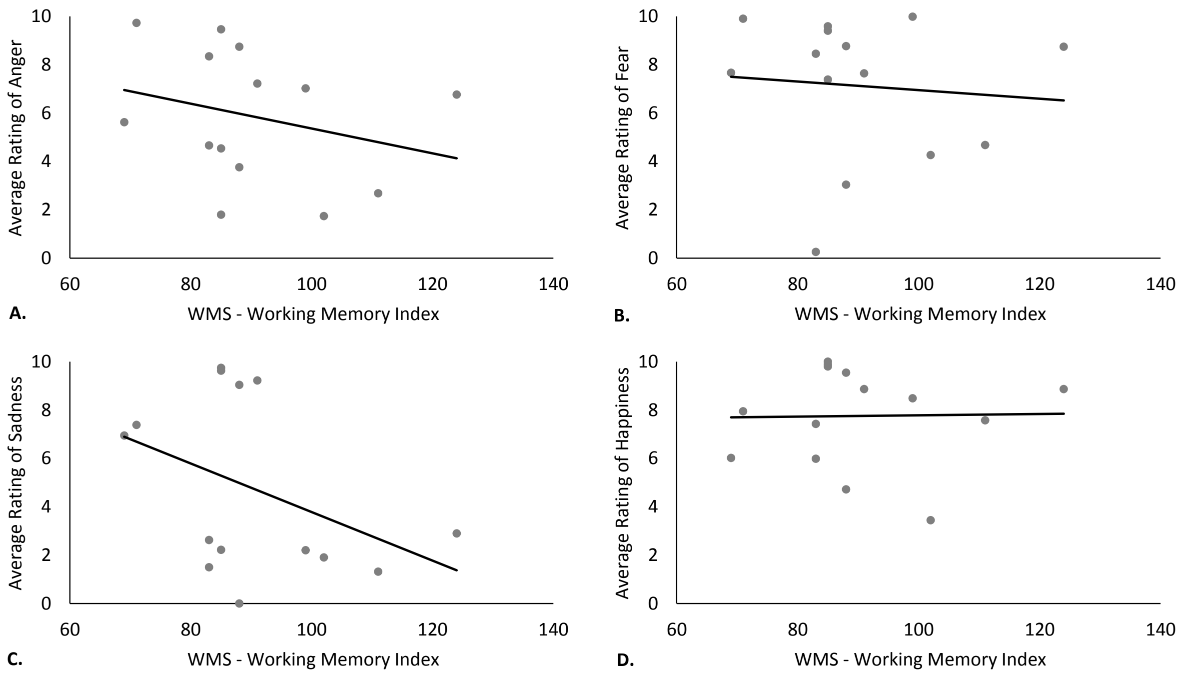

Figure 56. The relation between Korsakoff patients' WMS-III R Working Memory Index scores and emotion ratings.

The correlations between the intensity of the target emotions and the Wechsler memory Scale III-R – Working Memory Index for the Korsakoff patients were not significant.

In conclusion, only the intensity was sadness was significantly (and negatively) correlated with a measure of episodic memory (WMS III-R Auditory Recognition Delayed index). The findings indicate a rich avenue for further empirical study, but the present data come short of providing definitive support of this relationship. Although any generalisations of the current findings are limited by the small sample size of the patient group, the strong trend in the data and highly significant correlation, with a large effect size, merit further enquiry.

3.4.4.4b The relationship between the intensity of discrete emotions and measures of episodic memory (Wechsler Memory Scale III-R) for the control participants

The relationship between episodic memory and the intensity of the discrete target emotions was carried out for the control participants as well. The Wechsler Memory Scale III-R Auditory Immediate indices (see Figure 57 below) showed not to be significantly correlated with any of the target discrete emotions: *anger* ($r(16)=-0.09$, $p=.735$), *fear* ($r(16)=-0.14$, $p=.597$), *sadness* ($r(16)=0.08$, $p=.770$), or *happiness* ($r(16)=-0.21$, $p=.445$).

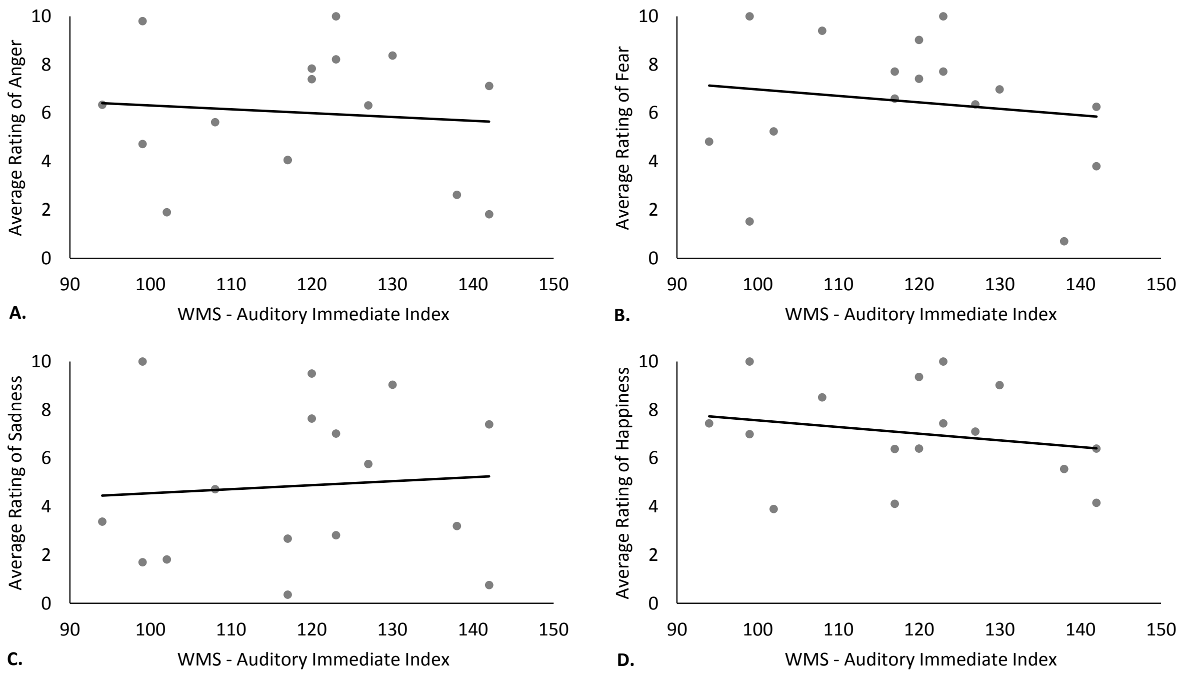

Figure 57. The relation between control participants' WMS-III R Auditory Immediate Index scores and emotion ratings.
The correlations between the intensity of the target emotions and the Wechsler memory Scale III-R – Auditory Immediate Index for the control participants were not significant.

Moreover, the analysis of the relationship between the intensity of sadness and the control participants' WMS III-R Auditory Delayed scores produced similar results (see Figure 58). None of the emotions intensities were correlated with the episodic memory index, as reported by the four non-significant Pearson's correlations: *anger* (*r*(16)=-0.37, *p*=.163), *fear* (*r*(16)=-0.35, *p*=.185), *sadness* (*r*(16)=-0.10, *p*=.707), and *happiness* (*r*(16)=-0.38, *p*=.148).

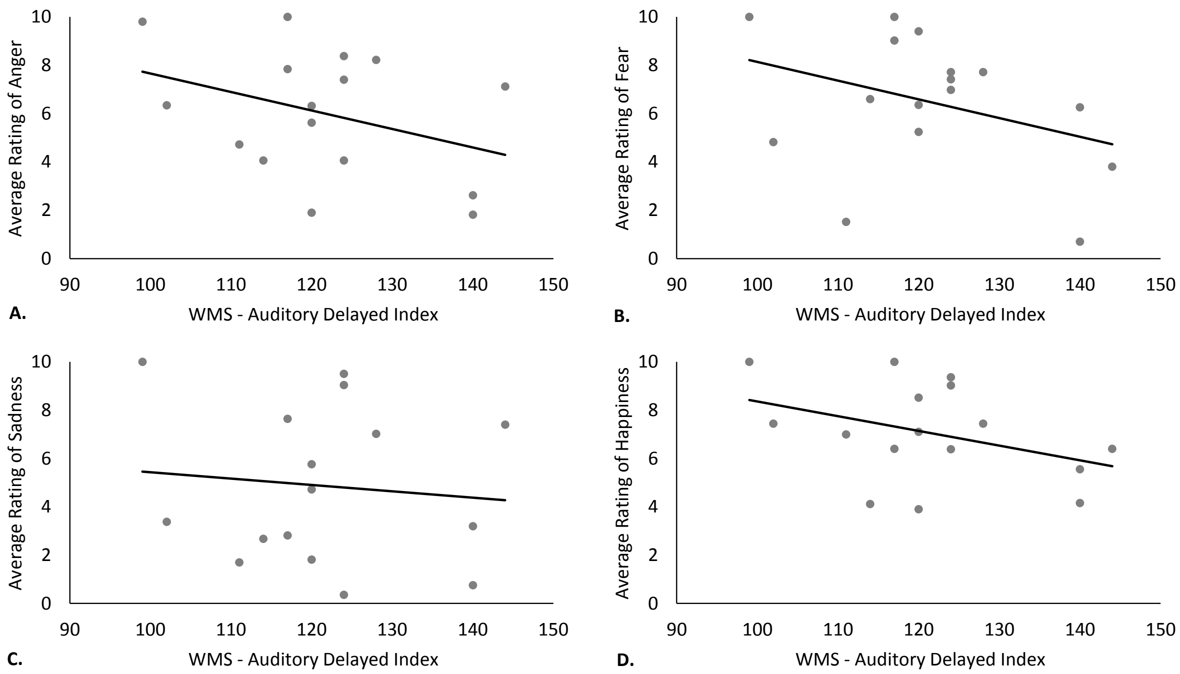

Figure 58. The relation between control participants' WMS-III R Auditory Delayed Index scores and emotion ratings.
The correlations between the intensity of the target emotions and the Wechsler memory Scale III-R – Auditory Delayed Index for the control participants were not significant.

In conclusion, main episodic memory measures of the WMS III-R (Auditory Immediate and Auditory Delayed indices) were not related to the intensity of the four discrete emotions reported by the control participants. The control participants were administered only a reduced version of the WMS III-R battery and the computation of the Auditory Delayed Recognition was not possible. This would have allowed a direct comparison with the Korsakoff patients' group who reported a significant correlation between delayed recognition and the experience of sadness. Future studies can address this question by extending the neurological assessment of control participants beyond that reported presently.

3.5 Discussion

The present study firstly investigated the differences in the re-experience of four discrete classes of emotions (*anger*, *fear*, *sadness* and *happiness*) between Korsakoff patients and neurologically normal controls. Secondly, the study sought to identify the relationship between episodic memory and the specific experience of the four discrete emotions. The emotion elicitation paradigm was a classic free recall procedure (involving four distinct stories which elicited discretely one of the four basic emotions). Participants were asked to recall a previously presented story and report separately the intensity of the four basic emotions. As expected, the Korsakoff patients recalled significantly less (between 3.5 to 5 times less) material from each of the four stories than did neurologically normal controls. However, despite the substantial difference in recall, the emotional experience of each discrete emotion was undifferentiated between the two groups of participants. Moreover, the separate investigation of the relationship between the amount of episodic recall and the intensity of each discrete emotion failed to report a significant value. Most notably, the Korsakoff's syndrome patients who recalled almost nothing (0-5%) of the original story, reported similarly high levels of emotional experience as neurologically normal controls who recalled the story almost entirely, and this finding was confirmed for all four classes of emotions.

Although the ability of amnesic patients to reliably re-experience past emotions without being able to reproduce the events that initially triggered these emotions has been well documented in the past (Chapelle, Philippot, & van der Linden, 2007), this is the first report that this phenomenon takes place for individual basic emotions (*anger*, *fear*, *sadness*, and *happiness*), and not just for *generic* positive or negative emotions. Furthermore, amnesic patients have shown the ability to re-experience each discrete emotion at levels similar to controls, failing to support previous suggestions (Feinstein, et al., 2010; Guzman-Velez et al., 2014) that, perhaps, certain classes of emotions (e.g., sadness) could show a more sustained stability in the case of amnesic patients than controls.

The findings of Feinstein and colleagues (2010), later reproduced for a different group of amnesic patients (Guzman-Velez et al., 2014), provide an interesting parallel with the present study. In 2010, a small group of five hippocampal amnesic patients continued to experience sustained levels of *happiness* and *sadness* long after the memory for the episodic details of the eliciting film clips were forgotten. Similarly, in 2014, a larger group of 17 patients with a probable Alzheimer's Disease (AD) pathology and clear memory deficits reported similar findings on an identical experimental paradigm. On both occasions, the prolonged experience of one emotion (sadness) was particularly elevated for more than 30 minutes after being unable to recall the emotional stimuli. Both findings draw two significant comparisons with the present study of Korsakoff patients.

Firstly, both groups of the hippocampal and AD patients showed a substantially impaired recall of the emotional stimuli (film clips), as did the Korsakoff patients (verbal stories). However, all three groups of patients presented a broad range of memory scores, ranging from complete amnesia to levels overlapping with those of the control participants. Thus, in many cases, much like in the present study episodic memory, albeit for only a part of the emotional stimuli, was preserved. Notably, the paradigm employed by Feinstein and Guzman-Velez did not re-examine episodic memory beyond the initial post-induction time-point, although emotional experience was re-assessed 30 minutes later. Therefore, it is unknown if the episodic details retained by substantial segment of the hippocampal and AD patients were retained or not after 30 minutes. Time intervals of 15-30 minutes are particularly relevant for amnesic patients, and commonly feature as a prominent dimension in established neuropsychological assessments of episodic memory, such as the Wechsler Memory Scale III (1997), Ray Auditory Verbal Learning Test (Schmidt, 1996), and others. In the present study, both the episodic recall and emotional re-experience of the Korsakoff patients were assessed after presentation, post-interference recall and after a 30 minutes delay. Recall accuracy was remarkably stable, albeit significantly impaired when compared to controls'. Thus, surviving fragments of episodic memory may indeed have contributed to the continued affective experience of the hippocampal and AD patients, and the emotional re-experience of the Korsakoff patients.

Secondly, the paradigm used for the hippocampal and AD patients employed self-report measures of emotions (*sadness* and *happiness*), as did the present paradigm employed for Korsakoff patients. However, the results diverge in terms of the differentiation between the experience of positive and negative emotions. Feinstein and Guzman-Velez report a particularly sustained experience of sadness compared to controls, which was not found in the present study. The Korsakoff patients re-experienced all four emotions at similar levels with controls, and moreover at similar levels between the four emotions. This finding is important because it reveals a greater ability of affective systems to accurately encode and reactivate specific classes of emotions with limited input from episodic memory systems, and in some cases apparently with no input at all. The current theory accepted that this may be the case for generic positive and negative affect, which originates in phylogenetically older structures of the brain, in particular, the periaqueductal grey (Panksepp, 2009), but questioned whether the same could happen for emotions usually involving more complex neural regions of the cortex (Vytal & Hamman, 2010). The possibility that discrete classes of basic emotions can be re-experienced completely independently of an accurate episodic recall suggests that a larger set of basic emotions should be investigated concomitantly in the case of amnesic patients than has been done in the past.

A key question regarding the current findings refers to the *quality* as opposed to the quantity of amnesic patients' episodic recall. Although the number of episodic details reproduced by the Korsakoff patients was substantially reduced by comparison with controls', the question remains whether, perhaps, the amnesic patients managed to remember the *key* emotional events of the stories, or the gist, without the details surrounding these events.

Indeed, the retrieval of past experiences from episodic memory seems to integrate information from a number of distinct but interconnected basic systems, such as multiple senses, language, narrative, and emotion (Rubin, 2006). According to this basic-systems model, episodic memory becomes highly constructive, with recollections being guided by the specific organisation (schema) of information in the systems involved. Thus episodic memory errors (or lapses) can be seen as occurring within particular systems or interactions between systems, rather than affecting the entire episodic material encoded in memory (Rubin & Kontis, 1983). For example, surface information or the gist of a memory seems to be encoded in a distinct schema from other episodic details (Rubin, Stoltzfus, & Wall, 1991). In agreement with this view, neurological studies have shown that gist-based conceptual processing is preserved in amnesic patients (Deason, Hussey, Budson, & Ally, 2012). Clinical observations also routinely find that amnesic patients typically hold meaningful conversations and make relevant remarks regarding events beyond the extent of their episodic and working memory stores (Gooding, Isaac, & Mayes, 2005; Rosenbaum, Gilboa, Levine, Winocur, & Moscovitch, 2009), which suggests that amnesic patients appear to retain elements of gist. Experimental evidence has also shown that amnesic patients' gist memory performance was no different to that of healthy controls (Baddeley & Wilson, 2002; Nissan, Abrahams, & Della Sala, 2013). To explain such findings Winocur and Moscovitch (2011) proposed that hippocampally dependent, episodic, or context-specific memories transform into semantic or gist-like versions that are represented in extra-hippocampal structures (the transformation hypothesis).

Therefore, in the context of the present findings, despite the substantially impaired episodic recall of the Korsakoff patients, the gist of the emotional stories may have been retained. Moreover, amnesic patients have been reported to show a reduced confidence in their recollections (Meudell & Mayes, 1984). Thus, retrieval of episodic information may have been possible beyond the amount reported during the free recall procedure, and which nonetheless could have contributed to the emotional re-experience. However, the semantic gist of emotional memories relies on neural structures central to affective experience, such as the amygdalae (Adolphs, Denburg, & Tranel, 2001), making gist information a central part of emotional memory.

Moreover, it is possible for short descriptions of episodic events to produce a relatively complete and specific emotional experience (Mouilso, Glenberg, Havas &

Lindeman, 2007). Addressing this issue would have involved a separate classification (or rating) of each episodic detail (recall unit) according to their emotional value, in the context of each story. The relation (if there is one) between the emotional value (or intensity) of each recall unit correctly reproduced and the overall emotional experience after recalling the entire story is a distinct empirical question, which exceeded the aim of the current study. However, the present study found that some of those few patients who failed to recall anything at all from the stories (i.e., whose recall accuracy was indeed nil), reported moderate-to-very high levels of the correct discrete emotions. This is a clear indication that the specific emotional re-experience of each basic emotion, admittedly only for these select few patients, was completely independent of any episodic memory influence.

Although the present study is conceptually and methodologically grounded in the theory of discrete emotions, the present findings can also be interpreted in the context of strongest competing theory of emotional experience, namely the constructivist model (Barrett et al., 2007). As presented in Chapter 1 (see subsection 1.1.2, p. 10), the constructivist view argues that the subjective sense of emotional experience is the result of a series of mental processes (i.e., psychological construction). The mental representation of affect is seen to originate from the pleasure/displeasure (positive/negative) dichotomy (known as core affect) and integrate contextual sensory and somatosensory information, prior knowledge about relevant objects and situations, and conceptual knowledge about emotions. This complex constructivist process is beyond conscious control or awareness and relies on the interaction between a series of distributed neural networks (Oosterwijk, Lindquist, Anderson, Dautoff, Moriguchi, & Barrett, 2012). Although episodic information about the past often influences and contributes to the final subjective experience of emotions (Spreng & Grady, 2010), the constructivist model points towards semantic and conceptual knowledge, as well as key executive function processes (Yeo et al., 20110) as being fundamental in the generation and maintenance of the subjective experience of affect. In particular three neural networks were identified to support the emotional experience: (1) the limbic network (Yeo et al., 2011), including the bilateral anterior and medial temporal lobe, subgenual anterior cingulate cortex, medial and lateral orbitofrontal cortex; (2) the “salience network” (Seeley et al., 2007), notably involved in cognitive control and set maintenance, and involving the bilateral anterior mid-cingulate cortex, anterior insula, mid-insula, frontal opercularis, parts of the pars opercularis, and the temporoparietal junction; (3) the "frontoparietal network" (Dosenbach et al., 2008; Vincent, Kahn, Snyder, Raichle, & Buckner, 2008), responsible for executive functions such as task-switching, planning, rule-specific processing, and working memory, and involving the bilateral dorsolateral prefrontal cortex, inferior parietal lobe, inferior parietal sulcus, and parts of the middle cingulate cortex.

The neuropsychological assessments of the Korsakoff patients confirmed that they appeared normal on most of the above executive functions, and only borderline impaired on abstract reasoning (DKEFS Proverb Test), among the tasks that did not require time limited processing of visual stimuli (a known deficit for Korsakoff patients). Thus, the ability to re-experience discrete emotions even in the absence or with significantly impaired recall of the stories may have been facilitated by constructivist processes supported by intact executive and semantic memory neural networks.

The contribution of semantic memory to emotional self-reports has also been recognised in previous models of emotion experience (e.g., the accessibility model, Robinson & Clore, 2002). This account argues that emotional reports are representations of the original emotion, based on available information at the time of recall. Three types of information primarily contribute to the re-experience of past emotions in a cascading order (i.e., when the first type of information is not available or is incomplete, the following category of information is accessed). These are: (1) specific information about the details of the original event (episodic memory); (2) general beliefs about what a typical emotion would be for the similar type of situation; and (3) lastly identity beliefs about what own emotions are in general. Thus, Korsakoff patients' lapses in episodic memory may have been supplemented by their conceptual, decontextualised (i.e., sematic) beliefs about the emotional experiences associated with the stories. This may have particularly been the case for the emotional self-report measures used in the present study, where ratings on the same four scales of discrete emotions were repeatedly provided by patients. On each of the four sessions, the successive presentation, and recall of the same emotional story, targeting the same discrete emotion, may have allowed patients to learn and reproduce the same ratings of emotional self-report (using their intact semantic memory processes), rather than their true momentary subjective experience.

Such an experimental artefact is arguably difficult to discount entirely, when using self-report measures of emotions, but key aspects of the experimental design, and the patients' reports seem to indicate that this may have been only the exception rather than the rule. Firstly, the orienting task required participants to report their momentary emotional experience, rather than the emotional experience associated with the story. In many cases the episodic recall was so impaired that participants barely reproduced any details of the stories. In these situations the emotional report task took the form of an exit strategy commonly used to allow participants to escape the pressure of a task they cannot perform, and move on to a seemingly unrelated activity. Often participants seemed relieved to abandon the story recall and focus on something they could control more, such as the assessment of their own momentary affective state. Secondly, there was no relationship (i.e., correlation) between the recall accuracy of the emotional stories and the self-reported intensity of the target emotions. This was because the range of the self-reported intensity of the target emotions was equally broad (from hardly no emotion at all, to very intense emotional re-experience) for both patients who barely recalled anything from the stories (poor episodic recall) and those who recalled a few more episodic details. Thus, the data doesn't seem to support the argument that the poorer the episodic recall, the more participants wilfully digressed from the task of reporting their momentary emotional experience when facing difficulties recalling the stories. Implicit influences of the semantic memory on emotional re-experience and indeed emotional self-reports are difficult to discount completely, but semantic memory is more likely to influence the explicit emotional memory, than the implicit forms of affective re-experience (Levine, Lench, & Safer, 2009). Thus, on balance, it appears that the argument that an experimental artefact may have contributed to the consistently specific ratings of the Korsakoff patients is rather unlikely. However, future investigations could seek to clarify this possibility by also employing implicit (physiological or neuroimaging) measures of affective experience. Possible discrepancies between explicit and implicit measures of affect may be explained by experimental artefacts, or different psychological processes leading to the self-reports of the subjective experience of emotions.

The findings of the current study are limited by the very few such cases of profoundly amnesic patients, which overall varied in the extent to which they re-experienced the target emotion. However, managing to capture this phenomenon in a relatively small sample of amnesic patients, and doing this separately for all classes of basic emotions investigated, is encouraging for future studies. An obvious challenge in establishing the necessary scientific rigour required to confirm the independence of emotional re-experience from episodic memory is represented by the relative scarcity of completely amnesic patients, with a selective episodic memory impairment rather than a generalised cognitive decline. As a first report of a specific re-experience of discrete classes of emotions in the absence of any episodic memory of the eliciting events, these findings should encourage further enquiries into the ability of profoundly amnesic patients to accurately relive specific basic emotions elicited by forgotten past events.

The relationship between executive function and emotion regulation has been reported in numerous studies, but never in relation with the self-reported intensity of a full set of distinct basic emotions. The present study reported a summary analysis of the relationship between measures of executive function and the self-reported intensity of re-experience of four basic emotions (*anger*, *fear*, *sadness*, and *happiness*) for a group of memory impaired participants and partially age matched controls. To account for the substantial difference in episodic memory function, the analysis between executive function measures and emotion intensities was carried out both simple and partial correlations controlling for the recall accuracy of the stimuli responsible for the emotion elicitation.

The results showed a mixed picture, with marked differences and unexpected similarities between basic emotions. Executive functions were correlated with all discrete emotions, and more complex cognitive tasks correlated with most, but not all basic emotions.

The Design Fluency test (from the Delis-Kaplan Executive Function Scale) showed a consistent moderate positive correlation with the intensities of *fear*, *sadness*, and *happiness*, but surprisingly not with *anger*. The test assesses, cognitive flexibility, response inhibition and fluency in generation of visual patterns, above and beyond contributions from motor speed. The present findings are consistent with previous reports that verbal fluency, trail making, and the Stroop task correlate with the ability to down-regulate negative emotions, and up-regulate positive emotions (Gyurak et al., 2012). However, the homologous tests from the DKEFS battery failed to report a significant relation with the intensity of re-experienced emotions, despite the larger dataset available for the analyses. Surprisingly, the intensity of *anger* did not correlate with any of these functions, but instead showed only a small negative correlation with a secondary measure of the Trail Making test concerning motor speed.

More complex cognitive tasks from the Wechsler Adult Intelligence Scale (i.e., Processing Speed, and Performance IQ) showed a moderate positive correlation with the intensity of fear, sadness, and *happiness*, but, again, not with *anger*. Moreover, the correlation was increasingly stronger for *happiness* compared with sadness and compared with fear. *Anger* showed only a moderate negative relationship with a singular test from the WAIS battery (Verbal Comprehension), which is from a different family than Performance IQ, but is used to compute the Verbal IQ score. This is the first account to date of a relationship between the intensity of the re-experience of basic emotions and standard measures of adult intelligence, and shows that *anger* is possibly differently interrelated with executive function compared to all the other discrete emotions.

The current study benefited from a sample of patients and controls with a varied memory ability which presents a unique opportunity to investigate the re-experience of basic emotions in the presence of impaired and normal episodic recall. This is the first direct and concomitant investigation of the re-experience of four discrete classes of emotion and the relationship with executive function and other superior cognitive functions. The results expand previous reports about the relationship between cognition and emotion, and in particular between executive function and emotion regulation and re-experience. Furthermore, the present findings suggest that the experience of basic emotions may exert and receive an influence from different cognitive functions and specifically executive control functions.

Nonetheless, this first investigation of the relationship between the re-experience of basic emotions and the executive function should be considered in the context of two obvious and significant limitations. The first related to the unusually small sample size (for correlational studies), and large amount of missing neuropsychological assessment data. The second major limitation derives from the first, and refers to the mixed sample of neurologically impaired and neurological normal participants. Ideally, the analyses reported here would have been carried out separately on the two groups of participants, but practical considerations regarding sample size prevented this approach presently. Given the relative paucity of patients with a selective memory impairment, future studies could seek to replicate the present findings in a comparable population, and pool the data collected for a joint analysis.

In conclusion, the present study reports the first investigation of the specific emotional re-experience of four basic emotions (anger, fear, sadness, and happiness), after the normal and impaired recall of the eliciting events. Results showed that the intensity and accuracy of emotional re-experience were not related to the amount of episodic information recalled from the eliciting events, and indeed, in the few cases when nothing was remembered from the original events, participants were able to re-experience the correct basic emotions at substantial levels of intensity. This is the first empirical indication that emotional memory systems are capable of encoding and reactivating a broad range of discrete classes of basic emotions, rather than just generic positive and negative emotions, even in the complete absence of episodic memory support. If indeed, the emotional re-experience of basic emotions can operate independently of episodic memory, future investigations of affective processes are encouraged to pursue the study of discrete classes of emotions in profoundly amnesic patients to further assess the differences between basic emotions and which other specific cognitive functions, perhaps, influence the intensity and accuracy of emotional re-experience.

Chapter 4. The theoretical and computational basis of the intensity, specificity and accuracy of affective experiences is based on individual ratings of basic emotions

4.1 Abstract

The study of discrete emotions is a dynamic and growing area of research, supported by a large body of empirical evidence and which usually involves the elicitation and individual measurement of a distinct set of basic emotions – most commonly: anger, fear, sadness, and happiness. The concomitant measurement of four discrete emotions raises yet answered challenges of summarising the affective experience. The present paper introduces the concepts of affective specificity and accuracy, and presents a computational method for calculating the intensity, specificity and accuracy of negative and overall affect from the individual intensities of the most common four basic emotions (mentioned earlier). Emotional specificity is defined as the degree to which the affective experience is described by a single basic emotion. Emotional accuracy is the degree to which the intended (or expected) basic target emotion is experienced in relation to the other (non-target) basic emotions. Intensity adjusted indices for specificity and accuracy are also presented. Notably, the computational formulae can be adapted to include a larger number of basic emotions, should future studies reveal compelling evidence that other emotions (e.g., disgust) represent a basic manifestation of affect. Future studies should investigate the possible differences between the four basic emotions and establish the factors that influence and correlate with the intensity, specificity and accuracy of the affective experience.

Keywords: discrete emotions; affective intensity, specificity and accuracy; negative affect; emotional experience.

4.2 Introduction

The study of discrete, basic emotions (e.g., anger, fear, sadness, and happiness) has long attracted a special interest from affective scientists, and is currently an active area of enquiry in a wide range of other domains. Discrete emotions have been traditionally the focus of affective and cognitive research, for example, addressing the expression and regulation of emotions (Barrett, Gross, Christensen, & Benvenuto, 2001; Gross, 1999; Izard, 1990), and the interaction between affective and cognitive functions, such as memory (Levine & Pizzaro, 2006), information processing (Connolly & Butler, 2006), decision making (Lerner & Tiedens, 2006; Nabi, 2003), and many others. More recently, the range of investigations has extended to applied psychology fields, as discrete emotions are considered to play a significant and distinctive role in influencing treatment adherence and health outcomes (Chipperfield, Perry, & Weiner, 2003; Consedine & Moskowitz, 2007), enhancing professional athletes' performance (Cerin, 2003; Lane & Terry, 2000; Lazarus, 1999), improving work relations and organisational life (Khan, Quratulain, & Crawshow, 2013; Lazarus & Cohen-Charash, 2001; Spector, Fox, & Domagalski, 2006), and understanding spirituality and religious beliefs (Fuller, 2007). The overwhelming support in favour of a distinct set of basic emotions, has been further enhanced in recent years (Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012; Vytal & Hamann, 2010) by meta-analyses of broad sets of neuroimaging studies, which have decisively concluded that a specific set of discrete, basic emotions (e.g., anger, fear, sadness, and happiness) are processed in dedicated neural systems. Thus, in future, the investigation of discrete emotions is likely to take an even more prominent position.

One of the most consistent findings across an extensive literature is that although distinctive, discrete basic emotions are almost invariably experienced together – admittedly at different levels of intensity. Usually this is commonly the case for negative emotions (Barrett, 1998), but sometimes, complex events cause the experience of both positive and negative emotions (Larsen, McGraw, & Cacioppo, 2001). This finding is commonly reproduced in studies using self-report measures of emotions, when participants are asked to assess independently the intensity of each basic.

Moreover, neuroimaging studies reliably confirmed that discrete emotions share a vast array of neuroanatomic structures, with only few areas being specific to each basic emotion. Thus, the accurate assessment of the affective experience in general, and specifically the study of discrete emotions, requires information not only about the emotion of interest, but the concomitant measurement of the full spectrum of basic emotions.

Intensity and discreteness are two fundamental metrics that define the efficacy of emotional stimuli (Rottenberg, Ray, & Gross, 2007). Intensity refers to the degree to which a discrete emotion is experienced or not (i.e., the higher the intensity, the stronger the emotion elicitation). Discreteness is commonly defined as the degree to which participants report feeling the target emotion more intensely than the non-target emotions. Although emotional intensity has been widely employed in assessing the affective state, the use of the *discreteness* metric has been relatively limited, especially by comparison to the wealth of affective stimuli reported in the literature and targeting discrete emotions. Moreover, a number of different interpretations have been given to methodological application and calculation of the metric.

There are two fundamental approaches to formalising the discreteness metric: one which is stimulus-centric and seeks to establish the degree to which a stimulus is able to elicit the discrete target emotion in most situations, for most participants (Gross & Levenson, 1995); and a second, participant-centred, and which seeks to establish the discreteness of the emotional experience of each participant. After a brief inspection, it is easily obvious that the second approach has a higher resolution, because it is able to provide the same amount of information about the discreteness of the stimulus as the first approach, while at the same time, describing the discreteness of the subjective affective experience of each participant.

An example of the first approach to calculating discreteness, was provided by studies seeking to validate new sets of emotional stimuli (e.g., film clips). In these cases discreteness was calculated as the proportion of participants who reported feeling the target emotion at least *one point* more intensely than all other non-target emotions (Gross & Levenson, 1995). The minimum discriminant value referred to *one point* on whichever scale would be used for emotion self-report. This early metric was dependent on large numbers of participants and made the comparison of stimuli assessed by unequal samples of participants statistically problematic. Later approaches to calculating *discreteness* have abandoned this first approach and considered calculating the discreteness of each participant's emotional experience, which could then be aggregated for individual stimuli. Alternative attempts to evaluate the specificity (or discreteness) or the emotional elicitation have assessed whether the target emotion was elicited at significantly higher level than other emotions, among the ratings provided by a group of participants (Jurásová & Špajdel, 2013; Salas, Radovic, & Turnbull, 2011). Although the inferential significance test provide statistical robustness to the method, this too misses the within subjects variability, because a single participants cannot be attributed a "discreteness rating".

The second approach to quantifying the discreteness of the emotional experience most commonly involves a similar process of identifying instances when the target emotion was at least one point greater than the non-target emotions. However, instead of comparing the number of participants who satisfied this condition with the total number of participants (including those for whom the target emotion was not higher than all non-target emotions), the second approach attempts to assign a discreteness rating to each participant, for each instance of emotion self-report involving more than two discrete emotions. The advantage of this approach is that it leverages the power of parametric statistical tests for comparing different groups of participants, and emotional stimuli. At least two fundamentally different methods of calculating the discreteness of the emotional elicitation have been proposed previously.

The method formulated by Rottenberg, Ray, and Gross (2007) factors in the number of non-target emotions measured at the same time as the target emotion. The discreteness is then calculated as the number of non-target emotions whose intensity is lower than the target emotion, divided by the total number of non-target emotions. For example, Gabert-Quillen, Bartolini, Abravanel and Sanislow (2014) reported a paradigm involving nine discrete emotions (one of which is the target emotion, and eight non-target). A participant who rated the target emotion at least 1-point greater than seven (out of the eight) non-target emotions would produce a discreteness score of .875 (7 divided by 8). Thus, the discreteness score would range from .00 (i.e., the target emotion was not 1 point greater than any non-target emotions) to 1.00 (i.e., the target emotion was at least 1 point greater than all non-target emotions). The computational system provides a fundamental advantage over the stimuli-centric methods, by assigning a single *discreteness* index to each participant, on each occasion emotion self-reports are provided. Also, the indicator takes values from the *unit interval* ([0-1]), which is commonly used in mathematical calculations (0-1). This makes it intuitively simple to illustrate and interpret its value. However, the *unit interval* is limited in the number of operations and transformations in which it can be used (for example, the power function has a negative momentum on the unit interval). Although, simple data transformations can be applied to the discreteness index to extend the interval, another limitation is perhaps of a greater concern. The method of calculation losses an important part of the richness of the emotion self-report ratings, by using only an ordinal count of the non-target emotions whose ratings were 1-point less than the target emotion. To illustrate this, let's assume for the sake of simplicity that the ratings of four discrete emotions (anger, fear, sadness, and happiness) are provided on a scale from 1-10, and that the target emotion is *anger*. Two participants would provide the following emotion ratings:

Participant 1:	- anger: 10	Participant 2:	- anger: 10
	- fear: 0		- fear: 9
	- sadness: 0		- sadness: 9
	- happiness: 0		- happiness: 9

Since both participants rated the target emotion (anger) at least 1-point higher than all of the non-target emotions, they would both receive a discreteness index of 1. However, the difference between the discreteness of the emotional experience of participant 1 is clearly superior to that of participant 2. This dimension is unable to be captured following the proposed calculation, and represents a fundamental limitation of the information provided by the index in common experimental situations. The method also suffers from a computational limitation, which affects the ability to use and interpret the absolute values of the index. The resolution of the index (the actual values it can take) depends on the number of non-target emotions which are measured at the same time, and not on the resolution of the initial emotion self-report scores that formed the basis of its calculation. For example, in the system employed by Gabert-Quillen and colleagues (2014), the possible values of the *affective discreteness* were: 0; 0.125; 0.25; 0.375; 0.5; 0.675; 0.75; 0.875; and 1. From a computational perspective this is fortunate, because the number of non-target emotions (eight) approaches the resolution of the original measure of the intensity of discrete emotions (ten). However, there is limited empirical evidence to support the concomitant measurement and comparison of such a high number of discrete emotions. Recent empirical evidence (Hamann, 2012; Murphy et al., 2003; Tettamanti et al., 2012; Vytal & Hamann, 2010), suggests that perhaps four or five emotions can be classed as basic (anger, fear, sadness, happiness, and possibly disgust). Therefore, in most conservative cases, only three non-target emotions would contribute to the calculation of the discreteness index, giving it a considerably fewer possible values: 0; 0.333; 0.666; 1. Thus, using a high resolution 10- or perhaps 100-points visual analogue scale (or other emotion self-report) to produce a discreteness index that can take any of only four possible values, represents a large loss in primary information collected. Fortunately, both of these limitations can be avoided by the computational method presented later in this chapter.

An alternative approach to this model proposed an improved calculation of affective the discreteness by subtracting from the intensity ratings of the target emotion, the averaged intensities of the non-target emotions (Schaefer, Nils, Sanchez, & Phillipot, 2010). This model retains the resolution of the original self-report measures, which is an improvement over the model proposed by Rottenberg et al., 2007. Such discreteness coefficients were calculated for all discrete emotions, alongside a *mixed feelings* (MF) coefficient, which estimates how mixed/blended were the feelings elicited by each film. The formula was previously reported by Hemenover and Schimmack (2007) and Schimmack (2001), and assigns the MF score the minimum intensity of two discrete emotions. For example, a participant reporting a score of 5 for *anger* and 2 for *fear*, would produce a MF score of 2. Thus, the *discreteness* measure summarises how much a specific state is activated relative to an average of all other states, while the *mixed feelings* index measures how much two specific states are mixed/differentiated on a pairwise basis. Although the discreteness measure retains the resolution of the original emotion self-reports, it presents a possibly greater limitation regarding the accuracy and validity of the indicator, because it reduces the intensities of the non-target emotions to their common average. This way, two problems may arise: (1) although the average of the non-target emotions may be lower than the intensity of the target emotion (indicating some degree of discreteness), the intensity of one (or more of the non-target emotions) may actually higher than the target emotion (meaning that the target emotion was not the dominant affective category) – both of these interpretations being mutually exclusive; (2) by averaging the non-target emotion, a lot of information is lost regarding between-discrete emotions variability. Admittedly, such a loss in information would be less than in the Rottenberg model, but both these limitations can be avoided by the improved model presented next in this chapter.

4.2.1 Affective experience described by multiple basic emotions

The study of discrete emotions as independent, but concomitant descriptors of affect raises significant methodological challenges regarding the analysis, interpretation, and application of these measures. It is increasingly accepted that valence is a fundamental dimension of all basic emotion experiences and negative basic emotions (anger, fear, sadness) share a common underlying neuroanatomy, and are often experienced and co-elicited together. By contrast, positive affect seems to have fewer *basic* manifestations and it is most often captured by the generic term of happiness (or joy). Various other affective states, such as pride, satisfaction, enthusiasm, etc. have usually been attributed a positive valence, but are generally considered as complex emotion states and are seen to be the result of a mix of basic emotions and superior cognitions. Thus, positive affect has usually one, but almost always far fewer classes than negative affect. Attempts to summarise the individual scores of discrete emotion classes using a simple arithmetic mean result in reducing the natural variance of scores for negative affect compared to the single rating of positive affect. The degree to which the target emotion is elicited needs to be considered now alongside the experience of at least three other non-target emotions, and the differences in the experience of non-target emotions can potentially represent key elements of the affective experience and reveal previously confounded effects.

4.2.2 The intensity of emotional experience: positive and negative affect.

The elementary assessment of affective experience is its intensity. The intensity of basic emotions can be readily measured through self-reports or other behavioural, neuroimaging, and more rarely physiological techniques. However, calculating the overall intensity of an emotional experience from separate ratings of discrete emotions presents at least two challenges: basic emotions have either a positive or negative valence; and, at least presently, there appears to be a different number of positive and negative emotions.

It is increasingly accepted that valence is a fundamental dimension of all basic affective experiences, and negative emotions (anger, fear, sadness), which share a common underlying neuroanatomy are often experienced together. In contrast, positive affect seems to have fewer distinct *basic* manifestations and it is most often captured by the generic term of happiness (or joy). Various other affective states, such as pride, satisfaction, and others have been generally labelled as complex emotion states, and seem to be the result of a mix of basic emotions and superior cognitions. Attempts have been made to formalise the study of positive and negative affect by proposing a similar number of positive and negative basic emotions (e.g., PANAS-X) and calculating a simple arithmetic mean of negative or positive emotions. However, such attempts lack the evidence base to support that there are indeed as many positive as there are negative basic emotions. The comprehensive neuroanatomical and neuro-physiological literature at the moment seems to suggest that most likely there are more basic negative emotions than are positive (happiness possibly being the only one). Thus, computational solutions should be prepared to reflect this imbalance in the number of basic emotions either side of the valence spectrum. The simple arithmetic mean cannot represent a solution, because the average of all negative emotions at any one time, will consistently and significantly underestimate the range and variance of negative affect by comparison with the single rating of happiness for positive affect. For example, a highly fearful event that elicits little anger or sadness (fear=10, anger=1, sadness=1), would be described by the same average negative valence as an event eliciting a considerably more moderate but indistinctive emotional experience (fear=4, anger=4, sadness=4). Thus, a valid computational technique should distinguish between positive and negative emotions and should be flexible enough to allow a growing and yet unknown number of discrete emotion ratings, on either side of the valence spectrum.

4.2.3 The specificity of emotional experience.

Basic emotions are most often experienced together, at various levels of intensity. On occasions, certain basic emotions dominate the affective experience. The degree to which the dominant emotion is superior to all other basic emotions describes the specific of an emotional experience and has so far been overlooked by the affective literature. Information about the specificity of an emotional experience can distinguish between situations when a certain emotion is only marginally more intense than the others, or when it is virtually the only emotion experienced.

4.2.4 The accuracy of emotional experience.

A further improvement on the specificity of the emotional experience can be made by referring to the accurate experience of a certain a-priori established basic emotion. An attempt to elicit a certain basic emotion is likely to elicit other basic emotions as well. A fundamental question is how distinct (or *pure*) was the elicitation of the target discrete emotion.

4.2.5 Consideration about Model Metrics

The present model assumes that the individual intensities of discrete emotions are measured on a ratio scale. This offers more opportunities to apply transformations and more power for inferential analysis. For simplicity, it is assumed that the measures of discrete emotions are on a scale from 0-10, but the model can be easily translated to any other scalar ranges. The model uses direct (e.g., self-report) measures of four discrete emotions intensities (i.e., anger, fear, sadness, and happiness) and calculates the overall emotional intensity, specificity, and accuracy of the affective experience. The positive-negative dimension of basic emotions is retained by the present model as a key distinction. Thus, a set of indexes (intensity, specificity and accuracy) is calculated for the negative emotions from the ratings of anger, fear, and sadness (i.e., within negative emotions, further denoted by the subscript “w”). Separately, the model incorporates the ratings of happiness to calculate the intensity, specificity and accuracy of the complete affective experience (i.e., between positive and negative emotions, further denoted by the subscript “b”).

4.3 Intensity, Specificity, and Accuracy of Discrete Emotions

Let A, F, S, H be the emotional intensity ratings for the discrete emotions *anger*, *fear*, *sadness*, and *happiness*, and $A, F, S, H \in [0,10]$.

4.3.1 Intensity and specificity within discrete negative emotions.

Let Δ_{w1} and Δ_{w2} be defined as the following differences (as shown in Figure 59):

$$\Delta_{w1}: [0,10] \times [0,10] \times [0,10] \rightarrow [0,10]$$

$$\Delta_{w1} = Max(A, F, S) - Min(A, F, S) \qquad (1)$$

$$\Delta_{w2}: [0,10] \times [0,10] \times [0,10] \rightarrow [0,10]$$

$$\Delta_{w2} = Max(A, F, S) - [A + F + S - Max(A, F, S) - Min(A, F, S)] \qquad (2)$$

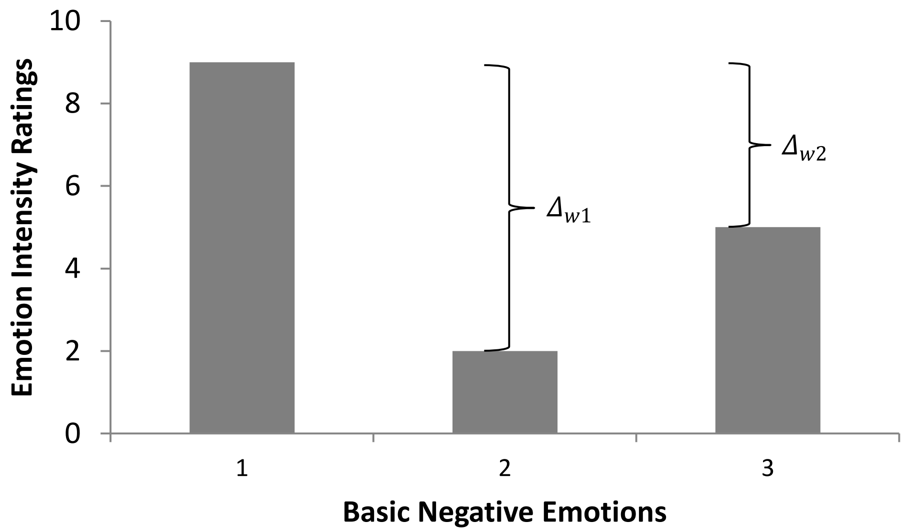

Figure 59. Defining the intensity and specificity of negative emotions.
The individual intensity ratings of basic negative emotions 1, 2, 3 correspond to anger, fear, sadness, in any order. The overall intensity of negative affect is represented by the intensity of the strongest basic emotion (here emotion 1). The specificity of negative affect is calculated from the differences between the intensity of the dominant emotion (1) and the remaining two basic negative emotions (i.e., 2 and 3).

Then, $Intens_{(w)}$ and $Spec_{(w)}$ represent the intensity and specificity within discrete negative emotions, respectively, where:

$$Intens_{(w)}: [0,10] \times [0,10] \times [0,10] \rightarrow [0,10]$$

$$Intens_{(w)} = Max\ (A, F, S) \tag{3}$$

$$Spec_{(w)}: [0,10] \times [0,10] \rightarrow [0,10]$$

$$Spec_{(w)} = \sqrt{(\Delta_{w1} + .125) * (\Delta_{w2} + .125)} - .125 \tag{4}$$

The following statements result from the above definition:

Observation 1: For any A, F and S, $\Delta_{w1} \geq \Delta_{w2}$, and $Spec_{(w)} \leq Intens_{(w)}$

Observation 2: For any $\Delta_{w1} = \Delta_{w2}$, then $Spec_{(w)} = \Delta_{w1} = \Delta_{w2}$. In particular, it needs noting that if $\Delta_{w1} = \Delta_{w2} = 0$, then $Spec_{(w)} = 0$, and if $\Delta_{w1} = \Delta_{w2} = 10$, then $Spec_{(w)} = 10$

Observation 3: If $\Delta_{w1} = 10$ and $\Delta_{w2} = 0$, then $Spec_{(w)} = 1$

As illustrated in Figure 60, the specificity within negative emotions is a monotonic function, with a positive Gaussian curvature (except when $\Delta_{w1}=\Delta_{w2}=Spec_{(w)}$, when the graph is a straight line). In the notable case when $\Delta_{w1} = 10$ and $\Delta_{w2} = 0$

(e.g., A=10, F=10, and S=0), the specificity within negative emotions was given the unitary value ($Spec_{(w)} = 1$).

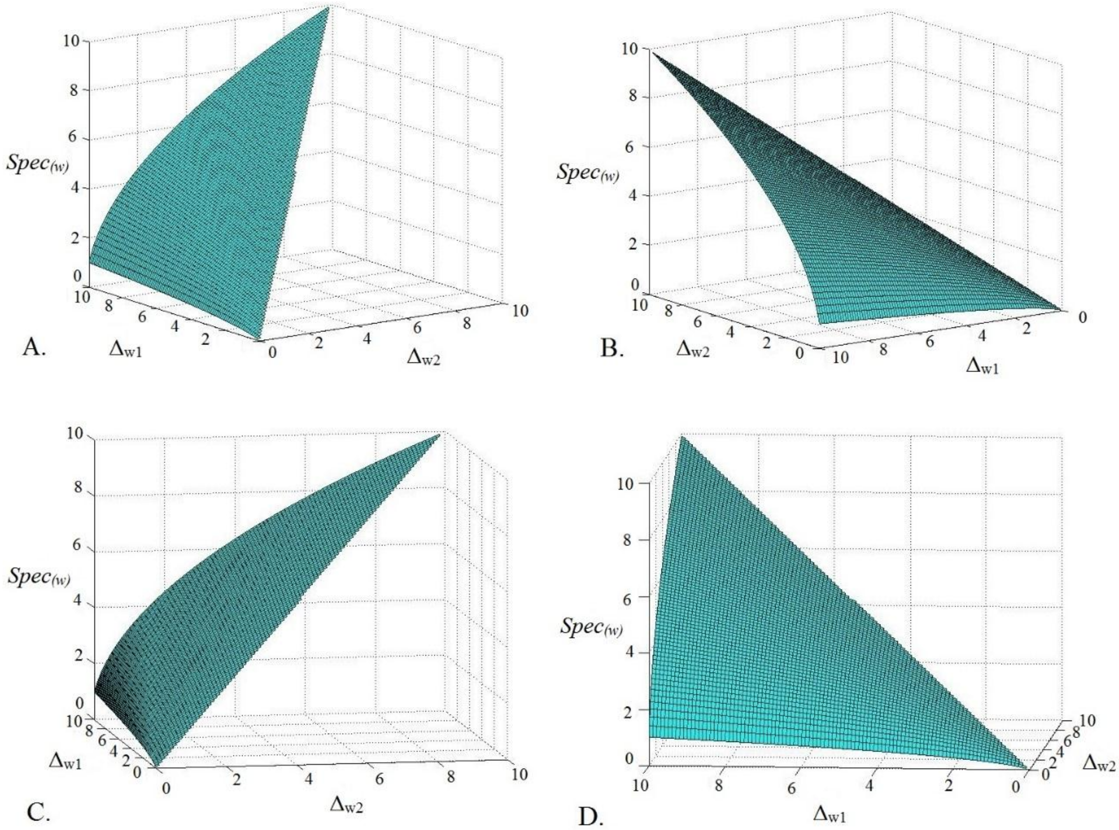

Figure 60. Simulation of the specificity of negative affect (*anger*, *fear* and *sadness*). The simulation of the specificity within discrete negative emotions shows a surface with a positive Gaussian curvature with the exception when the three coordinates are equal ($\Delta_{w1}=\Delta_{w2}=Spec_{(w)}$), and the value of the specificity within negative emotions rests on the diagonal of the cube (zero Gaussian curvature). A. view from azimuth (az=– 35) and elevation (el=15); B. azimuth (az=235) and elevation (el=15); C. azimuth (az=– 10) and elevation (el=10); D. azimuth (az=275) and elevation (el=10).

Importantly, although the specificity is always lower than the intensity (see Observation 1, above), there is no other relation between the magnitude of the two indices. For example:

(1) If A=1, F=0, S=0, then $Intens_{(w)}$=1, and $Spec_{(w)}$=1, and

(2) If A=10, F=9, S=9, then $Intens_{(w)}$=10, and $Spec_{(w)}$=1.

NB: Here F=S, and $Spec_{(w)}$=1 were chosen for the benefit of the simplicity of calculations.

As can be seen above, $Spec_{(w)}$ provides the same information about examples (1) and (2), because the difference between the discrete emotions is the same. However, the intensity of the emotional experience is dramatically different in the two examples. In example (1), the specificity within negative emotions (although low in absolute value) describes the entire intensity of the emotional experience (i.e., there is no noise from other discrete emotions). In contrast, example (2) shows a similarly low specificity within negative emotions, but for a dramatically higher affective intensity. However, the added intensity of example (2) is provided by the noise from other discrete negative emotions, and thus the specificity within negative emotions remains the same. Therefore, since the specificity index alone cannot differentiate between any situations where the intensity of negative emotions is different (including such extreme examples as above), a secondary index can be computed to take into account the intensity within negative emotions.

4.3.1.1 Intensity adjusted specificity within discrete negative emotions.

Let $SpecInt_{(w)}$ be the intensity adjusted specificity within discrete negative emotions, where:

$$SpecInt_{(w)}: [0,10] \times [0,10] \rightarrow [0,10]$$

$$SpecInt_{(w)} = \frac{Spec_{(w)}}{Intens_{(w)}} * 10 \tag{5}$$

$SpecInt_{(w)}$ is the proportion from the intensity of negative emotions which is represented by the specificity of the emotional experience. In example (1), above, the specificity within negative emotions $Spec_{(w)}$=1, but the intensity adjusted (or weighted) specificity within negative emotions $SpecInt_{(w)}$=1. In stark contrast, example (2) has a similar specificity $Spec_{(w)}$=1, but a dramatically lower intensity adjusted specificity within negative emotions $SpecInt_{(w)}$=1. In conclusion, the specificity within negative emotions for similar emotion intensities is best described by $Spec_{(w)}$. In situations when the intensity within negative emotions is significantly different, both $Spec_{(w)}$ and $SpecInt_{(w)}$ are needed to describe the differences in the specific experience of a discrete negative emotion.

However, the specificity within negative emotions refers to the degree to which the dominant discrete emotion (whichever it may be) is higher than all other discrete emotions. This index does not describe the difference in intensity between a target discrete negative emotion and other non-target negative emotions. For this purpose a separate index (called *accuracy*) is describe below.

4.3.2 Accuracy within discrete negative emotions.

Let *anger* be the target emotion and *A, F and S* the individual intensities of *anger*, *fear*, and *sadness* respectively. $Acc_{(w)A}$ is the accuracy of *anger* within discrete negative emotions, defined as:

$$Acc_{(w)A}: [0,10] \times [0,10] \times [0,10] \rightarrow [-10,10]$$

$$Acc_{(w)A} = \left(\sqrt{\left(\frac{10 + A - F}{2}\right) * \left(\frac{10 + A - S}{2}\right)} - 5 \right) * 2 \tag{6}$$

Unlike the specificity index, the accuracy within negative emotions can take negative values. This happens when the intensity of the target emotion (here *anger*), is lower than the intensities of *either* of the non-target emotions (*fear* or *sadness*), as presented in Observation 4 below:

Observation 4: If $A<F$, or $A<S$, then $Acc_{(w)A}<0$

Furthermore:

Observation 5: For any A, F and S, $Acc_{(w)A} \leq Intens_{(w)}$

Observation 6: If $A - F = -10$, then for any $\mathrm{A} - \mathrm{S} \in [-10,10]$, $Acc_{(w)A} = -10$, and alternatively, if $A - S = -10$, then for any $\mathrm{A} - \mathrm{F} \in [-10,10]$, $Acc_{(w)A} = -10$

Observation 7: If $A - F = \mathrm{A} - \mathrm{S} = 0$, then $Acc_{(w)A} = 0$

Observation 8: If $A - F = 10$, and $\mathrm{A} - \mathrm{S} = 10$, then $Acc_{(w)A} = 10$

Observation 9: For $A - F = 0$ and $\mathrm{A} - \mathrm{S} = 10$, or $A - F = 10$, and $\mathrm{A} - \mathrm{S} = 0$, then $Acc_{(w)A} = 4.14213562373095 \cong 4$

The accuracy of *fear* and *sadness* within negative emotions is calculated similarly, replacing the target emotion (*anger*) accordingly. As shown in Figure 61, the accuracy (in this case of *anger*) within negative emotions is a monotonic function, with a positive Gaussian curvature.

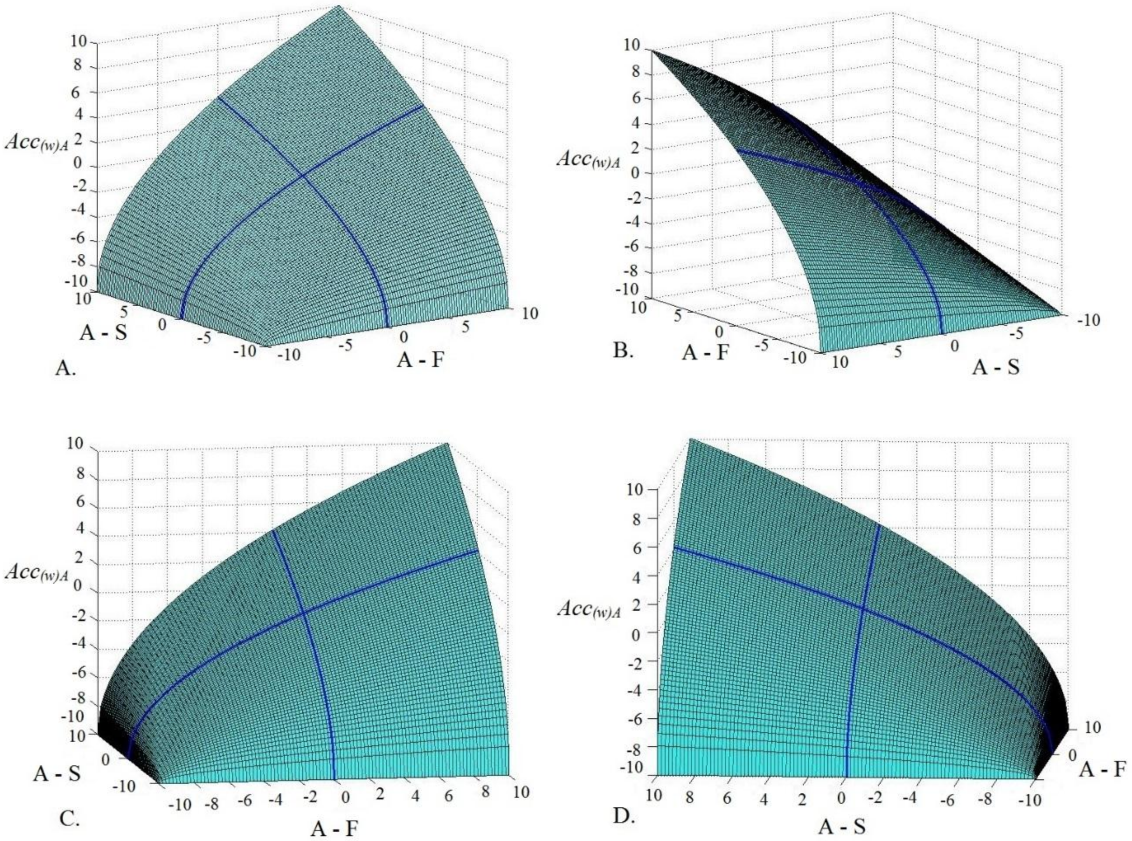

Figure 61. The simulation of the accuracy of negative affect (*anger*, *fear* and *sadness*). The simulation of the accuracy within discrete negative emotions shows a surface with a positive Gaussian curvature throughout. The dark blue lines indicate cases when anger and *sadness* ratings are equal (A – S=0) and *anger* and *fear*, respectively (A – F=0). **A.** view from azimuth (az=– 35) and elevation (el=15); **B.** azimuth (az=235) and elevation (el=15); **C.** azimuth (az=– 10) and elevation (el=10); **D.** azimuth (az=275) and elevation (el=10).

The accuracy index is always lower than the intensity within negative emotions (see Observation 5, above), but there is no other relation between the magnitude of the two indices. Thus, in order to account for the intensity of negative emotions, (for reasons similar with the ones described in the examples above, for specificity within negative emotions) an intensity adjusted accuracy within negative emotions can be calculated.

4.3.2.1 Intensity adjusted accuracy within discrete negative emotions.

Let $AccInt_{(w)A}$ be the intensity adjusted accuracy of anger within discrete negative emotions, where:

$$AccInt_{(w)A}: [-10,10] \times [0,10] \to [-10,10]$$

$$AccInt_{(w)A} = \frac{Acc_{(w)A}}{Intens_{(w)}} * 10 \tag{7}$$

The intensity adjusted accuracy of anger within negative emotions is the proportion from the intensity of negative emotions which is represented by the accurate experience of *anger*, as the target emotion. Moreover, the intensity adjusted accuracy within negative emotions can be calculated similarly for any other discrete negative emotions.

The intensity, specificity and accuracy indices introduced above describe the experience of discrete negative emotions. The same concepts (i.e., variables) can extended to the full range of basic emotions (including happiness). The added complexity posed by the introduction of a new discrete emotion (i.e., happiness) is accommodated in the modified functions, and visual representation of indices.

4.3.3 Intensity and specificity between discrete positive and negative emotions

Let Δ_{b1}, Δ_{b2}, and Δ_{b3}, be the differences between the intensity ratings of the four discrete emotions (*anger*, *fear*, *sadness* and *happiness*), shown in Figure 62, and defined as follows:

$$\Delta_{b1}\colon [0,10] \times [0,10] \times [0,10] \times [0,10] \to [0,10]$$

$$\Delta_{b1} = Max(A,F,S,H) - Min(A,F,S,H) \tag{8}$$

$$\Delta_{b2}\colon [0,10] \times [0,10] \times [0,10] \times [0,10] \to [0,10]$$

$$\begin{aligned}\Delta_{b2} = Max(A,F,S,H) - {} & [A + F + S + H - Min(A,F,S,H) \\ & - Max(A+F, A+S, A+H, F+S, F+H, S+H)]\end{aligned} \tag{9}$$

$$\Delta_{b3}\colon [0,10] \times [0,10] \times [0,10] \times [0,10] \to [0,10]$$

$$\begin{aligned}\Delta_{b3} = Max(A,F,S,H) - {} & [A + F + S + H - Max(A,F,S,H) \\ & - Min(A+F, A+S, A+H, F+S, F+H, S+H)]\end{aligned} \tag{10}$$

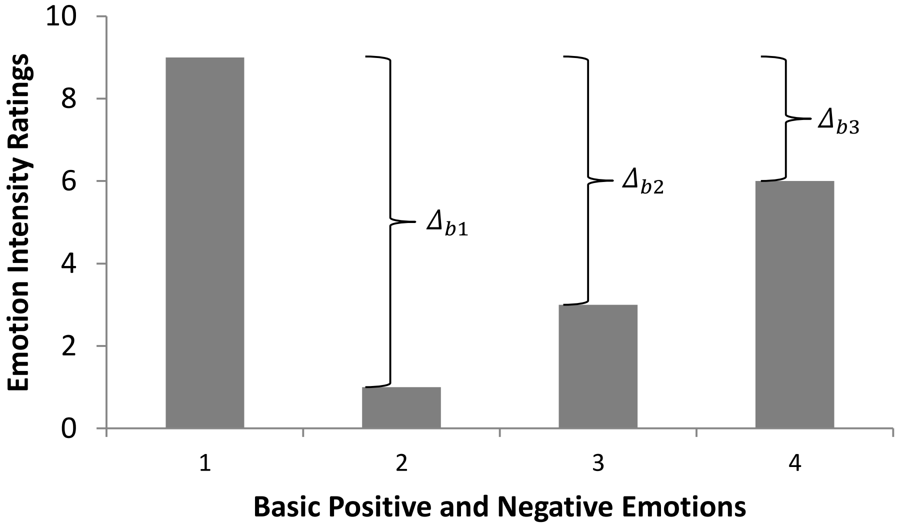

Figure 62. Defining the intensity and specificity of positive and negative emotions. The individual intensity ratings of basic emotions 1, 2, 3, 4 correspond to *anger*, *fear*, *sadness*, and *happiness* in any order. The overall intensity of affect is represented by the intensity of the strongest basic emotion (here emotion 1). The specificity of negative affect is calculated from the differences between the intensity of the dominant emotion (1) and the remaining two basic negative emotions (i.e., 2, 3, and 4).

Then, $Intens_{(b)}$ and $Spec_{(b)}$ represent the intensity and specificity between discrete positive and negative emotions, where:

$$Intens_{(b)}: [0,10] \times [0,10] \times [0,10] \times [0,10] \rightarrow [0,10]$$

$$Intens_{(b)} = Max\ (A, F, S, H) \tag{11}$$

$$Spec_{(b)}: [0,10] \times [0,10] \times [0,10] \rightarrow [0,10]$$

$$Spec_{(b)} = \sqrt[3]{(\Delta_{b1} + .0102907) * (\Delta_{b2} + .0102907) * (\Delta_{b3} + .0102907)} - .0102907 \tag{12}$$

The formulae for the intensity and specificity between positive and negative are extensions of formulae for the corresponding indices within negative emotions. Both indices take values on the same interval as their within negative emotions counterparts (i.e., [0,10]). Similarly with the case within negative emotions, the following consequences need noting:

Observation 10: For any A, F, S and H, $\Delta_{b1} \geq \Delta_{b2} \geq \Delta_{b3}$ and $Spec_{(b)} \leq Intens_{(b)}$

Observation 11: For any $\Delta_{b1} = \Delta_{b2} = \Delta_{b3}$, then $Spec_{(b)} = \Delta_{b1} = \Delta_{b2} = \Delta_{b3}$. In particular, this is relevant for the limits of the [0,10] interval when, if $\Delta_{b1} = \Delta_{b2} = \Delta_{b3} = 0$, then $Spec_{(b)} = 0$ and if $\Delta_{b1} = \Delta_{b2} = \Delta_{b3} = 10$, then $Spec_{(b)} = 10$

Observation 12: If $\Delta_{b1} = \Delta_{b2} = 10\ and\ \Delta_{b3} = 0, then\ Spec_{(b)} = 1.00000000792215 \cong 1$

The specificity between positive and negative emotions is a 4-D object defined by $Spec_{(b)}$, Δ_{b1}, Δ_{b2}, and Δ_{b3}, where always $\Delta_{b1} \geq \Delta_{b2} \geq \Delta_{b3}$. Thus, the visual representation of $Spec_{(b)}$ is done using a 3-D level set, for five key values of Δ_{b2} (see Figure 63): values approaching the upper and lower limits and three evenly distributed intermediary values. The middle difference between discrete basic emotions (Δ_{b2}) was chosen for visual clarity.

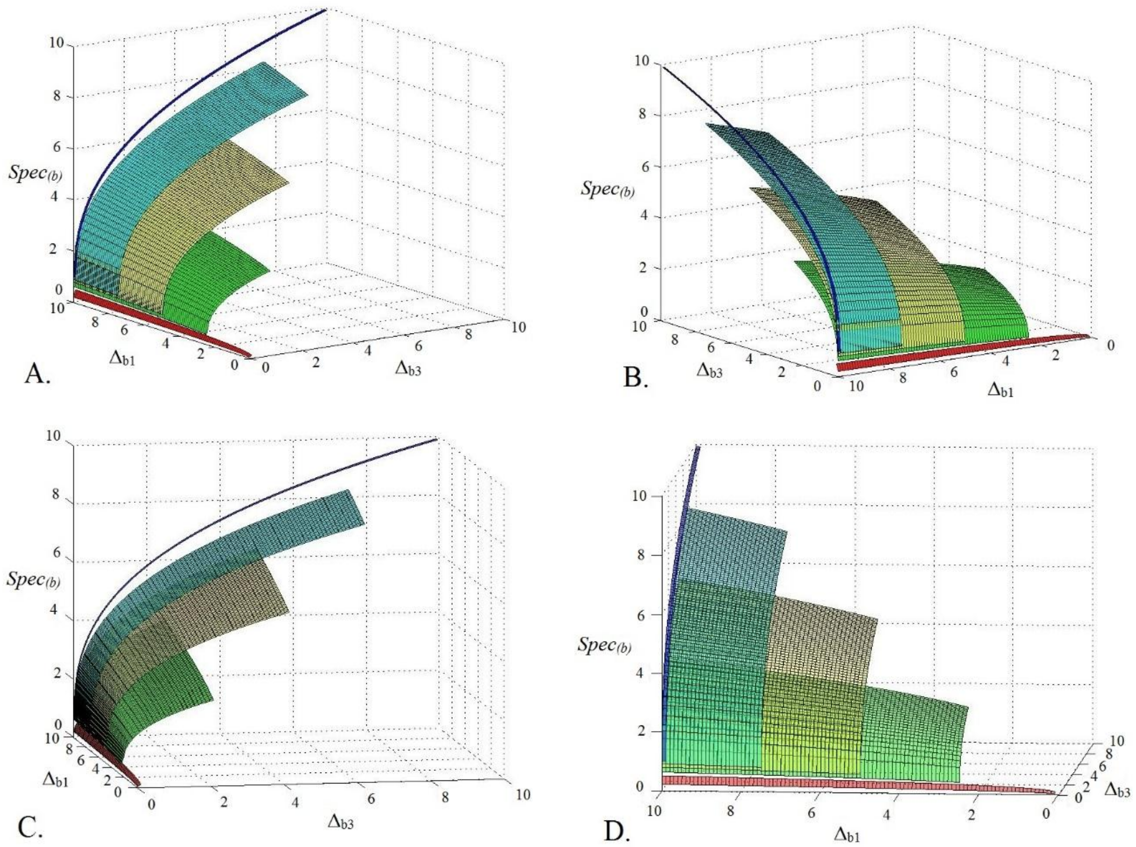

Figure 63. Simulation of affective specificity between positive and negative emotions. The simulation of the specificity between positive and negative emotions is shown for five key values of Δ_{b2} shown in *red* (Δ_{b2}=0.1), *green* (Δ_{b2}=2.5), *yellow* (Δ_{b2}=5.0), *cyan* (Δ_{b2}=7.5) and *blue* (Δ_{b2}=9.9). All level surfaces have a positive Gaussian curvature throughout. **A.** view from azimuth (az=– 35) and elevation (el=15); **B.** azimuth (az=235) and elevation (el=15); **C.** azimuth (az=– 10) and elevation (el=10); **D.** azimuth (az=275) and elevation (el=10).

Similarly with the specificity within negative emotions, the specificity between positive and negative emotions provides no information about the overall intensity of the affective experience (i.e., intensity between positive and negative emotions), other than the intensity being larger than specificity (see Observation 9, above). Thus, for the same reasons as described earlier, an intensity adjusted specificity between positive and negative emotions can be calculated.

4.3.3.1 Intensity adjusted specificity between discrete positive and negative emotions.

Let $SpecInt_{(b)}$ be the intensity adjusted specificity between discrete positive and negative emotions, where:

$$SpecInt_{(b)}: [0,10] \times [0,10] \rightarrow [0,10]$$

$$SpecInt_{(b)} = \frac{Spec_{(b)}}{Intens_{(b)}} * 10 \tag{13}$$

$SpecInt_{(b)}$ is the proportion from the intensity of positive and negative emotions which is represented by the specific experience of the single dominant discrete emotion. As earlier, for similar levels of intensity the specificity between positive and negative emotions is best described by $Spec_{(b)}$. However, when the intensity between positive and negative emotions is significantly different, $Spec_{(b)}$ and $SpecInt_{(b)}$ best describe together the differences in the specific experience of a discrete positive or negative emotion.

Similarly with the case within negative emotions, the specificity index presented above only refers to the dominant emotion as it is experienced, rather than the intended target emotion. Thus, in order to describe the difference in intensity between a target discrete positive or negative emotion and other non-target emotions a similar accuracy index is described below.

4.3.4 Accuracy <u>between</u> discrete <u>positive and negative</u> emotions

Let *anger* be the target emotion and *A*, *F*, *S* and *H* the individual intensities of *anger*, *fear*, *sadness*, and *happiness* respectively. $Acc_{(b)A}$ is the accuracy of *anger* between discrete positive and negative emotions, defined as:

$$Acc_{(b)A}\colon [0,10] \times [0,10] \times [0,10] \times [0,10] \to [-10,10]$$

$$Acc_{(b)A} = \left(\sqrt[3]{\left(\frac{10 + A - F}{2}\right) * \left(\frac{10 + A - S}{2}\right) * \left(\frac{10 + A - H}{2}\right)} - 5\right) * 2 \tag{14}$$

Similarly with the previous accuracy index, and unlike the specificity indices, the accuracy between positive and negative emotions takes negative values for cases when the intensity of the target emotion (here anger), is lower than the intensities of *any* of the non-target emotions (*fear*, *sadness*, or *happiness*).

Observation 13: If $A<F$, or $A<S$, or $A<H$, then $Acc_{(b)A}<0$

In addition to this:

Observation 14: For any A, F, S, H, $Acc_{(b)A} \leq Intens_{(b)}$,

Observation 15: If $A - F = -10$, then for any $\mathrm{A - S}$ and $\mathrm{A - H} \in [-10,10]$, $Acc_{(b)A} = -10$ Symmetrically, if $A - S = -10$, then for any $\mathrm{A - F}$ and $\mathrm{A - H} \in [-10,10]$, $Acc_{(b)A} = -10$, and if $A - H = -10$, then for any $\mathrm{A - F}$ and $\mathrm{A - S} \in [-10,10]$, $Acc_{(b)A} = -10$

Observation 16: If $A - F = \mathrm{A - S} = \mathrm{A - H}$, then $Acc_{(b)A} = A - F = \mathrm{A - S} = \mathrm{A - H}$. In particular, if $A - F = \mathrm{A - S} = \mathrm{A - H} = 0$, then $Acc_{(b)A} = 10$, and if $A - F = \mathrm{A - S} = \mathrm{A - H} = 10$, then $Acc_{(b)A} = 10$

Observation 17: If $A - F = 0, and$ $\mathrm{A - S = A - H} = 10,$ then $Acc_{(b)A} = 5.87401051968199 \cong 6$

The accuracy between positive and negative emotions is a 4-D object defined (in the case of anger) by $Acc_{(b)A}$, $A - F$, $A - S$ and $A - H$. Thus, the visual representation of $Acc_{(b)A}$ is done using a 3-D level set, for five key values of A – F (see Figure 64) approaching the two limits and three evenly distributed intermediary values. The difference A – F is chosen arbitrarily, as there is no necessary relationship between the three differences (i.e., A – F, A – S and A – H).

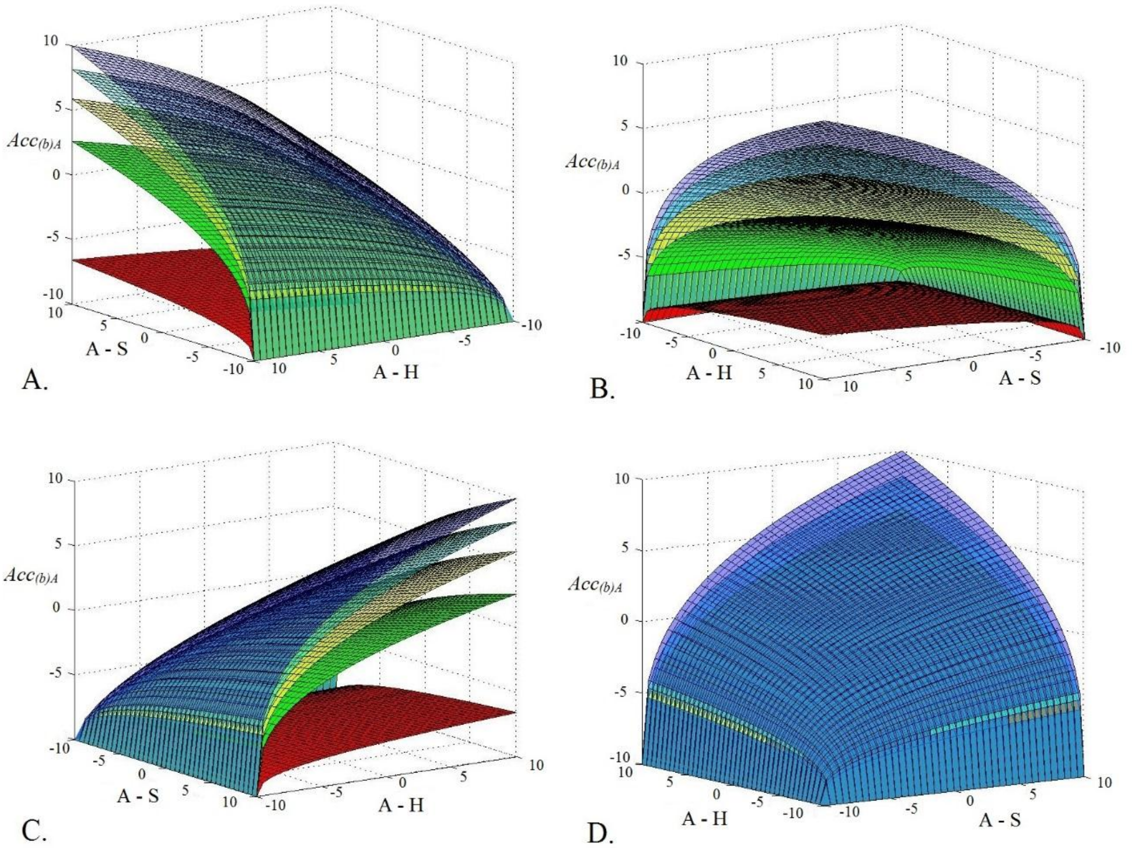

Figure 64. Simulation of affective accuracy between positive and negative emotions.

The simulation of the accuracy between positive and negative emotions is shown for five key values of A – F shown in *red* (A – F =–9.9), *green* (A – F =–5.0), *yellow* (A – F =0), *cyan* (A – F =5.0) and *blue* (A – F =9.9). All level surfaces have a positive Gaussian curvature throughout. **A.** view from azimuth (az=– 35) and elevation (el=15); **B.** azimuth (az=235) and elevation (el=15); **C.** azimuth (az=– 10) and elevation (el=10); **D.** azimuth (az=275) and elevation (el=10).

As presented earlier, the accuracy between positive and negative emotions offers no information about the overall intensity of the positive and negative emotions, except that the intensity is always larger than accuracy (see Observation 12, above). Thus, for similar reasons with the ones described earlier, an intensity adjusted accuracy between positive and negative emotions can be calculated.

4.3.4.1 Intensity adjusted accuracy __between__ discrete __positive and negative__ emotions.

Let $AccInt_{(b)A}$ be the intensity adjusted accuracy of anger between discrete positive and negative emotions, where:

$$AccInt_{(b)A}: [0,10] \times [0,10] \rightarrow [-10,10]$$

$$Acc2_{(b)A} = \frac{Acc_{(b)A}}{Intens_{(b)}} * 10 \tag{15}$$

The intensity adjusted accuracy between positive and negative emotions is the proportion from the intensity of positive and negative emotions which is represented by the accurate experience of the previously established target discrete emotion. As earlier, for similar levels of intensity the accuracy, for example of *anger*, between positive and negative emotions is best described by $Acc_{(b)A}$. However, when the intensity between positive and negative emotions is significantly different, $Acc_{(b)A}$ and $AccInt_{(b)A}$ best describe together the differences in the accurate experience of *anger* among all the other discrete positive or negative emotions.

4.4 A first application of the affective intensity, specificity and accuracy indices: The discrete re-experience of negative emotions is improved after the interference of positive emotions, while the discrete re-experience of happiness is reduced after the interference of negative emotions

The present section presents the detailed analysis of the three datasets included in previous chapters. The analysis of the intensity ratings of the fours discrete emotions included in Chapters 2 and 3 are presented side-by-side with the novel indices of overall affective intensity, specificity and accuracy for negative and positive emotions, introduced previously in the present chapter.

The main aim of the present section is to illustrate the practical application of the novel indices. As a first application of the intensity, specificity and accuracy indices on real datasets, the analyses will follow an exploratory approach, rather than hypothesis-driven. This is in order to a present a broader perspective of the applicability and opportunities offered by each of the new indices, to assess assumptions on which statistical inferences could be based, to support the selection of appropriate statistical tools and techniques, and to provide a basis for further data collection and implementation in future experimental designs. Furthermore, this chapters allows the further detailed exploration of the emotion ratings, at each time point when they were collected, whereas in earlier chapters the data was often summarised across time points and iterations.

A summary of findings is presented at the end of this section (4.4.4), which suggest a different experience of positive and negative emotions after a brief affective interference of the opposite valence. The results are further discussed in section 4.5.

4.4.1 Sample 1: Neurologically normal undergraduate students

The data included in this section also underpins Chapter 2. The full details regarding sample characteristics, measures and stimuli used, and the design and procedure of the data collection have already been presented in Chapter 2, and will not be repeated below.

4.4.1.1 Data Analysis

The ratings of *anger*, *fear*, *sadness*, and *happiness* are analysed in a global 4x4 repeated-measures ANOVA, with the two factors being Emotion and Time (Baseline, Presentation, Recall after 30 minutes and Recall after 7 days). The significant interactions and main effects are explored further using planned contrasts and pair-wise comparisons.

The affective intensity, specificity and accuracy scores are presented together, but analysed separately. Firstly, the intensity between positive and negative emotions and the intensity within negative emotions are subjected to a repeated-measures 2x4 ANOVA, with the significant interaction and main effects being followed-up with planned contrasts. Secondly, the indices of specificity between positive and negative emotions and the specificity within negative emotions are analysed together in a similar 2x4 repeated-measures ANOVA. And thirdly, the accuracy between positive and negative emotions and the accuracy within negative emotions are analysed using a similar 2x3 repeated-measures ANOVA. The analysis of the accuracy indices omits the Baseline time point, because the target emotion only refers to the emotion induction tasks of presentation and recall.

4.4.1.2 Results

The Results section is structured to mirror the traditional analysis of the emotion ratings (presented on the left side of the page) and the analysis of the novel summary indices of affective intensity, specificity and accuracy (shown on the right). Although the emotion ratings data represent a repeated measures design, the figures (shown on the left side of the page throughout this section) use a bar chart for the benefit of visual clarity. The expected/target emotion at Baseline was happiness. Thus the accuracy within negative emotions is not calculated at Baseline in any of the section below, and also for any of the time points in the case of the *happiness* stories (see section 4.4.1.2.4 below, figures on the right side).

The novel intensity, specificity, and accuracy indices are shown in figures on the right side using the following abbreviations:

Intens(b) – the intensity between positive and negative emotions;

Intens(w) – the intensity within negative emotions;

Spec(b) – the specificity between positive and negative emotions;

Spec(w) – the specificity within positive and negative emotions;

Acc(b) – the accuracy between positive and negative emotions;

Acc(w)A – the accuracy within negative emotions, when *anger* is the target/expected emotion;

Acc(w)F – the accuracy within negative emotions, when *fear* is the target/expected emotion;

Acc(w)S – the accuracy within negative emotions, when *sadness* is the target/expected emotion;

Acc(w)H – the accuracy within negative emotions, when *happiness* is the target/expected emotion.

4.4.1.2.1 The affective experience after the presentation and recall of the endings of the anger stories

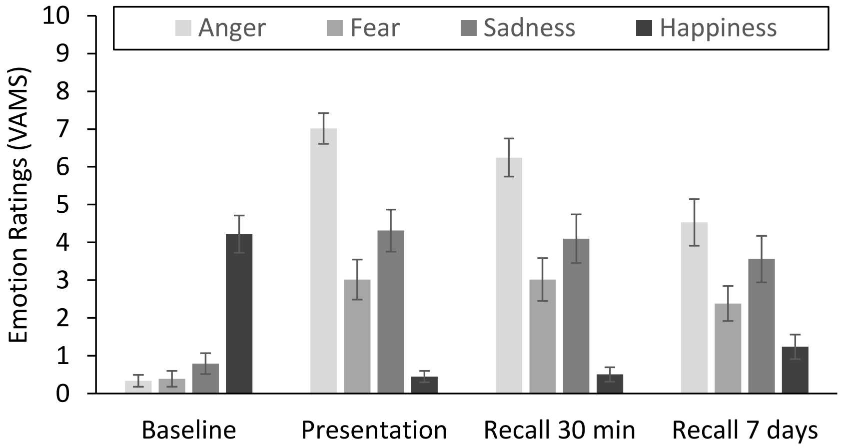

*Figure 65.*Emotion ratings after the *endings* of the anger stories

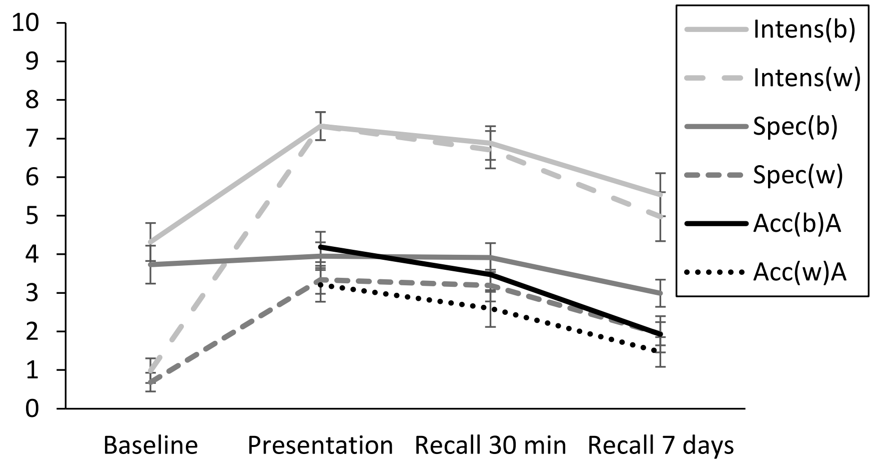

Figure 66. Affective intensity, specificity and accuracy after the presentation and recall of the *endings* of the anger stories.

An overall repeated-measures 4x4 ANOVA reported a significant main effect of *Time* (F(2.42,74.86)=27.27, p<.001, η_p^2=.468), *Emotion* (F(2.46,76.20)=25.45, p<.001, η_p^2=.451),

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The 2x4 repeated-measures ANOVA for the affective intensity scores produced a main effect of *Time* (F(2.27,70.47)=45.12, p<.001, η_p^2=.593; degrees of freedom correction:

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and a significant *Time*Emotion* interaction (F(1,31)=39.95, p<.001, η_p^2=.563). Degrees of freedom were applied the Greenhouse-Geisser, Greenhouse-Geisser, and lower bound corrections respectively.

The planned-contrasts follow-up analysis indicated that the interaction best fitted (F(1,31)=132.04, p<.001, η_p^2=.810) the quadratic contrast of *Time* (F(1,31)=57.91, p<.001, η_p^2=.651) when emotion ratings increased from Baseline to Presentation and Recall 30 minutes, and receded after seven days, and the linear contrast of *Emotion* (F(1,31)=71.46, p<.001, η_p^2=.697). The main effect of *Emotion* indicated that the target emotion *anger* and was significantly more intensely experienced than *fear*, *sadness*, and *happiness*.

Greenhouse-Geisser), a main effect of *Intensity* (F(1,31)=36.26, p<.001, η_p^2=.539), and a significant *Time*Intensity* interaction (F(1,31)=25.88, p<.001, η_p^2=.455; degrees of freedom correction: lower-bound). The main effect of *Time* best fitted a quadratic contrast (F(1,31)=136.23, p<.001, η_p^2=.815), explained by an increase in the intensity of emotions from Baseline to Presentation, and Recall after 30 minutes, followed by a decrease for the Recall after 7 days. The intensity between negative and positive emotions was significantly higher than the intensity within negative emotions, effect mainly driven by the difference between the two indices at Baseline.

The analysis of the specificity indices (2x4 repeated-measures ANOVA) produced a main effect of *Time* (F(3,93)=6.02, p<.001, η_p^2=.163), a main effect of *Specificity* (F(1,31)=52.68, p<.001, η_p^2=.630), and a significant *Time*Specificity* interaction (F(1,31)=12.59, p<.001, η_p^2=.289). The effect of *Time* best fitted a quadratic contrast (F(1,31)=14.06, p=.001, η_p^2=.312) and together with the interaction were mostly driven by the

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reduced specificity within negative emotions at Baseline. The specificity between positive and negative emotions was consistently higher than the specificity within negative emotions ($F(1,31)=52.68$, $p<.001$, $\eta_p^2=.630$).

Lastly, the analysis of the accuracy indices (2x3 repeated-measures ANOVA) found a main effect of *Time* ($F(2,62)=9.12$, $p<.001$, $\eta_p^2=.227$), a main effect of *Accuracy* ($F(1,31)=27.68$, $p<.001$, $\eta_p^2=.472$), and a significant *Time*Accuracy* interaction ($F(1,31)=5.03$, $p=.032$, $\eta_p^2=.139$; degrees of freedom corrected using the lower-bound estimate). The interaction was driven by the stronger decrease of the accuracy between positive and negative emotions after one week, caused mostly by an unexpected increase of *happiness* ratings effect. The effect *Accuracy* confirmed that despite the stronger decrease at Recall after 7 days, the accuracy between positive and negative emotions remained consistently higher than the accuracy within negative emotions. Most significantly, the effect of *Time* fitted a linear contrast ($F(1,31)=15.31$, $p<.001$, $\eta_p^2=.331$) and confirmed that when

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calculated only among negative emotions, as the intensity of re-experienced emotions decreased over time, the accuracy of *anger* (the target emotion) also decreased, even when compared only with the other negative emotions. This effect suggest that as the affective re-experience of the *anger* stories becomes less intense, it also loses its initial accuracy.

4.4.1.2.2 The affective experience after the presentation and recall of the <u>endings</u> of the <u>fear</u> stories

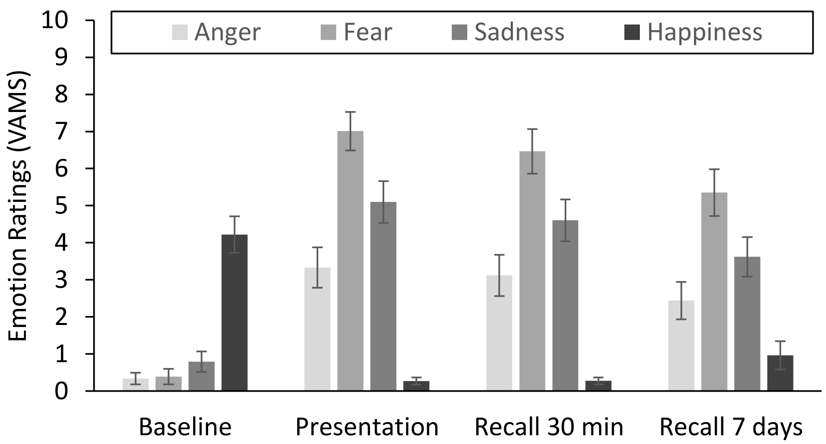

Figure 67. Emotion ratings after the *endings* of the anger stories

The overall 4x4 repeated-measures ANOVA produced a significant main effect of *Time* (F(2.53,78.31)=29.20, p<.001, η_p^2=.484), emotion (F(3,93)=32.61, p<.001, η_p^2=.513), and

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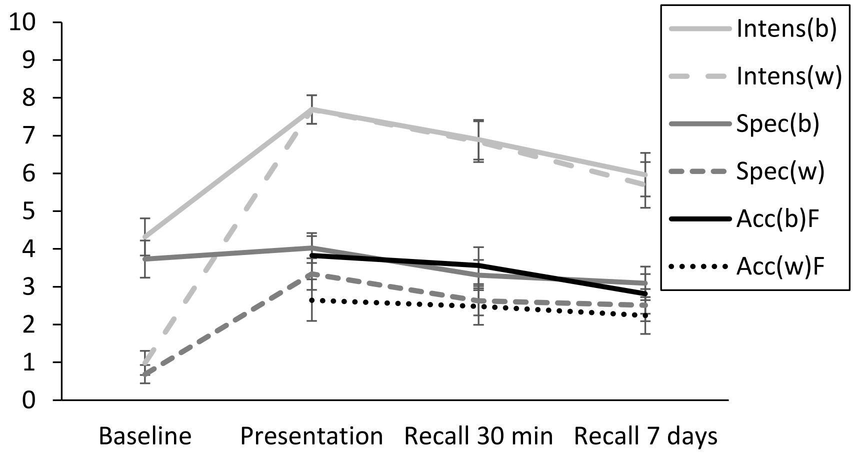

Figure 68. Affective intensity, specificity and accuracy after the presentation and recall of the *endings* of the *fear* stories.

The affective intensity 2x4 repeated-measures ANOVA reported a main effect of *Time* (F(2.32,71.86)=39.18, p<.001, η_p^2=.558; degrees of freedom correction: Greenhouse-Geisser),

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a significant interaction (F(5.92,183.41)=37.32, p<.001, η_p^2=.546). Degrees of freedom for *Time* and the *Time*Emotion* interaction were corrected using the Greenhouse-Geisser estimate.

The follow-up analysis indicated that the interaction was best described (F(1,31)=87.72, p<.001, η_p^2=.739) by the quadratic contrast of *Time* (F(1,31)=49.37, p<.001, η_p^2=.614) when emotion ratings increased from Baseline to Presentation and Recall 30 minutes, only to drop back after seven days), and the quadratic contrast of *Emotion* (F(1,31)=62.27, p<.001, η_p^2=.668). The main effect of *Emotion* showed that *fear* and to a lesser extend *sadness*, were overall more intensely experienced than *anger* and *happiness*.

a main effect of *Intensity* (F(1,31)=35.19, p<.001, η_p^2=.532), and a significant *Time*Intensity* interaction (F(1,31)=36.19, p<.001, η_p^2=.539; degrees of freedom correction: lower-bound). The main effect of *Time* best fitted a quadratic contrast (F(1,31)=103.31, p<.001, η_p^2=.769), caused by an increase in the intensity of emotions from Baseline to Presentation, and subsequent decrease at Recall after 30 minutes, and Recall after 7 days. The effect of *Intensity* as well as the *Time*Intensity* interaction were driven by the difference between the intensity between positive and negative emotions and the intensity within negative emotion at Baseline.

The analysis of the specificity indices (2x4 repeated-measures ANOVA) produced a marginal main effect of *Time* (F(3,93)=3.01, p=.034, η_p^2=.088), an effect of *Specificity* (F(1,31)=56.37, p<.001, η_p^2=.645), and a significant *Time*Specificity* interaction (F(1,31)=15.92, p<.001, η_p^2=.339; degrees of freedom corrected using the lower-bound estimate).

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The *Time*Specificity* interaction and the small effect of *Time* was best described by a quadratic contrast ($F(1,31)=6.10$, $p=.019$, $\eta_p^2=.164$), driven by the reduced specificity within negative emotions specificity at Baseline. Furthermore, the specificity between positive and negative emotions was significantly higher than the specificity within negative emotions ($F(1,31)=56.37$, $p<.001$, $\eta_p^2=.645$).

The 2x3 repeated-measures ANOVA for the affective accuracy indices reported a main effect of *Accuracy* ($F(1,31)=61.48$, $p<.001$, $\eta_p^2=.665$) and a significant *Time*Accuracy* interaction ($F(1,31)=6.45$, $p=.016$, $\eta_p^2=.172$; degrees of freedom corrected using the lower-bound estimate). The interaction was caused by the stronger decrease of the accuracy between positive and negative emotions at Recall after 7 days. In turn, this was caused by the unexpected increase in *happiness* ratings after the last recall procedure. Nonetheless, the accuracy between positive and negative emotions was always higher than the accuracy within negative emotions ($F(1,31)=61.48$, $p<.001$, $\eta_p^2=.665$).

4.4.1.2.3 The affective experience after the presentation and recall of the endings of the sadness stories

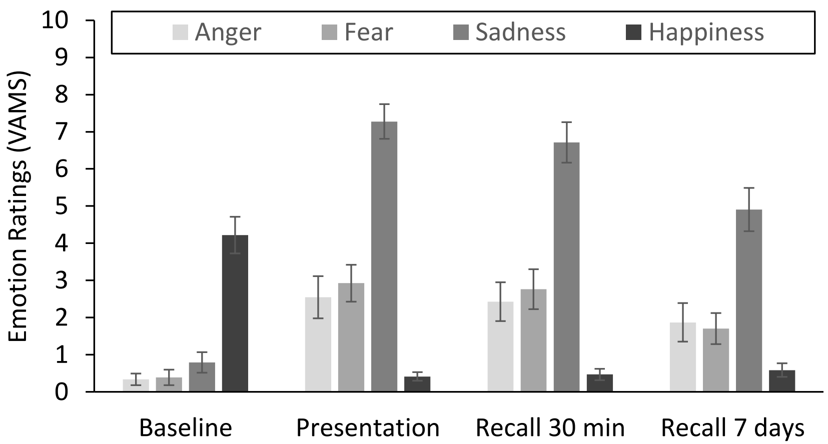

Figure 69. Emotion ratings after the *endings* of the sadness stories

The global 4x4 repeated-measures ANOVA produced a significant main effect of *Time* ($F(3,93)=24.95$, $p<.001$, $\eta_p^2=.446$), *Emotion* ($F(3,93)=41.74$, $p<.001$, $\eta_p^2=.574$), and

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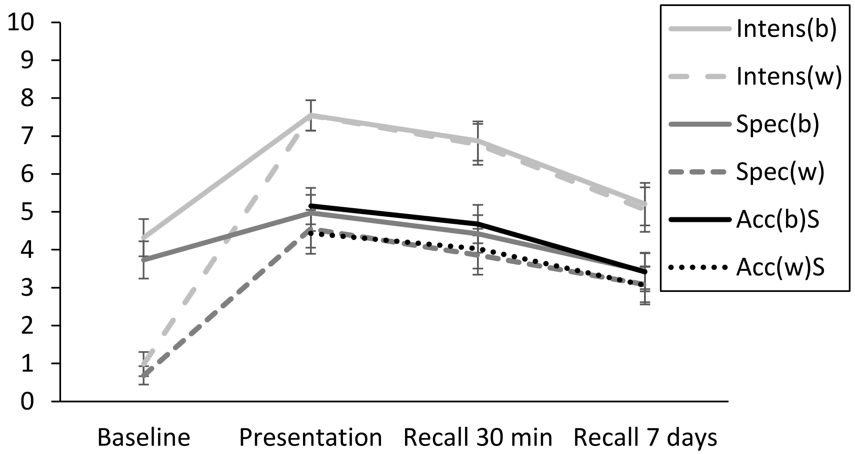

Figure 70. Affective intensity, specificity and accuracy after the presentation and recall of the *endings* of the sadness stories.

The 2x4 repeated-measures ANOVA of the affective intensity scores reported a main effect of *Time* ($F(2.54,78.58)=41.75$, $p<.001$, $\eta_p^2=.574$; degrees of freedom correction:

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a significant interaction (F(1,31)=39.58, p <.001, η_p^2=.561). Degrees of freedom for the *Time*Emotion* interaction were corrected using the lower bound estimate to correct for violation of sphericity.

The planned-contrasts follow-up analysis indicated that the interaction was best described (F(1,31)=91.48, p<.001, η_p^2=.747) by the quadratic contrast of *Time* (F(1,31)=46.86, p<.001, η_p^2=.602) when emotion ratings increased from Baseline to Presentation and Recall 30 minutes, only to drop back after seven days), and the quadratic contrast of *Emotion* (F(1,31)=53.18, p<.001, η_p^2=.632). The main effect of *Emotion* indicated that *sadness* and was overall more intensely experienced than *anger*, *fear* and *happiness*.

Greenhouse-Geisser), an effect of *Intensity* (F(1,31)=40.95, p<.001, η_p^2=.596), and a significant interaction (F(1,31)=37.08, p<.001, η_p^2=.545; degrees of freedom corrected using the lower-bound estimate). The interaction and the effect of *Intensity* were caused by the reduced intensity within negative emotions at Baseline. Notably, the effect of *Time* best fitted a quadratic contrast (F(1,31)=85.67, p<.001, η_p^2=.734), which indicated that, similarly with the emotion elicitation of *anger* and *fear* presented earlier, the affective intensity associated with the *sadness* stories increased from Baseline to Presentation, and then gradually decreased over time after 30 minutes and one week.

The analysis of the specificity indices (2x4 repeated-measures ANOVA) reported an effect of *Time* (F(2.57,79.53)=10.44, p<.001, η_p^2=.252; degrees of freedom correction: Huynh-Feldt), an effect of *Specificity* (F(1,31)=44.17, p<.001, η_p^2=.588), and a significant *Time*Specificity* interaction (F(1,31)=19.88, p<.001, η_p^2=.391; degrees of freedom corrected using the lower-bound estimate). The interaction and the effect of

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Specificity were caused by the reduced specificity within negative emotions at Baseline (when all negative emotions were at floor level). The main effect of *Time* best fitted a quadratic contrast ($F(1,31)=16.95$, $p<.001$, $\eta_p^2=.354$), which indicated that the affective specificity slightly increased from Baseline to Presentation, and then decreased over time after 30 minutes and seven days. Thus, as the affective re-experience became less intense at Recall 30 minutes and Recall 7 days, the differentiation between discrete emotions (affective specificity) also decreased.

The analysis of the affective accuracy (2x3 repeated-measures ANOVA) reported an effect of *Time* ($F(2,62)=6.27$, $p=.003$, $\eta_p^2=.168$), an effect of *Accuracy* ($F(1,31)=23.03$, $p<.001$, $\eta_p^2=.426$) and a significant *Time*Accuracy* interaction ($F(1,31)=6.82$, $p=.016$, $\eta_p^2=.180$; degrees of freedom corrected using the lower-bound estimate). As in the case of the other two negative emotions, the interaction was driven by the stronger decrease of the accuracy between positive and negative emotions at Recall after 7 days, which was caused by the increase in *happiness* ratings after one week. The accuracy between positive and negative emotions was higher than the accuracy within negative emotions ($F(1,31)=23.03$, $p<.001$, $\eta_p^2=.426$). The main effect of *Time* was best fitted by a linear contrast ($F(1,31)=9.38$, $p=.005$, $\eta_p^2=.232$), which confirmed that affective accuracy, just as specificity before decreased over time with the decrease in affective intensity.

4.4.1.2.4 The affective experience after the presentation and recall of the *<u>endings</u>* *of the* *<u>happiness</u>* *stories*

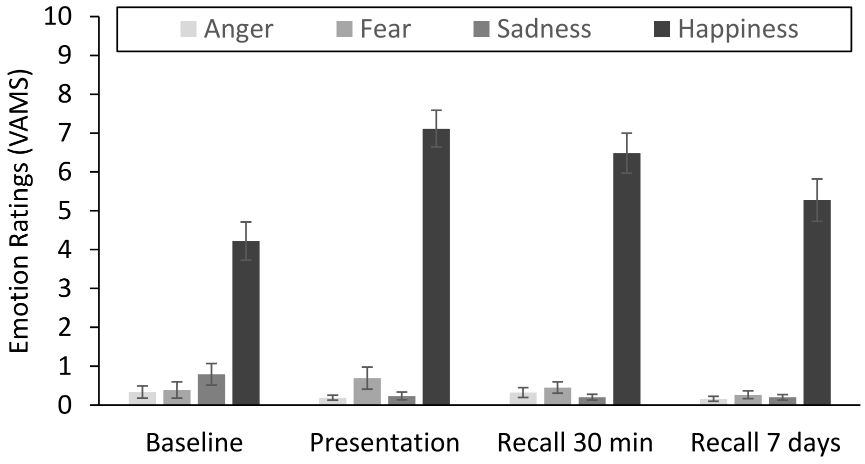

Figure 71. Emotion ratings after the *endings* of the *happiness* stories

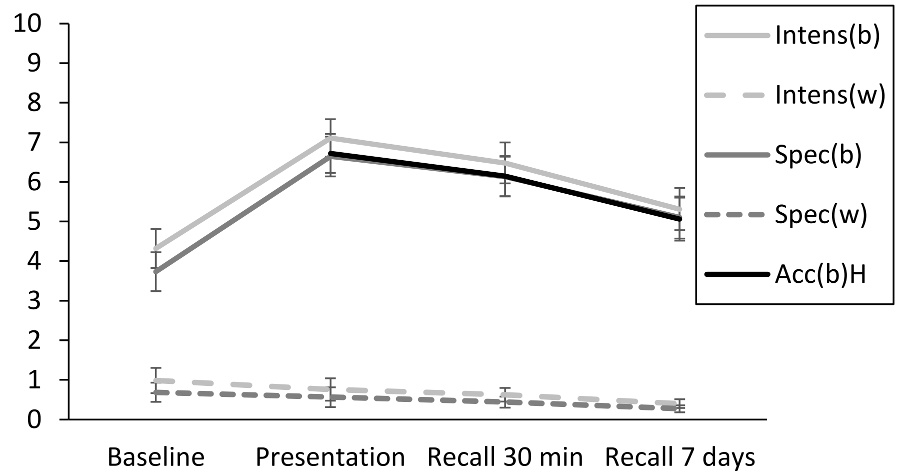

Figure 72. Affective intensity, specificity and accuracy after the presentation and recall of the *endings* of the *happiness* stories.

An overall repeated-measures 4x4 ANOVA reported a significant main effect of *Time* ($F(3,93)=9.38$, $p<.001$, $\eta_p^2=.232$), emotion ($F(1,31)=160.44$, $p<.001$, $\eta_p^2=.838$), and

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The analysis of the affective intensity (2x4 repeated-measures ANOVA) reported a main effect of *Time* ($F(3,93)=10.80$, $p<.001$, $\eta_p^2=.258$), an effect of *Intensity* ($F(1,31)=166.90$, $p<.001$,

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a significant interaction (F(1,31)=11.80, p=.002, η_p^2=.276). Degrees of freedom for Emotion the *Time*Emotion* interaction were corrected using the lower bound estimate.

The planned-contrasts follow-up analysis indicated that the interaction was driven (F(1,31)=21.71, p<.001, η_p^2=.412) by the quadratic contrast of *Time* (F(1,31)=22.82, p<.001, η_p^2=.424) when emotion ratings increased from Baseline to Presentation and Recall 30 minutes, only to drop back after seven days, and the cubic contrast of *Emotion* (F(1,31)=86.81, p<.001, η_p^2=.737). The main effect of *Emotion* indicated that *happiness* and was massively dominant over all other negative emotions.

η_p^2=.843), and a significant interaction (F(3,93)=11.03, p<.001, η_p^2=.262). The follow-up analysis indicated that the interaction was driven (F(1,31)=16.24, p<.001, η_p^2=.344) by the increase in the Intensity between positive and negative emotions from Baseline to Presentation and receded at Recall 30 minutes and after seven days, and the flat evolution of the intensity within negative emotions. The effect of *Time* best fitted a quadratic contrast (F(1,31)=23.73, p<.001, η_p^2=.434), and the intensity between positive and negative emotions was substantially higher than the intensity within negative emotions (F(1,31)=166.90, p<.001, η_p^2=.843).

The analysis of the affective specificity produced similar results with the intensity and accuracy indices as the affective experience was mostly described by a single emotion (i.e., *happiness*), and thus, there was little variation between the three indices. For the benefit of consistency, the results are briefly presented below. The 2x4 repeated-measures ANOVA of specificity indices reported a main effect of *Time* (F(3,93)=13.83, p<.001, η_p^2=.309), an effect of *Intensity* (F(1,31)=150.68, p<.001, η_p^2=.829),

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and a significant interaction ($F(1,31)=8.72$, $p<.001$, $\eta_p^2=.219$).

The analysis of the affective accuracy (one-way repeated-measures ANOVA) reported an effect of *Time* ($F(2,62)=6.88$, $p=.002$, $\eta_p^2=.182$), which best fitted a linear contrast ($F(1,31)=11.12$, $p=.002$, $\eta_p^2=.264$), indicating that the accuracy of the affective experience decreased over time from Presentation to Recall after 7 days mostly as a result of the decrease in the intensity of the target emotion (i.e., *happiness*).

4.4.1.2.5 The affective experience after the presentation of the stems of the anger stories

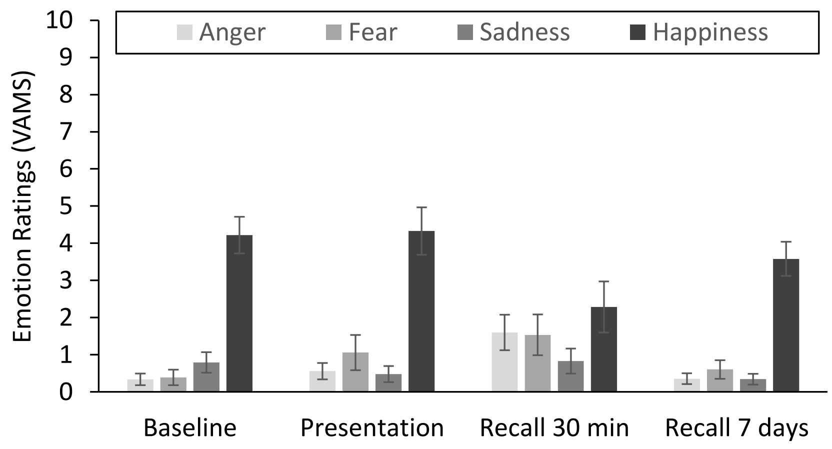

Figure 73. Emotion ratings after the *stems* of the anger stories

An overall repeated-measures 4x4 ANOVA reported a single significant main effect of *Emotion* ($F(1,16)=20.66$, $p<.001$, $\eta_p^2=.564$), degrees of freedom corrected using the lower

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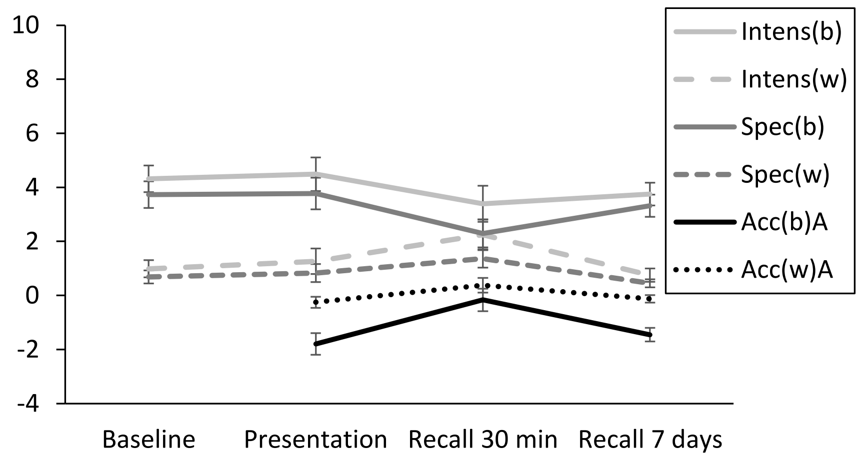

Figure 74. Affective intensity, specificity and accuracy after the presentation and recall of the *stems* of the anger stories.

The analysis of the affective intensity indices (2x4 repeated-measures ANOVA) reported a main effect of *Intensity* ($F(1,16)=27.24$, $p<.001$, $\eta_p^2=.630$), and a significant

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bound estimate. Surprisingly, there was no main effect of *Time*, and the *Time*Emotion* interaction failed to reach significance after correcting the degrees of freedom (F(1,16)=4.22, p=.057, η_p^2=.209). The follow-up analysis indicated that *happiness* was overall significantly more intensely experienced after the anger story *stems* than *anger* (F(1,16)=21.68, p<.001, η_p^2=.575), *fear* (F(1,16)=21.91, p<.001, η_p^2=.578), or *sadness* (F(1,16)=29.90, p<.001, η_p^2=.651). Notably, 15 participants failed to provide emotion ratings during the Presentation and Recall 30 minutes phases, and two participants did not provide emotion data a week later (Recall after 7 days).

*Time*Intensity* interaction *(*F(3,48)=3.32*,* p=.028*,* η_p^2=.172*).* The main effect of Intensity, in line with the previous analyses of affective intensity indices (see sections 4.4.1.2.1 to 4.4.1.2.4; also see Chapter 3), confirmed that the intensity between positive and negative emotions was higher than the intensity within negative emotions. Notably, the *Time*Intensity* interaction was caused by the increase of the intensity within negative emotions at Recall 30 minutes (t(16)= 2.55, p=.021), while the intensity between positive and negative emotions remained largely the same, even showing a negative trend (t(16)=-1.98, p=.066). The finding should be interpreted in the context of Chapter 2 (where the same data are analysed after a different transformation: change from Baseline) and indicate that as participants listen again to the semantically neutral beginning of the *anger* stories they re-experience the negative affect associated with the ending of the story (mostly represented by the *anger* ratings). However, as confirmed by the subsequent reduction of the intensity within negative emotions, (t(16)=-2.75, p=.014), the selective re-experience of the discrete emotions after the presentation of the

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anger story *stems* is no longer reproduced after seven days.

The analysis of the affective specificity (2x4 repeated-measures ANOVA) reported a single main effect of *Specificity* (F(1,16)=20.61, p<.001, η_p^2=.563), and no overall effect of *Time* or a significant interaction. The analysis of the affective accuracy (2x3 repeated-measures ANOVA) reported a single main effect of *Time* (F(2,32)=5.21, p=.011, η_p^2=.245), an effect of *Accuracy* (F(1,16)=17.52, p=.001, η_p^2=.523), and a significant *Time*Accuracy* interaction (F(2,32)=5.55, p=.009, η_p^2=.257). Most notably, the effect of *Time* was best fitted by a quadratic contrast (F(1,16)=6.71, p=.020, η_p^2=.295), which indicated that both affective accuracy indices showed a slight increase at Recall after 30 minutes. This finding put in the context of the analysis of the intensity indices and of Chapter 2 confirms that when participants first re-listened to the story *stems* of the *anger* stories after 30 minutes, they re-experienced more of the target emotion (*anger*) than at any time during the study – because at

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Presentation participants were not yet aware of the emotional ending of the story, and at Recall after 7 days, the *stem* was no longer sufficient to elicit the discrete emotion associated with the story ending.

It is worth noting at this stage that the affective accuracy indices were significantly affected by the high ratings of *happiness* at all time-points. Since *anger* was chosen as the target emotion the high ratings of *happiness* meant that for the first time the affective accuracy indices took negative values. This is an expected scenario when the intended emotion (i.e., target emotion) is not the most intensely experienced discrete emotion. Although the current analysis is exploratory and not strictly hypothesis driven, the accuracy indices are presented from the perspective of Chapter 2, where these data are first presented, and where it was expected that the emotionally neutral story *stems* would begin to elicit the discrete emotion associated with their respective *endings*, as participants become familiar with the story (i.e., at Recall 30 minutes and Recall 7 days). An alternative

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approach would be to consider that the semantically neutral *stems* should remain emotionally neutral over time (and hence the target emotion could be *happiness*, instead of *anger*), and the value and interpretation of the affective accuracy indices would change accordingly. This argument is further developed in the Discussion section below.

4.4.1.2.6 The affective experience after the presentation of the stems of the fear stories

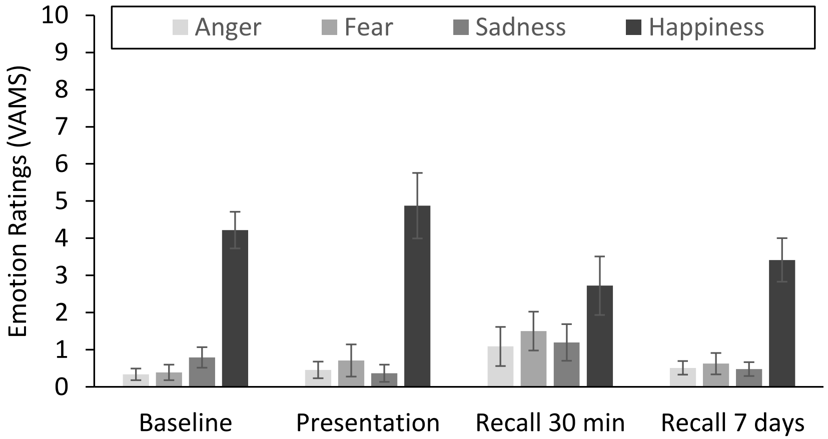

Figure 75. Emotion ratings after the *stems* of the *fear* stories

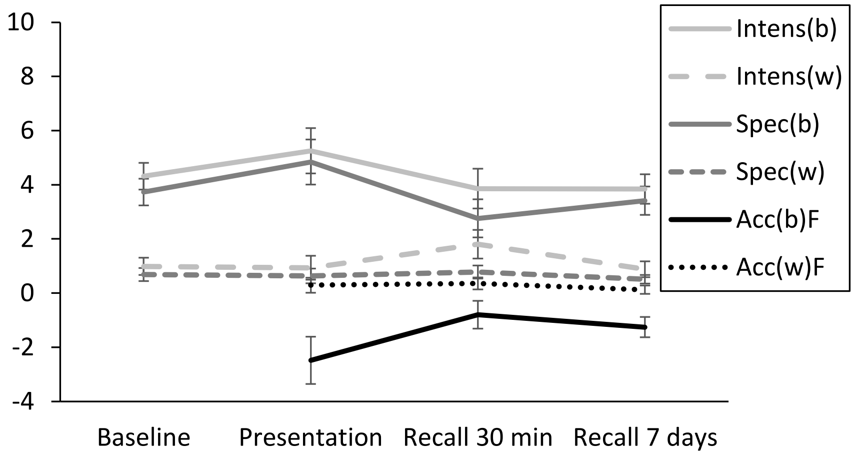

Figure 76. Affective intensity, specificity and accuracy after the presentation and recall of the *stems* of the *fear* stories.

The global 4x4 repeated-measures ANOVA reported only a significant main effect of *Emotion* ($F(1,16)=13.87$, $p=.002$, $\eta_p^2=.464$), degrees of freedom corrected using the lower bound

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The analysis of affective intensity (2x4 repeated-measures ANOVA) reported a main effect of *Intensity* ($F(1,16)=19.55$, $p<.001$, $\eta_p^2=.550$), and a significant *Time*Intensity* interaction

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estimate. As for the *stems* of the anger stories, there was no main effect of *Time*, and the *Time*Emotion* interaction was not significant after correcting the degree of freedom ($F(1,16)=3.67$, $p=.074$, $\eta_p^2=.187$). The follow-up planned contrasts showed that *happiness* remained significantly more intensely experienced after the *fear* story *stems* than any of the negative emotions: *anger* ($F(1,16)=15.80$, $p<.001$, $\eta_p^2=.497$), *fear* ($F(1,16)=12.42$, $p=.003$, $\eta_p^2=.437$), and *sadness* ($F(1,16)=14.85$, $p<.001$, $\eta_p^2=.481$). As for the *anger* stories, 15 participants did not provide emotion ratings after the story *stems* during the Presentation and Recall 30 minutes phases, and two participants a week later (Recall after 7 days).

($F(3,48)=3.27$, $p=.029$, $\eta_p^2=.169$). As in the case of the *stems* of the *anger* stories (see section 4.4.1.2.5) the interaction was driven by the increase in the intensity within negative emotions at Recall 30 minutes ($t(16)=2.09$, $p=.053$), while the intensity between positive and negative emotions had an overall downward trend ($t(16)=-1.83$, $p=.087$), although neither contrast reached significance.

The 2x4 repeated-measures ANOVA employed to analyse the affective specificity indices reported a main effect of *Specificity* ($F(1,16)=17.78$, $p=.001$, $\eta_p^2=.526$), and a significant interaction ($F(3,48)=3.04$, $p=.038$, $\eta_p^2=.160$). As reflected earlier by the analysis of the intensity indices, the interaction was driven by the increase of the specificity within negative emotions at Recall 30 minutes and the reduction of the specificity between positive and negative emotions at the same time point.

The analysis of the affective accuracy (2x3 repeated-measures ANOVA) reported a main effect of *Accuracy* ($F(1,16)=10.60$, $p=.005$, $\eta_p^2=.399$), and a *Time*Accuracy*

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interaction ($F(2,32)=3.71$, $p=.036$, $\eta_p^2=.188$). The interaction was driven by an increase of the accuracy between positive and negative emotions from Presentation to Recall after 30 minutes ($t(16)= 2.07$, $p=.055$), which failed to reach significance (unlike in the case of the *anger* stories – see section 4.4.1.2.5 above).

4.4.1.2.7 The affective experience after the presentation of the stems of the sadness stories

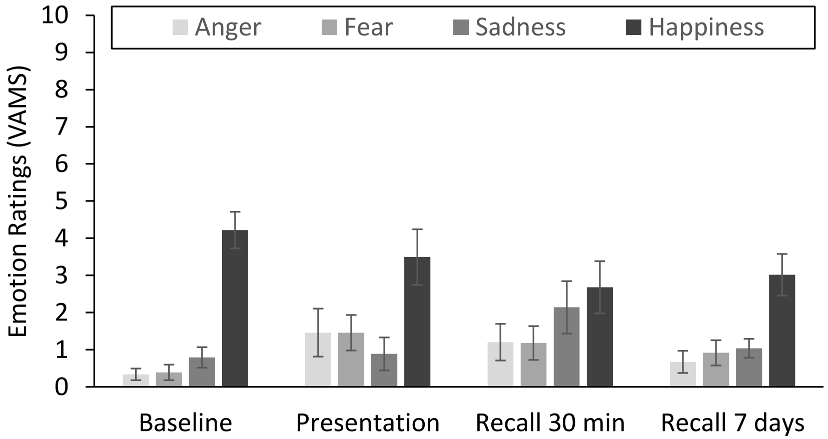

Figure 77. Emotion ratings after the *stems* of the sadness stories

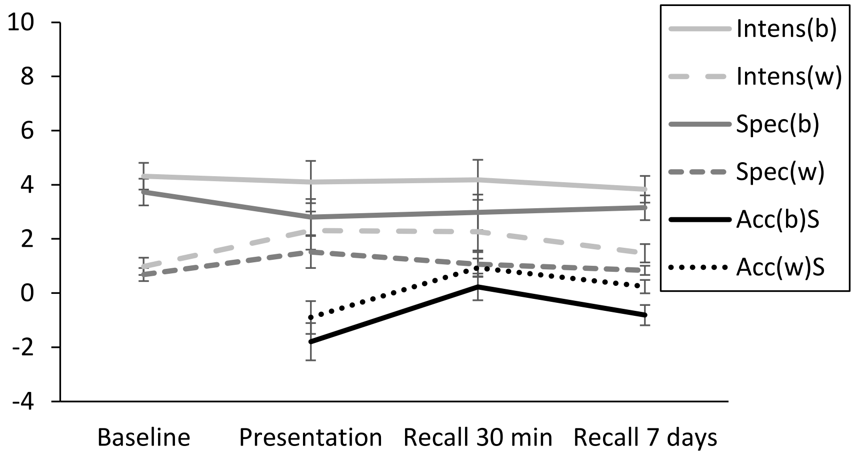

Figure 78. Affective intensity, specificity and accuracy after the presentation and recall of the *stems* of the sadness stories.

The global 4x4 repeated-measures ANOVA reported a single significant main effect of *Emotion* ($F(1,16)=10.38$, $p=.005$, $\eta_p^2=.394$), degrees of freedom corrected using the lower

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The analysis of the affective intensity after the *stems* of the sadness stories (2x4 repeated-measures ANOVA) found only a main effect of *Intensity* ($F(1,16)=18.68$, $p=.001$, $\eta_p^2=.539$).

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bound estimate. There was no main effect of *Time*, and no *Time*Emotion* interaction. The follow-up planned contrasts showed that *happiness* remained significantly more intensely experienced after the *sadness* story *stems* than any of the negative emotions: *anger* (F(1,16)=14.84, p=.001, η_p^2=.481), *fear* (F(1,16)=11.59, p=.004, η_p^2=.420), and *sadness* (F(1,16)=9.43, p=.007, η_p^2=.371). Fifteen participants failed to provide emotion ratings after the story *stems* during the Presentation and Recall 30 minutes phases, and two participants a week later (Recall after 7 days).

The intensity between positive and negative emotions was significantly higher than the intensity within negative emotions.

The analysis of the specificity indices (2x4 repeated-measures ANOVA) revealed a single main effect of *Specificity* (F(1,16)=16.39, p=.001, η_p^2=.506), indicating that the Specificity between positive and negative emotions (mainly driven by the higher ratings of *happiness*) was significantly higher than the specificity within negative emotions.

The analysis of the accuracy indices (2x3 repeated-measures ANOVA) reported a main effect of *Time* (F(2,32)=4.77, p=.015, η_p^2=.230), and an effect of *Accuracy* (F(1,16)=9.37, p=.007, η_p^2=.369). The most notable findings is the effect of *Time*, which was best fitted by a quadratic contrast (F(1,16)=8.72, p=.009, η_p^2=.353), and indicates that both the accuracy between positive and negative emotions and the accuracy within negative emotions increased at Recall after 30 minutes (t(16)=2.64, p=.018, and t(16)=2.57, p=.021 respectively). The finding corresponds to the substantial increase from Baseline in

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the discrete target emotion (*sadness*) after the presentation of the story *stems* of the *sadness* stories, effect which was recorded only at the Recall after 30 minutes time-point, and not after one week (see Chapter 2).

4.4.1.2.8 The affective experience after the presentation of the stems of the happiness stories

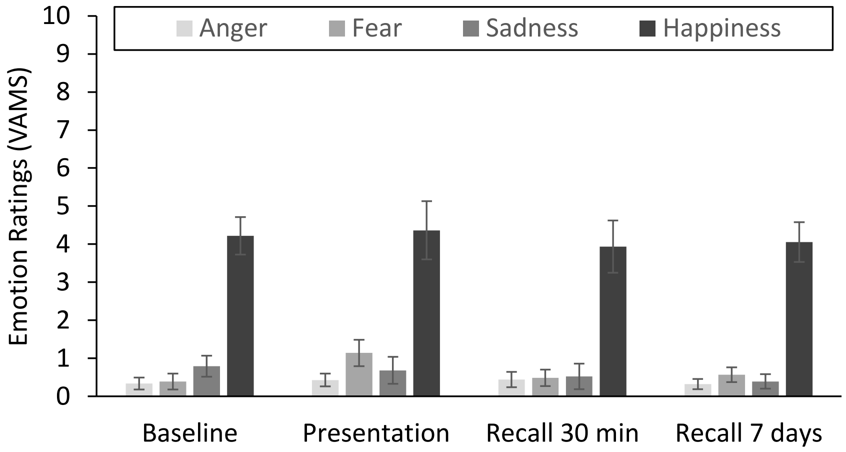

Figure 79. Emotion ratings after the *stems* of the *happiness* stories

An overall repeated-measures 4x4 ANOVA found a single significant main effect of *Emotion* ($F(1,16)=25.61$, $p<.001$, $\eta_p^2=.615$), degrees of freedom corrected using the lower bound

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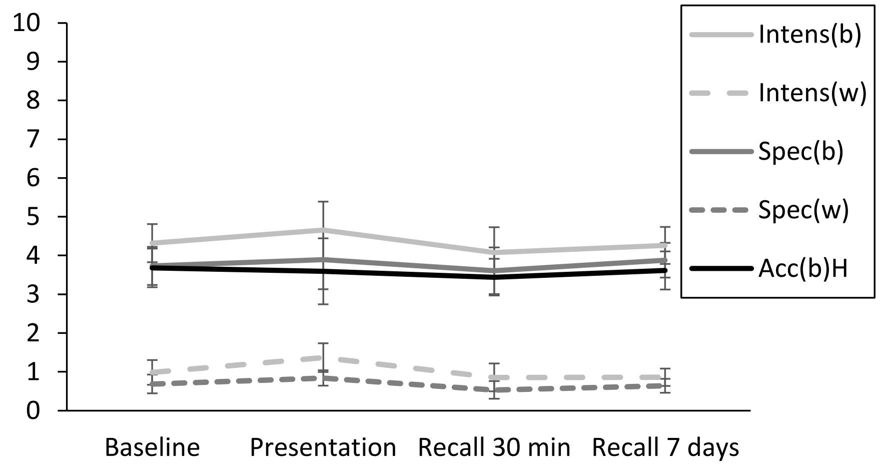

Figure 80. Affective intensity, specificity and accuracy after the presentation and recall of the *stems* of the *happiness* stories.

The analysis of the affective intensity after the *stems* of the sadness stories (2x4 repeated-measures ANOVA) found a single main effect of *Intensity* ($F(1,16)=24.84$, $p<.001$, $\eta_p^2=.608$).

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estimate. There was no main effect of *Time*, and no *Time*Emotion* interaction. The follow-up planned contrasts revealed that *happiness* ratings were significantly higher after the *happiness* story *stems* than any of the ratings for the negative emotions: *anger* ($F(1,16)=31.41$, $p<.001$, $\eta_p^2=.663$), *fear* ($F(1,16)=25.40$, $p<.001$, $\eta_p^2=.613$), and *sadness* ($F(1,16)=27.58$, $p<.001$, $\eta_p^2=.633$). Fifteen participants failed to provide emotion ratings after the story *stems* during the Presentation and Recall 30 minutes phases, and two participants a week later (Recall after 7 days). The intensity between positive and negative emotions was significantly higher than the intensity within negative emotions, which is expected as *happiness* the target emotion.

Similarly with the intensity indices, the analysis of the specificity indices (2x4 repeated-measures ANOVA) reported a single main effect of *Specificity* ($F(1,16)=20.44$, $p<.001$, $\eta_p^2=.561$), revealing that the Specificity between positive and negative emotions was significantly higher than the specificity within negative emotions.

Lastly, the analysis of the accuracy index (one-way repeated-measures ANOVA) reported failed to report a main effect of *Time* ($F(2,32)=.31$, $p=.734$, $\eta_p^2=.019$). The accuracy between positive and negative emotions did not change over the course of one week, since the Baseline levels of *happiness* remained largely the same, and all the negative emotions were at floor levels.

4.4.2 Sample 2: Neurologically normal elderly participants

The data presented in this section was also included in Chapter 3, as the neurologically normal control participants. The complete details regarding sample characteristics, measures and stimuli used, the design and procedure of the data collection, as well as the neuropsychological assessments of the neurologically unimpaired elderly participants have already been presented in Chapter 3, and will not be repeated below.

4.4.2.1 Data Analysis

The ratings of *anger*, *fear*, *sadness*, and *happiness* are analysed in a global 4x4 repeated-measures ANOVA, with the two factors being *Emotion* and *Time* (Baseline, Repetitions 1-3, Immediate Recall and Recall after 30 minutes). The significant interactions and main effects are explored further using planned contrasts and pair-wise comparisons.

Similarly with section 4.4.1.1 above, the affective intensity, specificity and accuracy scores are presented together, but analysed separately. Firstly, the intensity between positive and negative emotions and the intensity within negative emotions are subjected to a repeated-measures 2x6 ANOVA, with the significant interaction and main effects being followed-up with planned contrasts. Secondly, the indices of specificity between positive and negative emotions and the specificity within negative emotions are analysed together in a similar 2x6 repeated-measures ANOVA. And thirdly, the accuracy between positive and negative emotions and the accuracy within negative emotions are analysed using a similar 2x5 repeated-measures ANOVA. The analysis of the accuracy indices omits the Baseline time-point, because the target emotion only refers to the emotion induction tasks of presentation and recall.

4.4.2.2 Results

The Results section presents the traditional analysis of the emotion ratings (on the left side of the page) and the analysis of the novel summary indices of affective intensity, specificity and accuracy (on the right side). Although the emotion ratings data represent a repeated measures design, the figures (shown on the left side of the page throughout this section) use a bar chart for the benefit of visual clarity. The expected/target emotion at Baseline was *happiness*. Therefore, the accuracy within negative emotions is not calculated at Baseline in any of the sub-sections below. Furthermore, for the same reason, the accuracy within negative emotions is cannot be calculated for the *happiness* story (see section 4.4.4 below, figures on the right side).

The time-points presented in both figures use the following abbreviations:

Base – Baseline measure of emotions;

Rep 1 – the first repetition of the emotional story (recalled after presentation);

Rep 2 – the second repetition of the emotional story (recalled after presentation);

Rep 3 – the third repetition of the emotional story (recalled after presentation);

ImmUR – Immediate Unaided Recall (recall after the distraction story without a prior presentation of the emotional story);

30mUR – 30 minutes Unaided Recall (recall after 30 minutes without a prior presentation of the story);

The intensity, specificity, and accuracy indices are shown in figures on the right side using the same abbreviations as above:

Intens(b) – the intensity between positive and negative emotions;

Intens(w) – the intensity within negative emotions;

Spec(b) – the specificity between positive and negative emotions;

Spec(w) – the specificity within positive and negative emotions;

Acc(b) – the accuracy between positive and negative emotions;

Acc(w)A – the accuracy within negative emotions, when *anger* is the target/expected emotion;

Acc(w)F – the accuracy within negative emotions, when *fear* is the target/expected emotion;

Acc(w)S – the accuracy within negative emotions, when *sadness* is the target/expected emotion;

Acc(w)H – the accuracy within negative emotions, when *happiness* is the target/expected emotion.

4.4.2.2.1 The affective experience after the recall of the anger stories

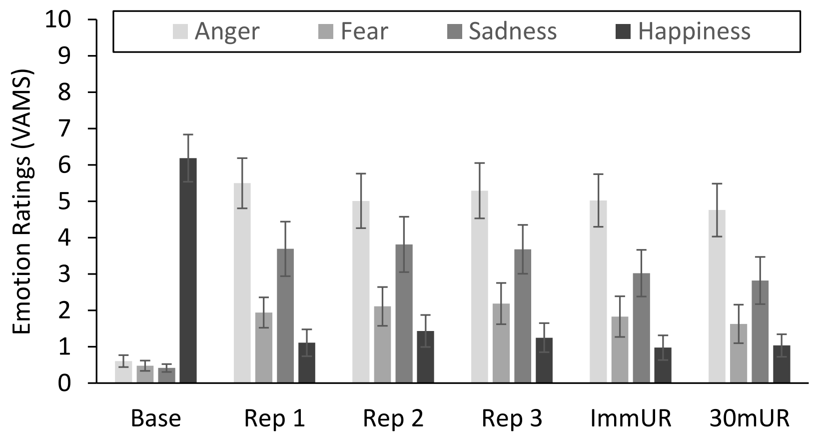

Figure 81. Emotion ratings after the recall of anger stories

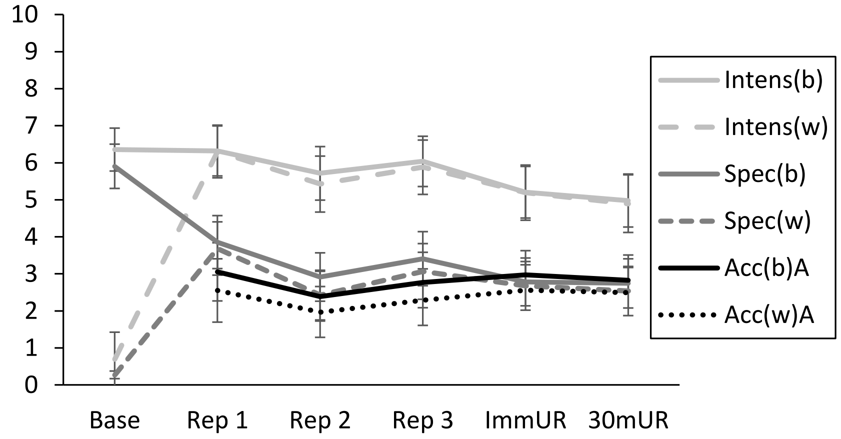

Figure 82. Affective intensity, specificity and accuracy after the recall of anger stories

An overall repeated-measures 4x6 ANOVA reported a significant main effect of *Emotion* (F(2.42,43.55)=9.70, p<.001, η_p^2=.352), and a significant *Time*Emotion* interaction (F(1,19)=23.26, p<.001, η_p^2=.564). Degrees of freedom were

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The 2x6 repeated-measures ANOVA for the affective intensity scores produced a main effect of *Time* (F(3.90,74.17)=6.47, p<.001, η_p^2=.241; degrees of freedom corrected using the Huynh-Feldt estimate), a main effect of *Intensity* (F(1,19)=112.06, p<.001, η_p^2=.855), and a

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applied the Huynh-Feldt, and lower-bound corrections respectively.

The planned-contrasts revealed that the complex interaction was driven by the decrease in the *happiness* ratings from Baseline (F(1,19)=33.61, p<.001, η_p^2=.651; lower-bound correction of degrees of freedom) and the corresponding increase in negative emotions, most strongly, *anger* (F(3.55,63.94)=16.70, p=.001, η_p^2=.481). The main effect of *Emotion* indicated that the target emotion *anger* and was significantly more intensely experienced than *fear*, *sadness*, and *happiness*.

significant *Time*Intensity* interaction (F(1,19)=55.78, p<.001, η_p^2=.746; degrees of freedom corrected using the lower-bound estimate). The main effect of *Time* best fitted a quadratic contrast (F(1,19)=10.90, p=.001, η^2=.365), explained by an increase in the intensity of emotions from Baseline to Repetitions 1-3 and subsequent decrease for Immediate Unaided Recall and the delayed unaided recall after 30 minutes. The interaction was driven by the substantial difference in the intensity between positive and negative emotions, and the intensity within negative emotions at Baseline (t(19)=8.57, p<.001)

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported that overall, the specificity indices did not vary over time (no effect of *Time*), except at Baseline, as indicated by the significant *Time*Specificity* interaction, (F(1,19)=52.20, p<.001, η_p^2=.733). The substantial difference at Baseline (t(19)=8.61, p<.001) also explained the effect of *Specificity* (F(1,19)=67.95, p<.001, η_p^2=.781).

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The analysis of the accuracy indices (2x5 repeated-measures ANOVA) reported a single main effect of *Accuracy* ($F(1,19)=5.00$, $p=.038$, $\eta_p^2=.208$), explained by the relatively higher values of the accuracy between positive and negative emotions. Notably, the accuracy indices did not vary over time (no effect of *Time*).

4.4.2.2.2 The affective experience after the recall of the fear stories

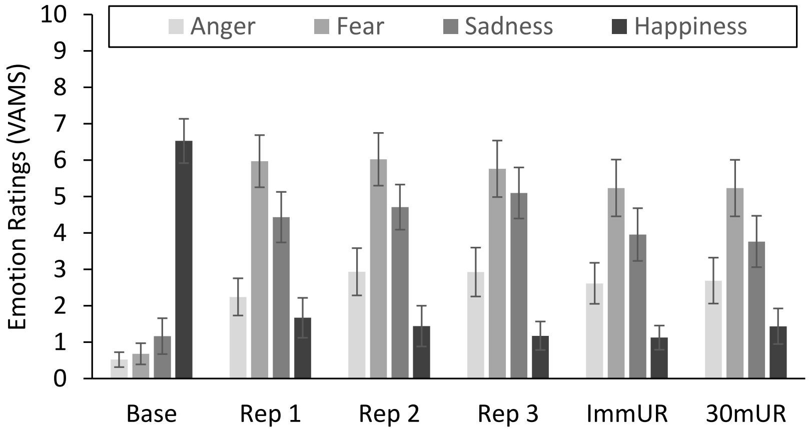

Figure 83. Emotion ratings after the recall of *fear* stories

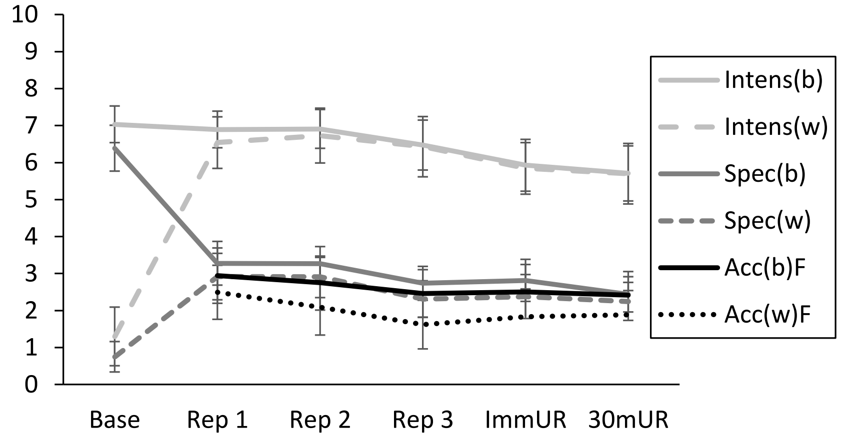

Figure 84. Affective intensity, specificity and accuracy after the recall of *fear* stories

The general repeated-measures 4x6 ANOVA reported a significant main effect of *Emotion* ($F(3,57)=8.83$, $p<.001$, $\eta_p^2=.317$), and a significant *Time*Emotion* interaction ($F(1,19)=21.98$, $p<.001$, $\eta_p^2=.536$; degrees of freedom corrected

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The 2x6 repeated-measures ANOVA for the affective intensity scores reported an effect of *Time* ($F(1,19)=5.94$, $p=.025$, $\eta_p^2=.238$; degrees of freedom corrected using the lower-bound estimate), a main effect of *Intensity* ($F(1,19) =$

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using the lower-bound estimate.

Similarly with section 4.4.2.2.1, the planned-contrasts revealed a complex interaction. A significant effect was reported for the decrease of the *happiness* ratings from Baseline (F(1,19)=33.01, p<.001, η_p^2=.635; lower-bound correction of degrees of freedom) and the corresponding increase in negative emotions, most strongly, *fear* (F(3.53,67.22)=20.22, p<.001, η_p^2=.516; Huynh-Feldt correction of degrees of freedom). The main effect of *Emotion* indicated that the target emotion *fear* and was significantly more intensely experienced than *anger*, *sadness*, and *happiness*.

95.02, p<.001, η_p^2=.833), and a significant *Time*Intensity* interaction (F(5,95)=55.78, p<.001, η_p^2=.685). The main effect of *Time* best fitted a quadratic contrast (F(1,19)=22.19, p<.001, η_p^2=.539), explained by an increase in the intensity of emotions from Baseline to Repetitions 1-3 and subsequent decrease for Immediate Unaided Recall and the delayed unaided recall after 30 minutes. The interaction was driven by the substantial difference in the intensity between positive and negative emotions, and the intensity within negative emotions at Baseline (t(19)=7.71, p<.001)

Similarly with section 4.4.2.2.1, the 2x6 repeated-measures ANOVA used to analyse the specificity indices reported that overall, the specificity indices did not vary over time (no effect of *Time*), except at Baseline, as indicated by the significant *Time*Specificity* interaction, (F(1,19)=28.22, p<.001, η_p^2=.598; degrees of freedom corrected using the lower-bound estimate). The interaction was cause by the difference between the specificity between positive and negative emotions

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and the specificity within negative emotions at Baseline ($t(19)=7.37$, $p<.001$), which also explained the effect of *Specificity* ($F(1,19)=56.77$, $p<.001$, $\eta_p^2=.749$).

The analysis of the accuracy indices (2x5 repeated-measures ANOVA) failed to reach significance, confirming that there was no difference between the two accuracy indices, and also that the accuracy didn't change over time.

4.4.2.2.3 The affective experience after the recall of the sadness stories

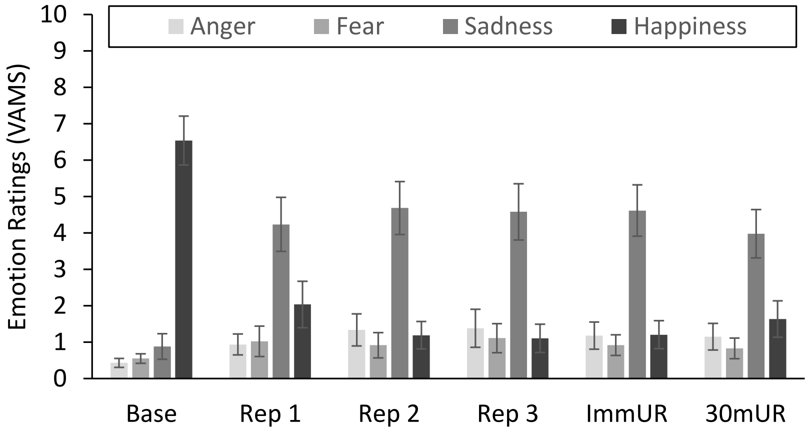

Figure 85. Emotion ratings after the recall of sadness stories

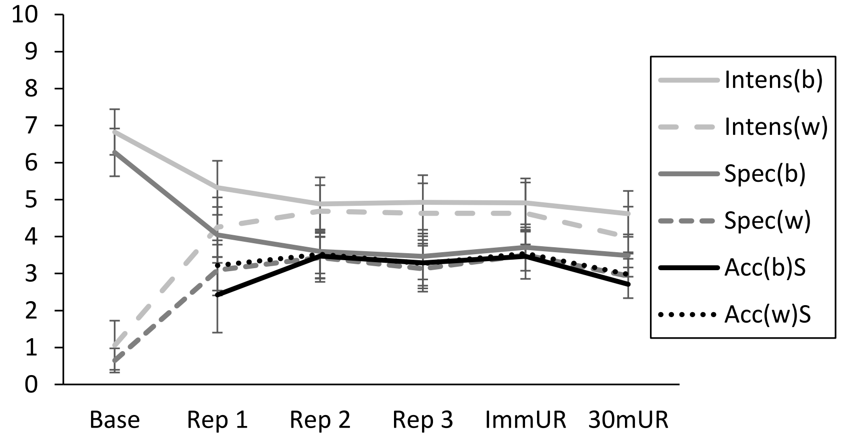

Figure 86. Affective intensity, specificity and accuracy after the recall of sadness stories

The general repeated-measures 4x6 ANOVA reported a significant main effect of *Emotion* ($F(1,19)=14.45$, $p=.001$, $\eta_p^2=.432$), and a significant *Time**Emotion* interaction ($F(1,19)=21.35$, $p<.001$, $\eta_p^2=.529$; degrees of freedom corrected using the lower-bound estimate.

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The analysis of the affective intensity scores (2x6 repeated-measures ANOVA) reported an effect of *Intensity* ($F(1,19)=33.53$, $p<.001$, $\eta_p^2=.638$; degrees of freedom corrected using the lower-bound estimate), and a significant

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Similarly with sections 4.4.2.2.1 and 4.4.2.2.2, the planned-contrasts of the complex interaction was driven to largest extent by the decrease of the *happiness* ratings from Baseline over time ($F(1,19)=25.71$, $p<.001$, $\eta_p^2=.575$; lower-bound correction of degrees of freedom) and the corresponding increase in negative emotions, most notably, *sadness* ($F(1,19)=15.39$ $p=.001$, $\eta_p^2=.447$; degrees of freedom corrected using the lower-bound estimate). The main effect of *Emotion* indicated that the target emotion *sadness* and was significantly more intensely experienced than *anger*, *fear*, and *happiness*.

*Time*Intensity* interaction ($F(1,19)=28.49$, $p<.001$, $\eta_p^2=.600$). The interaction was driven by the substantial difference in the intensity between positive and negative emotions, and the intensity within negative emotions at Baseline ($t(19)=7.69$, $p<.001$). The intensity indices did not vary over time between the Repetition to the Unaided Recall phases (no effect of *Time*).

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported an effect of *Specificity* ($F(1,19)=21.59$, $p<.001$, $\eta_p^2=.532$) and a significant *Time*Specificity* interaction ($F(1,19)=26.96$, $p<.001$, $\eta_p^2=.587$; degrees of freedom corrected using the lower-bound estimate). As in the case of the intensity indices, the interaction was caused by the difference between the specificity between positive and negative emotions and the specificity within negative emotions at Baseline ($t(19)=7.21$, $p<.001$), which also explained the effect of *Specificity*.

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Similarly with section 4.4.2.2.2, the analysis of the accuracy indices (2x5 repeated-measures ANOVA) failed to reach significance. The result confirmed that there was no difference between the two accuracy indices, and also that they remained constant between the Repetition and Unaided Recall phases.

4.4.2.2.4 The affective experience after the recall of the happiness stories

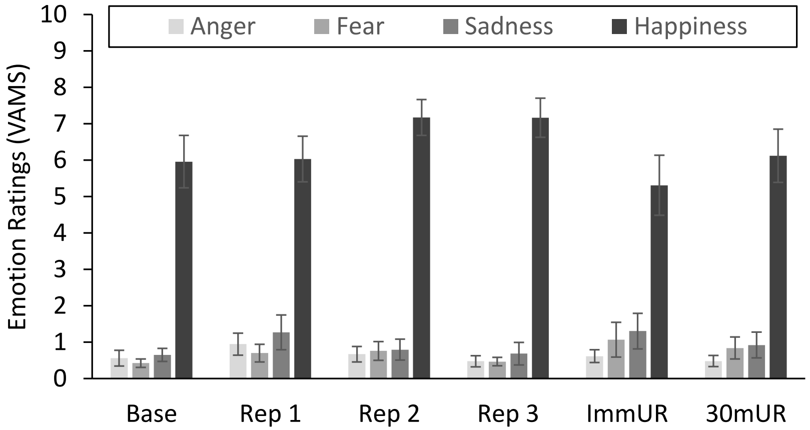

Figure 87. Emotion ratings after the recall of *happiness* stories

The overall repeated-measures 4x6 ANOVA reported a single significant main effect of *Emotion* ($F(1,18)=80.21$, $p<.001$, $\eta_p^2=.817$). Degrees of freedom were corrected using the lower-bound estimate. The effect of *Emotion* was best fitted by a

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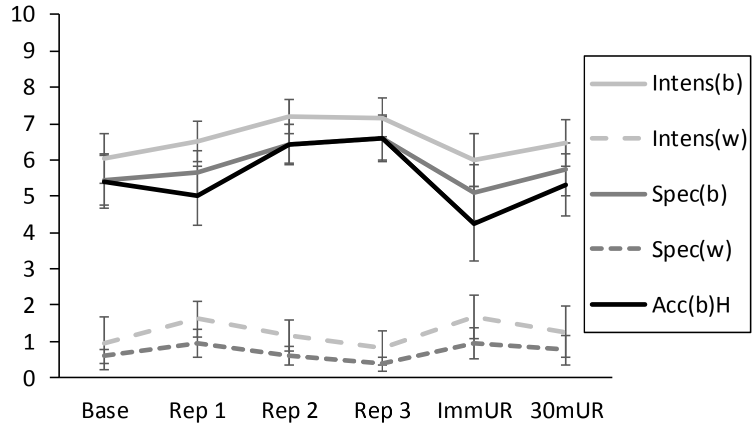

Figure 88. Affective intensity, specificity and accuracy after the recall of *happiness* stories

The analysis of the affective intensity indices (2x6 repeated-measures ANOVA) reported a single effect of *Intensity* ($F(1,18)=83.48$, $p<.001$, $\eta_p^2=.823$), and no effect of *Time* or an interaction. The results suggest that affective intensity remained

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linear contrast, showing that *happiness* was significantly higher rated than *anger*, *fear*, or *sadness*, throughout the six time points, from Baseline to Unaided Recall after 30 minutes ($F(1,18)=114.20$, $p<.001$, $\eta_p^2=.864$).

unchanged from Baseline to Repetitions 1-3 and Unaided Recall (immediate and 30 minutes delayed).

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported a similar single effect of *Specificity* ($F(1,18)=70.86$, $p<.001$, $\eta_p^2=.797$), as the intensity indices. Both the effect of *Time* and the *Time*Specificity* interaction failed to reach significance. Similarly with the intensity indices, the findings suggest that the affective specificity both between positive and negative emotions and within negative emotions remained largely similar from Baseline throughout the different recall tasks.

The one-way repeated-measures ANOVA used to analyse the accuracy between positive and negative emotions failed to reach significance after correcting the degrees of freedom to account for the violation of sphericity. The results suggest the index remained unchanged over time, from Baseline to the Repetition and the Unaided Recall tasks. The findings are consistent with the previous analysis of the specificity indices.

4.4.3 Sample 3: Korsakoff's syndrome patients

The data presented in this section is part of the data analysed in Chapter 3, representing the Korsakoff's syndrome patients. As for the previous sample (section 4.4.2), the details regarding sample characteristics, measures and stimuli used, the design and procedure of the data collection, and the detailed results of the neuropsychological assessments are presented in Chapter 3, and will not be repeated below.

4.4.3.1 Data Analysis

The ratings of *anger*, *fear*, *sadness*, and *happiness* are analysed in a global 4x6 repeated-measures ANOVA, with the two factors being Emotion and Time (Baseline, Repetitions 1-3, Immediate Recall and Recall after 30 minutes). The significant interactions and main effects are explored further using planned contrasts and pair-wise comparisons.

Similarly with section 4.4.4.2.1 above, the affective intensity, specificity and accuracy scores are presented together, but analysed separately. Firstly, the intensity between positive and negative emotions and the intensity within negative emotions are subjected to a repeated-measures 2x6 ANOVA, with the significant interaction and main effects being followed-up with planned contrasts. Secondly, the indices of specificity between positive and negative emotions and the specificity within negative emotions are analysed together in a similar 2x6 repeated-measures ANOVA. And thirdly, the accuracy between positive and negative emotions and the accuracy within negative emotions are analysed using a similar 2x5 repeated-measures ANOVA. The analysis of the accuracy indices omits the Baseline time-point, because the target emotion only refers to the emotion induction tasks of presentation and recall.

4.4.3.2 Results

Similarly with section 4.4.2.2 above, the traditional analysis of the emotion ratings is presented on the left side of the page and the analysis of the novel summary indices of affective intensity, specificity and accuracy on the right side. The emotion ratings is illustrated using a bar chart for the benefit of visual clarity, although the data represent a repeated measures design. As before, the expected/target emotion at Baseline was *happiness*, thus, the accuracy within negative emotions is not calculated at Baseline for any of the sub-sections below. Moreover, the accuracy within negative emotions is cannot be calculated for the *happiness* story (see section 4.4.4 below, figures on the right side).

The time-points presented in both figures use the same abbreviations as in the earlier section 4.4.2.2, as follows:

Base – Baseline measure of emotions;

Rep 1 – the first repetition of the emotional story (recalled after presentation);

Rep 2 – the second repetition of the emotional story (recalled after presentation);

Rep 3 – the third repetition of the emotional story (recalled after presentation);

ImmUR – Immediate Unaided Recall (recall after the distraction story without a prior presentation of the emotional story);

30mUR – 30 minutes Unaided Recall (recall after 30 minutes without a prior presentation of the story);

The intensity, specificity, and accuracy indices are shown in figures on the right side using the same abbreviations as previously:

Intens(b) – the intensity between positive and negative emotions;

Intens(w) – the intensity within negative emotions;

Spec(b) – the specificity between positive and negative emotions;

Spec(w) – the specificity within positive and negative emotions;

Acc(b) – the accuracy between positive and negative emotions;

Acc(w)A – the accuracy within negative emotions, when *anger* is the target/expected emotion;

Acc(w)F – the accuracy within negative emotions, when *fear* is the target/expected emotion;

Acc(w)S – the accuracy within negative emotions, when *sadness* is the target/expected emotion;

Acc(w)H – the accuracy within negative emotions, when *happiness* is the target/expected emotion.

4.4.3.2.1 The affective experience after the recall of the anger stories

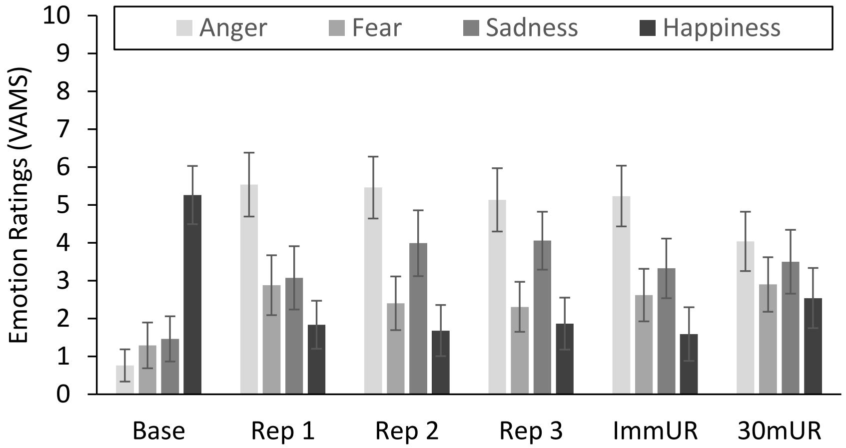

Figure 89. Emotion ratings after the recall of anger stories

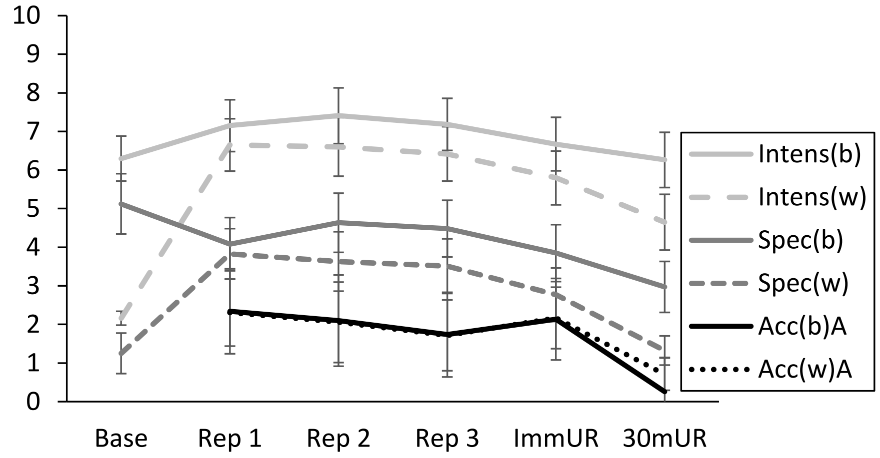

Figure 90. Affective intensity, specificity and accuracy after the recall of anger stories

The overall repeated-measures 4x6 ANOVA reported a single significant main effect of *Time* (F(3.97,75.44)=4.53, p=.005, η_p^2=.193; degrees of freedom corrected using the Greenhouse-Geisser estimate), and a significant *Time*Emotion*

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The analysis of the affective intensity scores (2x6 repeated-measures ANOVA) reported an effect of *Time* (F(1,19)=7.14, p=.015, η_p^2=.273; degrees of freedom corrected using the lower-bound estimate), an effect of *Intensity* (F(1,19)=7.58, p=.013,

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interaction (F(1,19)=7.50, p=.013, η_p^2=.283; degrees of freedom corrected using the lower-bound estimate). Notably, the effect of *Emotion* failed to reach significance after correcting the degrees of freedom for the violation of the sphericity assumption.

The complex interaction was best fitted by the quadratic contrast of *Time* and the linear contrast of *Emotion* (F(1,19)=23.68, p<.001, η_p^2=.555) showing that as the overall ratings of emotions increased from Baseline to the Repetitions phases, they then decreased over time in the unaided recall phases (immediate and 30 minutes delayed). This contrasted with the high ratings of *happiness* at Baseline which immediately subsided for the remaining phases (F(1,19)=8.71, p=.008, η_p^2=.314), while the ratings of the negative emotions, especially *anger* increased (F(1,19)=13.61, p=.002, η_p^2=.417) and remained dominant over time.

η_p^2=.285), and a significant *Time*Intensity* interaction (F(5,95)=10.87, p<.001, η_p^2=.364). The interaction was mostly driven by the difference between the intensity between positive and negative emotions and the intensity within negative emotions at Baseline (t(19)=4.53, p<.001) and at the last recall phase (Unaided Recall after 30 minutes; t(19)=2.19, p=.041). The effect of *Time* was best fitted by a quadratic contrast (F(1,19)=13.30, p=.002, η_p^2=.412), which indicated that overall, the intensity indices increased from Baseline to the Repetition phases and then decreased over time, in particular at the last phase (Unaided Recall after 30 minutes).

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported an small effect of *Time* (F(4.20,79.70)=2.59, p=.041, η_p^2=.120; degrees of freedom corrected using the Huynh-Feldt estimate), an effect of *Specificity* (F(1,19)=7.63, p=.012, η_p^2=.287), and a significant *Time*Specificity* interaction, (F(1,19)=7.71, p=.012, η_p^2=.289; degrees of freedom corrected using the lower-bound estimate). As

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in the case of the intensity indices, the interaction was mostly caused by the difference between the specificity indices at Baseline ($t(19)=3.95$, $p=.001$) and at the last recall phase (Unaided Recall after 30 minutes; $t(19)=2.17$, $p=.043$). The effect of *Time* was best fitted by a linear contrast ($F(1,19)=6.31$, $p=.021$, $\eta_p^2=.249$), which indicated that overall, the specificity indices decreased over time.

The 2x5 repeated-measures ANOVA used to analyse the affective accuracy indices failed to reach significance. This suggested that the accuracy between positive and negative emotions was similar with the accuracy within negative emotions, and both indices remained relatively stable over time. The downward trend observed at Unaided Recall after 30 minutes failed to reach significance.

4.4.3.2.2 The affective experience after the recall of the <u>fear</u> stories

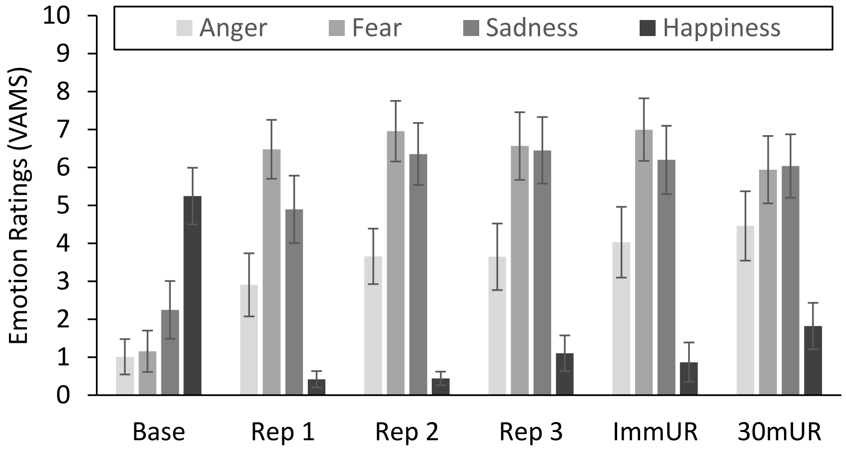

Figure 91. Emotion ratings after the recall of the *fear* stories

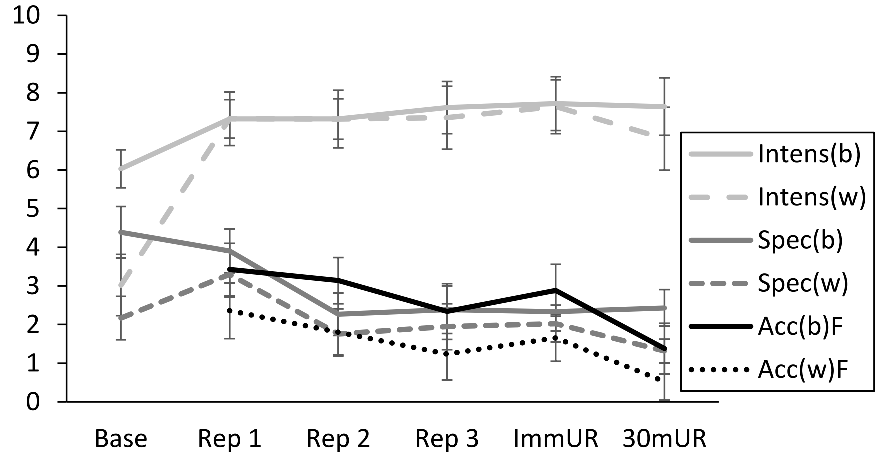

Figure 92. Affective intensity, specificity and accuracy after the recall of the *fear* stories

The overall repeated-measures 4x6 ANOVA reported a significant effect of *Time* (F(4.22,71.69)=6.91, p<.001, η_p^2=.289; degrees of freedom corrected using the Huynh-Feldt estimate), an effect of *Emotion* (F(3,51)=17.40, p<.001, η_p^2=.506) and a

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The analysis of the affective intensity scores (2x6 repeated-measures ANOVA) reported an effect of *Time* (F(3.68,62.60)=6.29, p<.001, η_p^2=.270; degrees of freedom corrected using the Huynh-Feldt estimate), an effect of *Intensity*

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significant *Time*Emotion* interaction ($F(10.51,178.81)=12.56$, $p<.001$, $\eta_p^2=.425$; degrees of freedom corrected using the Huynh-Feldt estimate).

The complex interaction was best fitted by the quadratic contrast of *Time* and a quadratic contrast of *Emotion* ($F(1,17)=33.20$, $p<.001$, $\eta_p^2=.661$) indicating that the overall ratings of emotions increased from Baseline to the Repetitions phases, and then decreased over time in the unaided recall phases (immediate and 30 minutes delayed), while the ratings of *happiness* dramatically subsided from Baseline ($F(1,17)=15.21$, $p=.001$, $\eta_p^2=.472$; degrees of freedom corrected using the lower-bound estimate), while the ratings of the negative emotions, especially *fear* increased from Baseline ($F(5,85)=16.10$, $p<.001$, $\eta_p^2=.486$) and remained dominant over time.

($F(1,17)=11.75$, $p=.003$, $\eta_p^2=.409$), and a significant *Time*Intensity* interaction ($F(5,85)=10.17$, $p<.001$, $\eta_p^2=.374$). The interaction was mostly driven by the difference between the intensity between positive and negative emotions and the intensity within negative emotions at Baseline ($t(18)=3.79$, $p=.001$). The effect of *Time* was best fitted by a linear contrast ($F(1,17)=11.51$, $p=.003$, $\eta_p^2=.404$), which indicated that overall, the intensity indices increased from Baseline over time, but when discounting the Baseline values, intensity was stable over time.

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported an small effect of *Time* ($F(5,85)=3.52$, $p=.041$, $\eta_p^2=.171$), and an effect of *Specificity* ($F(1,17)=14.91$, $p=.001$, $\eta_p^2=.467$). The *Time*Specificity* interaction failed to reach significance after correcting the degrees of freedom to account for the violation of the sphericity assumption. Similarly with the intensity indices, the main effect of *Time* best fitted a linear contrast, confirming that the specificity indices decreased

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over time, from Baseline to the Repetition and Unaided Recall phases.

The 2x5 repeated-measures ANOVA used to analyse the affective accuracy indices reported a single effect of *Accuracy* ($F(1,17)=37.13$, $p<.001$, $\eta_p^2=.686$), confirming that the accuracy between positive and negative emotions was significantly higher than the accuracy within negative emotions, effect which remained constant over time, regardless of the memory task performed.

4.4.3.2.3 The affective experience after the recall of the sadness stories

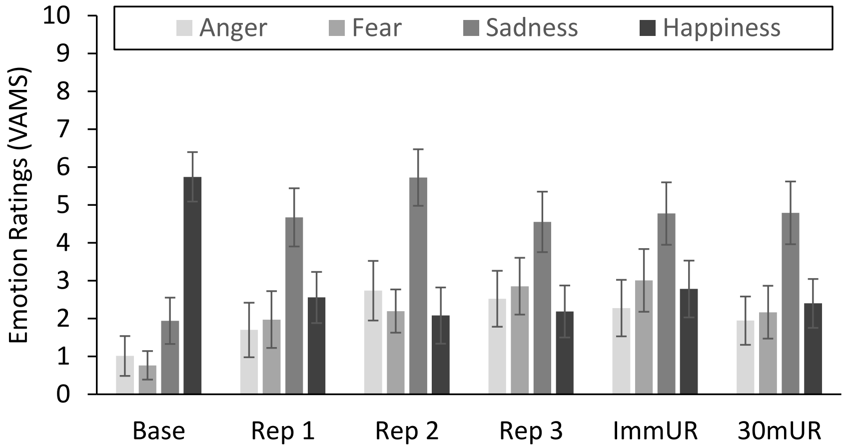

Figure 93. Emotion ratings after the recall of sadness stories

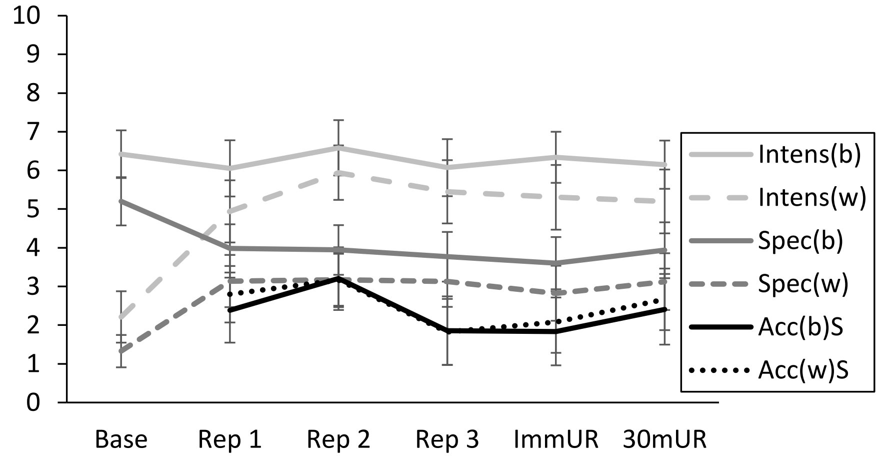

Figure 94. Affective intensity, specificity and accuracy after the recall of sadness stories

The overall repeated-measures 4x6 ANOVA reported a significant effect of *Emotion* (F(2.12,40.21)=5.23, p=.009, η_p^2=.216; degrees of freedom corrected using the Huynh-Feldt estimate), a significant *Time*Emotion* interaction (F(1,19)=8.45,

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The analysis of the affective intensity indices (2x6 repeated-measures ANOVA) reported an effect of *Intensity* (F(1,19)=22.10, p<.001, η_p^2=.538), and a significant *Time*Intensity* interaction (F(1,19)=12.65, p=.002, η_p^2=.400; degrees of freedom corrected

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P=.009, η_p^2=.308; degrees of freedom corrected using the lower-bound estimate).

Similarly with section 4.3.2.3, the complex interaction was best fitted by the quadratic contrast of *Time* and a quadratic contrast of *Emotion* ($F(1,19)$=28.20, p<.001, η_p^2=.597) indicating that the overall ratings of emotions increased from Baseline to the Repetitions phases, and then decreased over time in the unaided recall phases (immediate and 30 minutes delayed), while the ratings of *happiness* dramatically subsided from Baseline ($F(1,19)$=10.57, p=.004, η_p^2=.358; degrees of freedom corrected using the lower-bound estimate), while the ratings of the negative emotions, especially *sadness* increased from Baseline ($F(1,19)$=8.19, p<.010, η_p^2=.301) and remained the highest over time.

using the lower-bound estimate). The effect of *Time* failed to reach significance after correcting the degrees of freedom, due to the sphericity violation. The interaction was mostly driven by the difference between the intensity between positive and negative emotions and the intensity within negative emotions at Baseline ($t(18)$=5.79, p<.001).

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported an effect of *Specificity* ($F(1,19)$=22.37, p<.001, η_p^2=.541) and a *Time*Specificity* interaction ($F(5,95)$=8.34, p<.001, η_p^2=.305). Similarly with the intensity indices, the interaction was caused by the difference between the specificity between positive and negative emotions and the specificity within negative emotions at Baseline ($t(18)$=4.96, p<.001). Notably, there was no effect of *Time*, suggesting the specificity indices remained constant over time, regardless of the memory task employed.

The 2x5 repeated-measures ANOVA used to analyse the

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affective accuracy indices failed to reach significance, indicating that both accuracy indices were largely similar, and did not change over time, from Baseline, to the Repetition and Unaided Recall phases.

4.4.3.2.4 The affective experience after the recall of the <u>happiness</u> stories

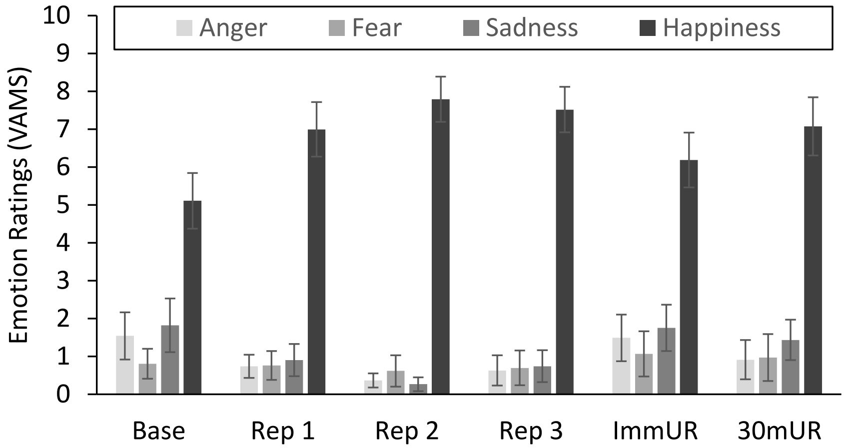

Figure 95. Emotion ratings after the recall of *happiness* stories

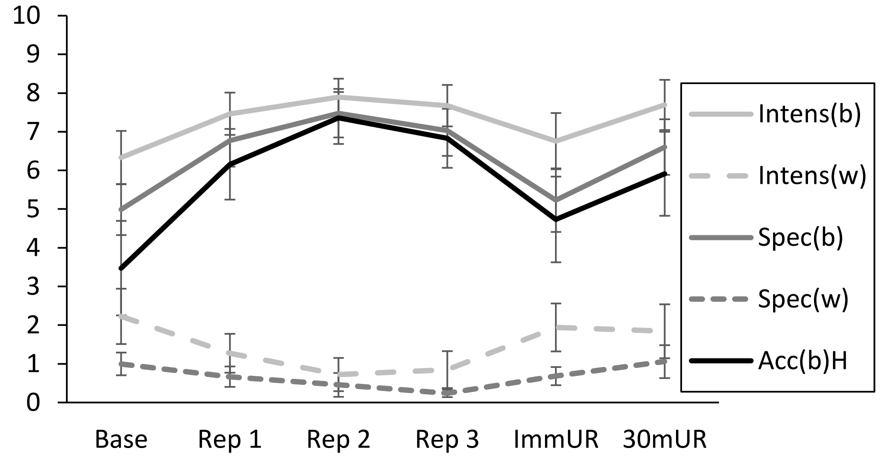

Figure 96. Affective intensity, specificity and accuracy after the recall of *happiness* stories

The overall repeated-measures 4x6 ANOVA reported a single significant main effect of *Emotion* (F(1,18)=66.06, p<.001, η_p^2=.786; degrees of freedom corrected using the lower-bound estimate). The *Time*Emotion* interaction failed to reach

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The analysis of the affective intensity indices (2x6 repeated-measures ANOVA) reported an effect of *Intensity* (F(1,18)=78.87, p<.001, η_p^2=.814). The *Time*Intensity* interaction failed to reach significance after degrees of freedom were adjusted to account for

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significance, after correcting the degrees of freedom to account for the violation of sphericity.

The effect of emotion best fitted a linear contrast (F(1,18)=74.11, p<.001, η_p^2=.805) showing that the ratings of *happiness* were significantly higher than those of any negative emotions (*anger*, *fear*, or *sadness*).

the violation of sphericity. The results suggest that the intensity indices remained largely stable from Baseline to Repetitions 1-3 and Unaided Recall (immediate and 30 minutes delayed).

The analysis of the specificity indices (2x6 repeated-measures ANOVA) reported a single effect of *Specificity* (F(1,18)=70.63, p<.001, η_p^2=.797). Both the effect of *Time* and the *Time*Specificity* interaction failed to reach significance after correcting the degrees of freedom. Similarly with the intensity indices, the findings suggest that the affective specificity both between positive and negative emotions and within negative emotions remained largely similar from Baseline throughout the different recall tasks.

The one-way repeated-measures ANOVA used to analyse the accuracy between positive and negative emotions failed to reach significance, indicating that the index remained unchanged over time, from Baseline to Unaided Recall after 30 minutes. The findings are consistent with the previous analysis of the specificity indices.

4.4.4 Summary of main findings relating to the affective intensity, specificity and accuracy indices

A brief summary of the main findings presented in sections 4.4.1.2.1 – 4.4.1.2.8, 4.4.2.2.1 – 4.4.2.2.4 and 4.4.3.2.1 – 4.4.3.2.4 are included in Table 11, below. The four discrete emotions and the stories (*endings* and *stems*) which were targeted to elicit them are presented in the same order as in previous chapters (i.e., anger, fear, sadness, and *happiness*) and are initialled only in the table (i.e., A – for anger stories, etc.). As in previous sections, the index for the accuracy within negative emotions cannot be calculated for the *happiness* stories, and this is indicated in Table 11 as "not applicable" (n/a). The intensity, specificity and accuracy indices and the experimental time points are presented using the same abbreviations as in previous chapters and sections:

Intens(b) – the intensity between positive and negative emotions;

Intens(w) – the intensity within negative emotions;

Spec(b) – the specificity between positive and negative emotions;

Spec(w) – the specificity within positive and negative emotions;

Acc(b) – the accuracy between positive and negative emotions;

Acc(w)A – the accuracy within negative emotions, when *anger* is the target/expected emotion;

Acc(w)F – the accuracy within negative emotions, when *fear* is the target/expected emotion;

Acc(w)S – the accuracy within negative emotions, when *sadness* is the target/expected emotion;

Acc(w)H – the accuracy within negative emotions, when *happiness* is the target/expected emotion.

ImmUR – Immediate Unaided Recall (recall after the distraction story without a prior presentation of the emotional story);

Table 11.

Summary of findings about the affective intensity, specificity, and accuracy indices. (1) Although the results don't fit the overall findings, a notable interference effect was observed during Immediate Unaided Recall. For the anger and fear stories (Sample 3 only) the Acc(b) and Acc(w) indices were significantly more pronounced at ImmUR, while, conversely, for the happiness story, the Acc(b) and Acc(w) indices were markedly lower at ImmUR, For the happiness stories (Samples 2 and 3) the Intens(b), Spec(b), and Acc(b) indices were notably lower after the negatively valenced interference story, and the Intens(w) and Spec(w) were notably higher than before; (2) Although the results did not reach significance, a distinct downward trend was noticeable, which is consistent with the findings for Sample 1 (neurologically normal students).

Stimuli	**Indices**	**Findings**	**Sample 1** **Students**	**Sample 2** **Elderly controls**	**Sample 3** **Korsakoff patients**
Story *endings* (semantically emotional)	Intensity	Intens(b) > Intens(w)	A, F, S, H	A, F, S, H	A, F, S, –
		Intens(b) decreases over time	A, F, S, H	A, F, –, (1)	A, –, –, (1)
		Intens(w) decreases over time	A, F, S, –	A, F, –, (1)	A, –, –, (1)
	Specificity	Spec(b) > Spec(w)	A, F, S, H	A, F, S, H	A, F, S, –
		Spec (b) decreases over time	A, F, S, H	–, –, –, (1)	A, F, –, (1)
		Spec(w) decreases over time	A, F, S, –	–, –, –, (1)	A, F, –, (1)

	Accuracy	Acc(b) > Acc(w)	A, F, S, n/a	A, –, –, n/a	–, F, –, n/a
		Acc (b) decreases over time	A, –, S, H	–, –, –, (1)	(1)(2), (1)(2), –, (1)
		Acc(w) decreases over time	A, –, S, n/a	–, –, –, n/a	(1)(2), (1)(2), –, n/a
Story *stems* (semantically neutral)	Intensity	Intens(b) > Intens(w)	A, F, S, –		
		Intens(b) decreases at ImmUR	A, F, –, –		
		Intens(w) *increases* at ImmUR	A, F, –, –		
	Specificity	Spec(b) > Spec(w)	A, –, –, –		
		Spec (b) decreases at ImmUR	A, F, –, –		
		Spec(w) *increases* at ImmUR	A, –, –, –		
	Accuracy	Acc(b) > Acc(w)	A, F, S, n/a		
		Acc (b) decreases at ImmUR	A, F, S, –		
		Acc(w) *increases* at ImmUR	A, –, S, n/a		

4.4.5 Conclusions

The experimental paradigm of emotion elicitation differed slightly between Sample 1 (the neurologically normal undergraduate students) and Samples 2 and 3 (Korsakoff's syndrome patients and partly age matched neurologically normal elderly participants). The students listened to the emotional stories once, and recalled them after 30 minutes and seven days, while the patients and elderly controls listened to the emotional stories in three successive iterations, followed by a differently valenced interference story (i.e., happiness story for all the negative target emotions, and *sadness* story when *happiness* was the target emotion). Subsequently, patients and elderly controls immediately tried to recall the original story, and then again after 30 minutes. The first noticeable difference is that the *Time* effect refers to a seven day period in case of the students (Sample) and only 30 minutes for elderly controls and patients (Samples 2 and 3 respectively). Secondly, the patients and controls allowed the observation of a possible emotional interference effect (corresponding to the well-established episodic memory interference), while this was not factored in the study design of the student sample.

The emotional interference effect was clearly noticeable for both Korsakoff's syndrome patients and elderly controls and differed between positive and negative emotions. The strongest and most consistent interference effect was noticed for *happiness*. Both groups of participants after listening to the *happiness* story for three times reported high levels of *happiness*, with barely any negative emotions, as expected. However, when recalling the *happiness* story immediately after listening and recalling a sad event, the intensity, specificity, and accuracy of the experience of *happiness* was markedly lower than before. When trying again to recall the *happiness* story after 30 minutes from the interference story, the intensity, specificity and accuracy of the *happiness* experience was restored to the *normal* levels before the interference. Notably, this effect was observed irrespective of the amount of information actually being recalled each time (after interference and 30 minutes later). The difference between the amount of episodic information recalled by both groups was significant, but the effect was present nonetheless. These findings mirror the classical episodic memory effect, where patients with a mild memory impairment are significantly affected by the memory interference task, but after a 30 minute delay manage to recall just as many episodic details as participants without a memory impairment. This is while patients with a severe memory impairment suffer from a substantial disruption of recall accuracy immediately after the interference task and fail to improve any further after the 30 minutes delay.

The second and different emotional interference effect was noticed for the negative emotions (anger and fear, but not sadness), and only for the Korsakoff's syndrome patients, and not the elderly (neurologically normal) controls. After the three successive repetitions of the negative stories, and the interference of a novel and unrelated *happiness* story, patients had to recall the initial negative story. While the intensity indices showed a downward trend (or at best remained unchanged over time), the accuracy of the emotional experience, both between positive and negative emotions (but more strikingly even within negative emotions) increased only immediately after the interference *happiness* story, and after 30 minutes decreased to the *normal* levels recorder before interference. What the effect shows is that after the positively valenced interference story, the attempt to recall a negative story elicited the re-experience of "purer" (i.e., more discrete) and at the same time accurate negative emotions, but not more intense. The finding was consistent across two negative emotions, generally classed as highly arousing, and only when recall of the negative stories produced very few episodic details (the Korsakoff's syndrome patients). The elderly control participants who managed to recall the stories accurately did not show an improvement in the affective accuracy following the interference story.

This is for the first time that such an emotional interference effect is produced for discrete classes of emotions, in neurologically normal and amnesic patients. The novel indices of affective intensity, specificity, and accuracy allowed the calculation of such an effect. Notably, this effect was different between neurologically normal participants and Korsakoff's syndrome controls. A first attempt to explain this difference between the two groups of participant would have to consider the starkest measured difference between the samples: the episodic recall of emotional stories. The literature on the interaction between memory and emotions has so far focused predominantly on the intensity of positive and negative emotions, and only rarely on differences between discrete emotions. The re-experience of emotions over time, and most importantly the differences in the specificity and accuracy of the re-experience of discrete emotions in neurologically normal and memory impaired patients over time is most incisively approached in the present work. Far from providing definitive answers, the theoretical construct and application of the affective intensity, specificity and accuracy indices could inform future study designs and investigations of the relationship between emotions and memory.

Other differences between the Korsakoff's syndrome patients and control participants could also direct future research, but their magnitude was insufficient to allow a further investigation in the current work. For example, difference in executive function, and emotion regulation could have explained the difference in the emotion interference effect beyond any memory component. However, although the Korsakoff's syndrome patients showed marginally lower executive function performance, and minimally raised anxiety and depression scores, these failed to reach significance and showed no correlation with the emotion ratings, or with the intensity, specificity, and accuracy ratings. Nonetheless, in other populations, larger differences on these factors could be linked to a different affective experience, which further and beyond the use of emotion ratings could be informed by the novel indices exemplified in this chapter.

4.5 Comparison between the intensity, specificity and accuracy of the Korsakoff patients and elderly controls

The new indices of emotional intensity, specificity and accuracy of the Korsakoff patients and the neurologically intact elderly controls were compared for each of the four stories, targeting a different discrete emotion (*anger, fear, sadness* and *happiness*). The results are presented separately for each story and summarised at the end. A series of 2x6 mixed-factorial ANOVA are performed for each index, with two Groups (Patients and Controls) and six Time points (Baseline, Repetitions 1-3, Immediate Unaided Recall, and 30 minutes Delayed Unaided Recall). Differences on the accuracy within negative emotions are assessed using a 2x5 mixed-factorial ANOVA (similar with the one before, but excluding the Baseline ratings, for which this accuracy index cannot be calculated). To avoid duplication with the previous sections (4.4.1-4.4.4), only the between-subjects effects are reported (comparing the Korsakoff patients and control participants) and any possible *Time*Group* interactions.

4.5.1 The intensity, specificity and accuracy of the affective re-experience of the Korsakoff patients and elderly controls after the *anger* story

Figure 97 (below) shows the index scores for the intensity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA performed on the indices of the intensity between positive and negative emotions failed to confirm a significant effect of G*roup* ($F(1,38)=1.83$, $p=.184$, $\eta_p^2=.046$), or *Time*Group* interaction ($F(3.62,137.78)=1.06$, $p=.375$, $\eta_p^2=.027$) – degrees of freedom corrected using the Greenhouse-Geisser estimate (GG). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after Repetition 2, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm a significant difference ($t(38)=-1.21$, $p=.235$).

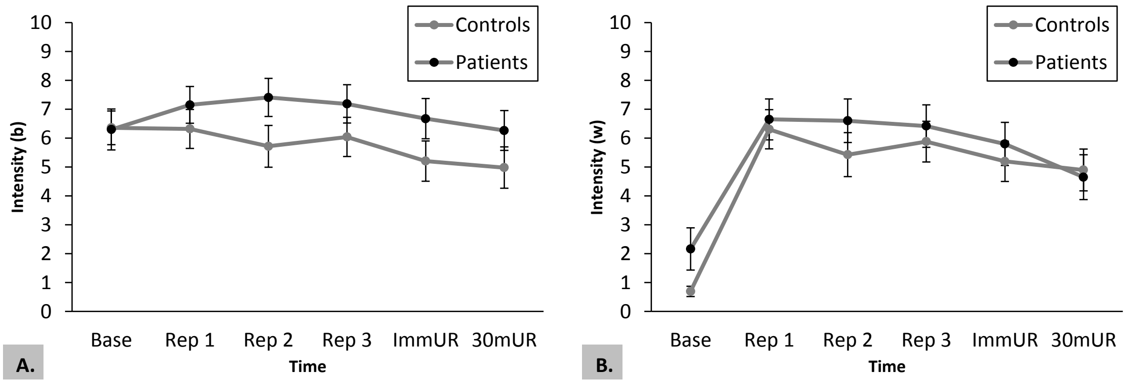

Figure 97. The intensity between positive and negative emotions (A.) and the intensity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the anger story.

The intensity between positive and negative emotions and the intensity within negative emotions was similar for Korsakoff patients and control participants throughout the series of presentations and recollections of the *anger* story.

A similar 2x6 mixed-factorial ANOVA tested the differences between the intensity within negative emotions for the two groups. The results showed no effect of G*roup* (*F(*1,38)=.67, *p*=.420, η_p^2=.017), or *Time*Group* interaction (*F*(3.72,141.29)=.89, *p*=.455, η_p^2=.023) – degrees of freedom corrected using the Huynh-Feldt estimate (HF).

Figure 98 (below) illustrates the specificity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. Possible differences in the intensity between positive and negative emotions of Korsakoff patients and elderly controls were compared using a 2x6 mixed-factorial ANOVA. The results failed to confirm a significant effect of G*roup* (*F(*1,38)=.57, *p*=.454, η_p^2=.015), or *Time*Group* interaction (*F*(3.91,148.63)=1.72, *p*=.149, η_p^2=.043, HF) for the specificity between positive and negative emotions. To confirm that the results were not compromised by the six levels of the *Time* factor and the associated α level correction, a separate independent-samples t-test was carried out for the specificity between positive and negative emotions after Repetition 2, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm a significant difference (*t*(38)=-1.71, *p*=.096).

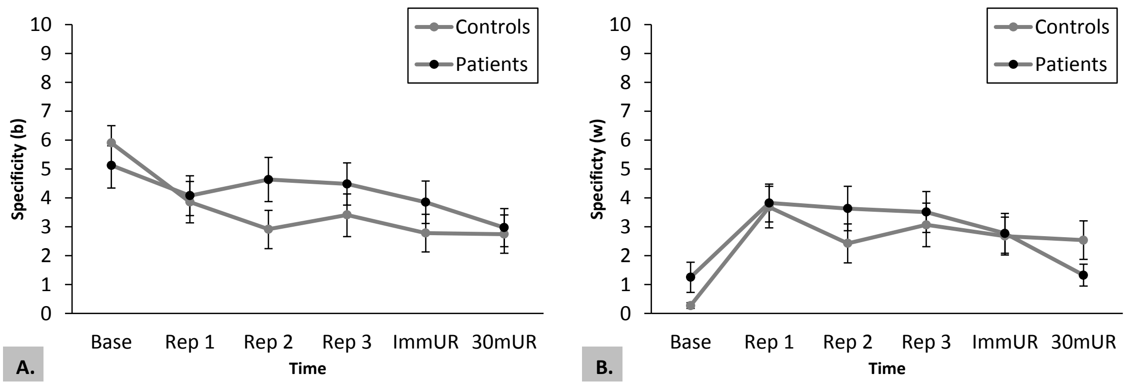

Figure 98. The specificity between positive and negative emotions (A.) and the specificity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the anger story.
The specificity between positive and negative emotions and the intensity within negative emotions was similar for Korsakoff patients and control participants throughout the series of presentations and recollections of the *anger* story.

A 2x6 mixed-factorial ANOVA was used to assess the differences between the specificity within negative emotions for the two groups. The results failed to confirm an effect of G*roup* ($F(1,38)=.17$, $p=.681$, $\eta_p^2=.005$), or *Time*Group* interaction ($F(3.77,143.14)=1.71$, $p=.155$, $\eta_p^2=.043$) – degrees of freedom corrected using the Huynh-Feldt estimate (HF). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the specificity within negative emotions after the Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to find a difference between the two groups ($t(38)=1.59$, $p=.120$).

Figure 99 (below) shows the index scores for the accuracy between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA applied to the indices of accuracy between positive and negative emotions failed to confirm a significant effect of G*roup* ($F(1,38)=1.55$, $p=.221$, $\eta_p^2=.039$), or *Time*Group* interaction ($F(1,38)=.77$, $p=.385$, $\eta_p^2=.020$) – degrees of freedom corrected using the lower-bound estimate of sphericity (LB). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the accuracy between positive and negative emotions after the Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test confirmed that the Korsakoff patients had lower accuracy indices than the control participants ($t(38)=2.29$, $p=.028$, $d=.73$).

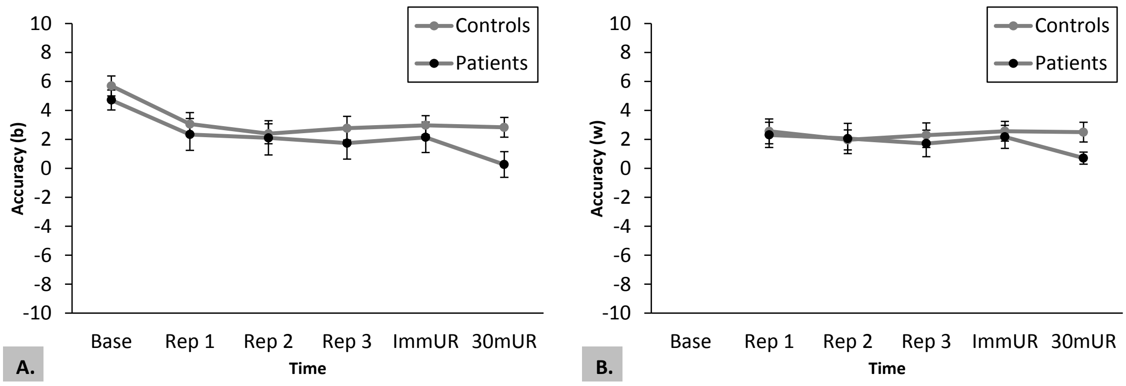

Figure 99. The accuracy between positive and negative emotions (A.) and the accuracy within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the anger story.

Korsakoff patients showed similar accuracy between positive and negative emotions and the accuracy within negative emotions were lower with the control participants during the Repetition and Immediate recall phases. However, both indices were significantly lower after the 30 minutes delayed recall.

A 2x5 mixed-factorial ANOVA tested the differences between the accuracy within negative emotions for the two groups. The results showed no effect of G*roup* ($F(1,38)=.35$, $p=.556$, $\eta_p^2=.009$), or *Time*Group* interaction ($F(4,152)=1.28$, $p=.282$, $\eta_p^2=.032$). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after the Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test confirmed that the Korsakoff patients had lower accuracy indices than the control participants ($t(38)=2.24$, $p=.031$, $d=.71$).

In conclusion, the only differences between the Korsakoff patients and the control participants following the repetition and recall of the anger story were for the accuracy indices (both between positive and negative emotions and within negative emotions) after the 30 minute delayed recall. As shown in Figure 100 (below) these results were not mirrored by the specificity indices because some of patients scored high on the specificity indices, but in the negative range on the accuracy indices. This indicates that after the 30 minute delay some of the patients re-experienced discretely a non-target emotion with a high level of specificity, unlike the control participants who largely re-experienced only the target emotion.

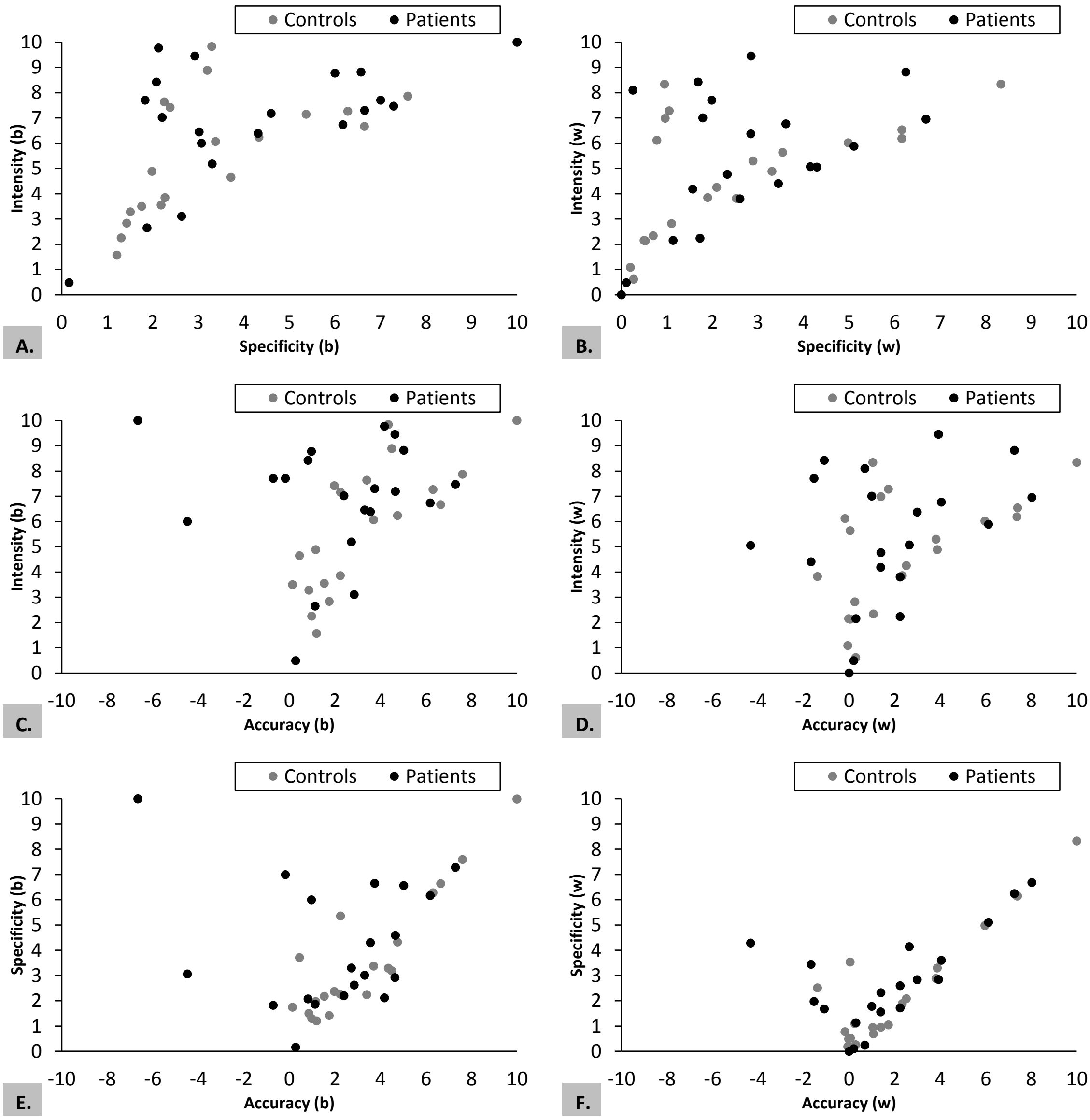

Figure 100. The average intensity, specificity and accuracy between positive and negative emotions (A., C., and E.) and within negative emotions (B., D., and F.) for Korsakoff patients and elderly controls after the presentation and recall of the *anger* story.

Some Korsakoff patients scored in the negative range on the index of the accuracy between positive and negative emotions, indicating that their levels of *happiness* exceeded the intensity of *anger*. The Korsakoff patients who scored negatively on the accuracy within negative emotions experienced another negative non-target emotion at higher levels than the target emotion (*anger*).

The loss of affective accuracy for the Korsakoff patients (compared to control participants) was even more pronounced after the 30 minutes delayed recall, and confirmed by the inferential statistical tests above. Figure 101 (below) shows that the accuracy indices of some Korsakoff patients were substantially in the negative range (as low as negative 10) for the accuracy between positive and negative emotions, while negative emotions were at reported at zero. Other Korsakoff patients scored negatively on the accuracy within negative emotions as they reported another negative non-target emotion at higher levels than the target emotion (*anger*).

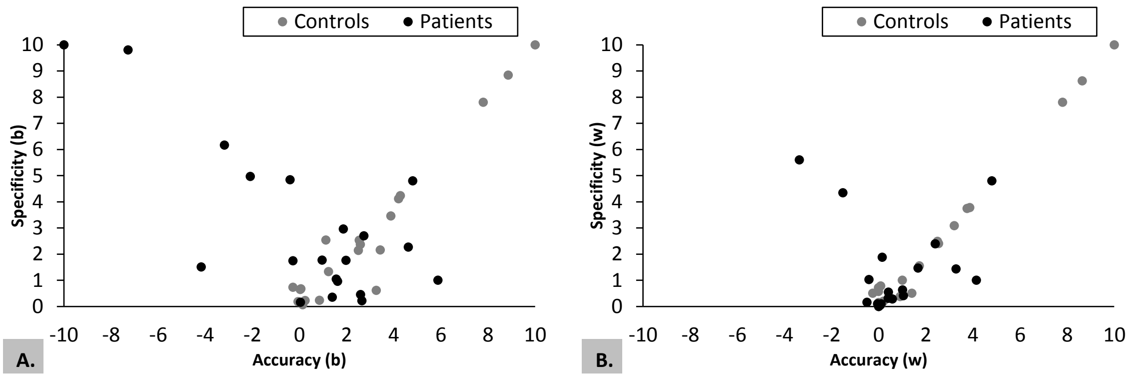

Figure 101. The average specificity and accuracy between positive and negative emotions (A.) and within negative emotions (B.) for Korsakoff patients and elderly controls after the 30 minutes Delayed Recall of the anger story.

The effect seen for the average scores (Figure 100, above) appears even more pronounced – as certain Korsakoff patients reported much higher levels of *happiness* than *anger,* and other Korsakoff patients experienced different negative non-target emotions at higher levels than the target emotion (*anger*).

The emotional re-experience following the *anger* story suggests that the Korsakoff patients and elderly controls experienced similarly intense and specific emotions following the presentation and recall of the anger stories, with a notable difference after the 30 minute Delayed Recall, when a few Korsakoff patients reversed to Baseline levels of affect, when *happiness* was the dominant emotion, and the negative emotions (including *anger*) were indistinguishable. The findings suggest that for a distinct minority of patients, emotion regulatory processes contributed to the extinction of the specific and intense affective state initially elicited by the anger story.

4.5.2 The intensity, specificity and accuracy of the affective re-experience of the Korsakoff patients and elderly controls after the *fear* story

Figure 102 (below) presents the index scores for the intensity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants following the presentation and recall of the *fear* story. A 2x6 mixed-factorial ANOVA performed on the indices of the intensity between positive and negative emotions found a significant *Time*Group* interaction ($F(3.31,119.12)=3.52$, $p=.0.14$, $\eta_p^2=.089$, HF *df*), but failed to confirm a significant effect of G*roup* ($F(1,36)=.85$, $p=.364$, $\eta_p^2=.023$) or *Time* ($F(3.31,119.12)=.65$, $p=.602$, $\eta_p^2=.018$, HF *df*). The *Time*Group* interaction was caused by the changes in the intensity ratings after the 30 minute Delayed Recall. At Baseline ($t(37)=-1.21$, $p=.235$), Repetition 1 ($t(37)=0.51$, $p=.614$), Repetition 2 ($t(38)=0.45$, $p=.651$), Repetition 3 ($t(38)=1.16$, $p=.254$), and Immediate Unaided Recall ($t(37)=1.8$, $p=.080$) there were no differences between the two groups. However, after the 30 minute Delayed Unaided Recall, the intensity between positive and negative emotions of the Korsakoff patients was significantly higher than the intensity of the control participants ($t(38)=2.08$, $p=.044$, $d=.661$). Thus, the overall affective intensity of the Korsakoff patients was maintained at significantly higher levels than that of the control participants after the 30 minutes delay.

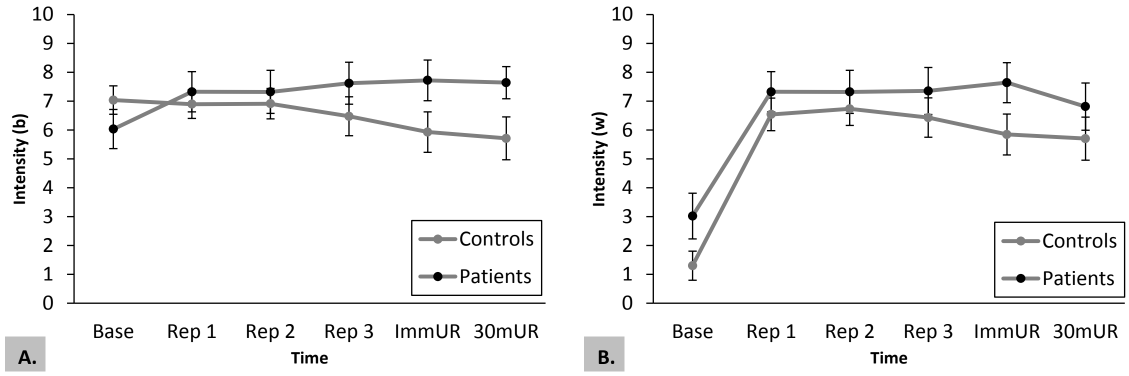

Figure 102. The intensity between positive and negative emotions (A.) and the intensity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *fear* story.
Korsakoff patients' emotion self-reports had a higher intensity between positive and negative after the 30 minutes delay than the affect ratings of the control participants., with no other significant differences.

A 2x6 mixed-factorial ANOVA tested the differences between the intensity within negative emotions for the two groups. The results showed no effect of G*roup* (*F(*1,36)=2.65, *p*=.113, η_p^2=.068), or *Time*Group* interaction (*F*(3.06,110.75)=.65, *p*=.587, η_p^2=.018, HF *df*). The effect of *Time* was reported previously in sections 4.4.2.2.2 and 4.4.3.2.2).

Figure 103 (below) shows the specificity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA tested the possible differences in the specificity between positive and negative emotions of Korsakoff patients and elderly controls. The results failed to confirm a significant effect of G*roup* (*F(*1,36)=2.41, *p*=.129, η_p^2=.063), or *Time*Group* interaction (*F*(4.39,157.93)=1.94, *p*=.101, η_p^2=.051, HF *df*) for the specificity between positive and negative emotions. To confirm that the results were not compromised by the six levels of the Time and associated α level correction, a separate independent-samples t-test was carried out for the specificity between positive and negative emotions at Baseline, where the *Mean Difference* between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm that the Korsakoff patients had a lower specificity between positive and negative emotions than control participants ($t(37)=2.21$, $p=.034$).

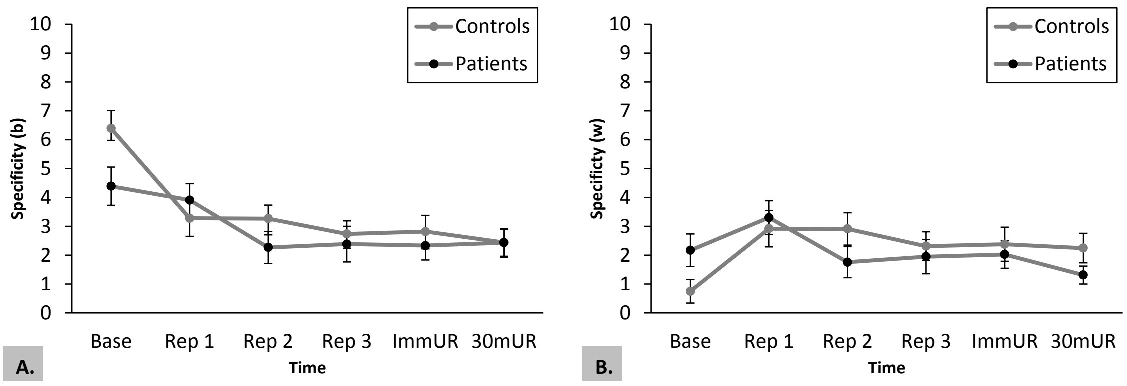

Figure 103. The specificity between positive and negative emotions (A.) and the specificity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *fear* story.

At Baseline, the Korsakoff patients' specificity between positive and negative emotions was lower, and the specificity within negative emotions was higher than those of the control participants, respectively. No other differences between the two groups were found.

A 2x6 mixed-factorial ANOVA was used to assess the differences between the specificity within negative emotions for the two groups. The results confirmed a significant *Time*Group* interaction ($F(3.80,136.66)=3.08$, $p=.020$, $\eta_p^2=.079$, HF *df*), but no effect of G*roup* ($F(1,36)=.23$, $p=.636$, $\eta_p^2=.006$). The interaction was led by the differences in specificity within negative emotions at Baseline, when contrary to expectations, Korsakoff patients' specificity was significantly higher than that of the control participants ($t(37)=2.06$, $p=.047$, $d=.65$). There were no further differences between the specificity within negative emotions of the Korsakoff patients and control participants after Repetition 1 ($t(37)=0.44$, $p=.661$), Repetition 2 ($t(38)=1.48$, $p=.146$), Repetition 3 ($t(38)=0.47$, $p=.636$), Immediate Unaided Recall ($t(37)=0.46$, $p=.652$), or the 30 minutes Delayed Unaided Recall ($t(38)=1.55$, $p=.129$).

Figure 104 (below) shows the index scores for the accuracy between positive and negative emotions (A.) and within negative emotions (B.) for the Korsakoff patients and the control participants. A 2x6 mixed-factorial ANOVA applied to the indices of accuracy between positive and negative emotions failed to confirm a significant effect of G*roup* (*F(*1,36)=.34, *p*=.563, η_p^2=.009), or *Time*Group* interaction (*F*(1,36)=1.62, *p*=.211, η_p^2=.043, LB *df*). To confirm that the results were not compromised by the six levels of the *Time* factor and associated *α* level correction, a separate independent-samples t-test was carried out for the accuracy between positive and negative emotions at Baseline and 30 minutes Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores were highest. The *t*-test was not significant for Baseline (*t*(37)=1.66, *p*=.104) and 30 minutes Unaided Recall (*t*(38)=1.12, *p*=.269).

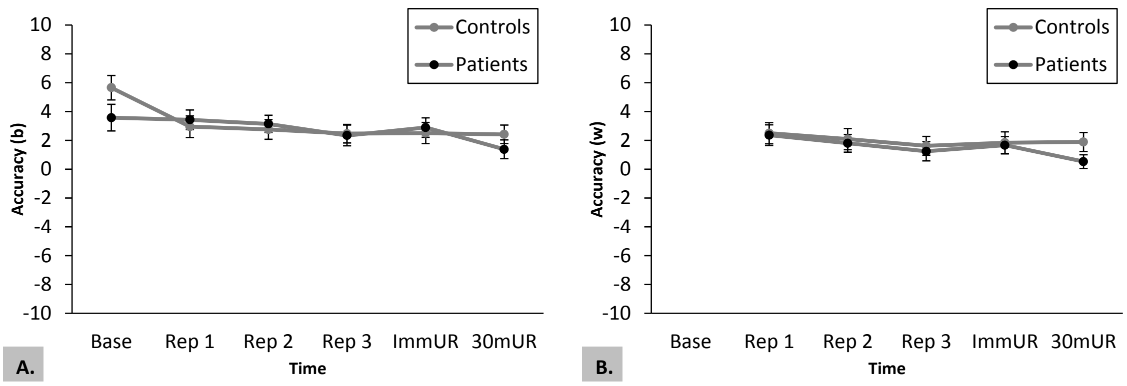

Figure 104. The accuracy between positive and negative emotions (A.) and the accuracy within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *fear* story.

There were no differences between the accuracy indices of the Korsakoff patients and the control participants.

A 2x5 mixed-factorial ANOVA tested the differences between the accuracy within negative emotions for the two groups. The results failed to find an effect of G*roup* (*F(*1,36)=.61, *p*=.440, η_p^2=.017), or *Time*Group* interaction (*F*(4,144)=.70, *p*=.592, η_p^2=.019). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after the Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test was not significant ($t(38)=1.69$, $p=.099$).

In conclusion, following the presentation and recall of the *fear* story the Korsakoff patients showed a higher intensity between positive and negative emotions after the 30 minutes delayed recall, higher specificity within negative emotions and lower specificity between positive and negative emotions at Baseline, when compared to the control participants. The surprising findings from the *anger* story, regarding the decreased accuracy between positive and negative emotions, and within negative emotions were not strong enough to be confirmed by inferential tests. However, a detailed view of the data (see Figure 105 below) shows that a minority of patients reported negative emotional accuracy between positive and negative emotions and within negative emotions. As before, this indicated that the respective Korsakoff patients experienced significant levels of *happiness* and other negative emotions (instead of *fear*).

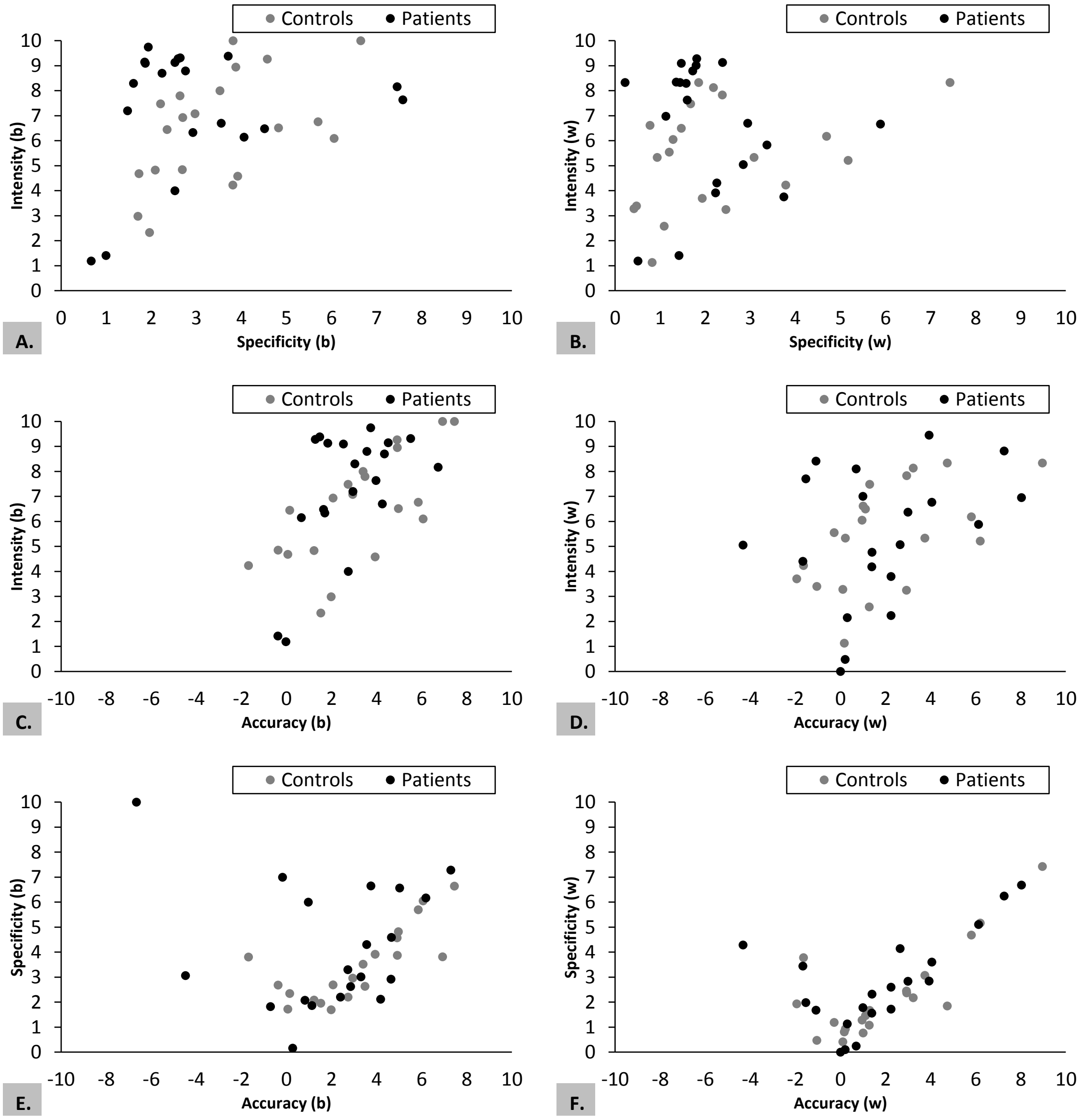

Figure 105. The average intensity, specificity and accuracy between positive and negative emotions (A., C., and E.) and within negative emotions (B., D., and F.) for Korsakoff patients and elderly controls after the presentation and recall of the *fear* story. Although not statistically significant for the group analysis, some Korsakoff patients had a negative emotional accuracy following the presentation and recall of the *fear* stories.

The emotional re-experience following the *fear* story suggests that the Korsakoff patients and elderly controls experienced similarly intense and specific emotions following the presentation and recall of the anger stories. Although the Korsakoff patients had a more intense overall emotional experience (between positive and negative emotions) after the 30 minutes Delayed Unaided Recall, this was not carried over into a higher specificity or accuracy of the emotional experience. Previously identified emotion regulatory processes leading Korsakoff patients to experience more increased levels of *happiness* and other non-target negative emotions than the control participants after the 30 minutes delay were not statistically confirmed. However, similarly with the anger stories, a few patients and to a lesser extent control participants indicated this trend, but the effect did not reach significance. The Baseline differences between Korsakoff patients and control participants, indicated that the patients group had somewhat lower levels of *happiness* and more specific (although not more intense) negative feelings before the beginning of the experimental emotion elicitation procedure.

4.5.3 The intensity, specificity and accuracy of the affective re-experience of the Korsakoff patients and elderly controls after the *sadness* story

Figure 106 (below) shows the index scores for the intensity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA failed to confirm a significant effect of G*roup* (*F(*1,38)=1.55, *p*=.221, η_p^2=.039), or *Time*Group* interaction (*F*(1,38)=2.08, *p*=.157, η_p^2=.052, LB *df*). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after Repetition 2 and 30 minutes Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm a significant difference after Repetition 2 (*t*(38)=-1.78, *p*=.084), or 30 minutes Delayed Unaided Recall (*t*(38)=-1.66, *p*=.105).

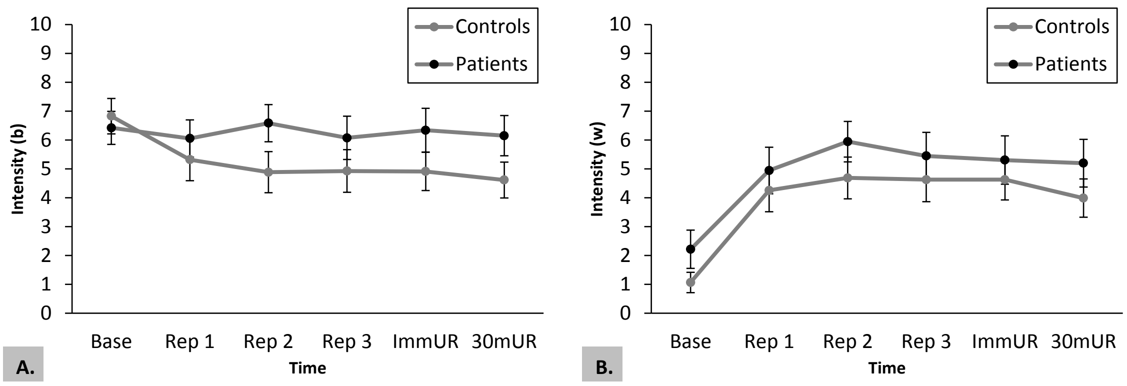

Figure 106. The intensity between positive and negative emotions (A.) and the intensity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *sadness* story.
There were no differences between the intensity of the emotional experience of Korsakoff patients and control participants, either between positive and negative emotions or within negative emotions.

A 2x6 mixed-factorial ANOVA tested the differences between the intensity within negative emotions for the two groups. The results showed no effect of G*roup* (*F(*1,38)=1.20, *p*=.280, $\eta_p{}^2$=.031), or *Time*Group* interaction (*F*(1,38)=.23, *p*=.636, $\eta_p{}^2$=.006, LB *df*). The main effect of *Time* is presented in sections 4.4.2.2.3 and 4.4.3.2.3.

Figure 107 (below) illustrates the specificity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. Possible differences in the intensity between positive and negative emotions of Korsakoff patients and elderly controls were compared using a 2x6 mixed-factorial ANOVA. The results failed to confirm a significant effect of G*roup* (*F(*1,38)<.01, *p*=.973, $\eta_p{}^2$<.001), or *Time*Group* interaction (*F*(1,38)=.72, *p*=.401, $\eta_p{}^2$=.019, LB *df*). The main effect of *Time* is presented in sections 4.4.2.2.3 and 4.4.3.2.3.

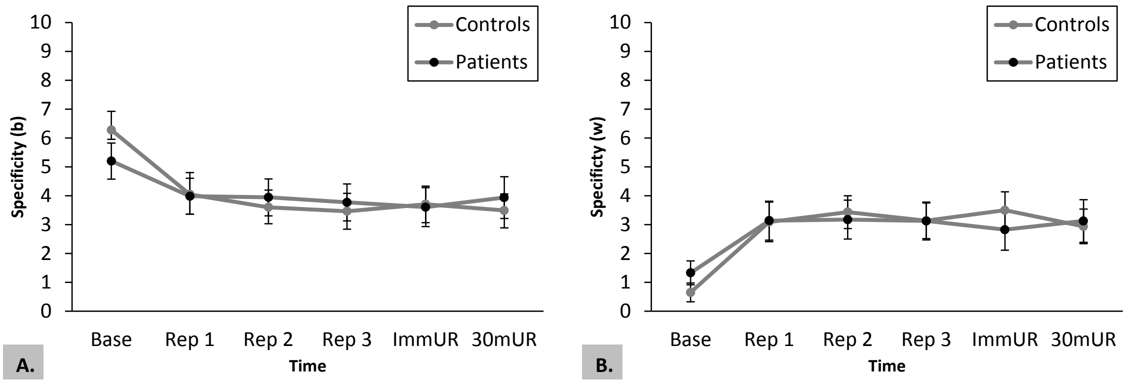

Figure 107. The specificity between positive and negative emotions (A.) and the specificity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *sadness* story.

There were no differences between the specificity of the emotional experience of Korsakoff patients and control participants, either between positive and negative emotions or within negative emotions.

A 2x6 mixed-factorial ANOVA was used to assess the differences between the specificity within negative emotions for the two groups. The results failed to confirm an effect of G*roup* (*F(*1,38)<.01, *p*=.997, η_p^2<.001), or *Time*Group* interaction (*F*(1,38)=.64, *p*=.427, η_p^2=.017, LB *df*).

Figure 108 (below) shows the index scores for the accuracy between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA failed to confirm a significant effect of G*roup* (*F(*1,38)=.96, *p*=.334, η_p^2=.025), or *Time*Group* interaction (*F*(1,38)=.77, *p*=.385, η_p^2=.020, LB *df*). The effect of *Time* is presented in sections 4.4.2.2.3 and 4.4.3.2.3. To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions at Baseline and after the Immediate Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest.

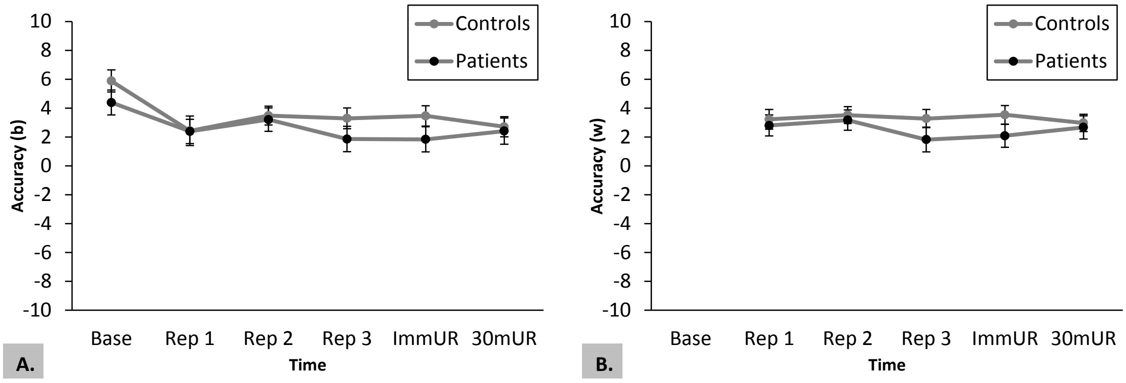

Figure 108. The accuracy between positive and negative emotions (A.) and the accuracy within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *sadness* story.

There were no differences between the accuracy of the emotional experience of Korsakoff patients and control participants, either between positive and negative emotions or within negative emotions.

A 2x5 mixed-factorial ANOVA tested the differences between the accuracy within negative emotions for the two groups. The results showed no effect of G*roup* ($F(1,38)=.75$, $p=.392$, $\eta_p^2=.019$), or *Time*Group* interaction ($F(1,38)=1.80$, $p=.188$, $\eta_p^2=.045$). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after Repetition 2 and the Immediate Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-tests were not significant after Repetition 3 ($t(38)=1.36$, $p=.182$) or Immediate Unaided Recall ($t(38)=1.42$, $p=.164$).

In conclusion, there were no differences between the Korsakoff patients and the control participants following the repetition and recall of the *sadness* story. Previously identified difference for the accuracy indices (both between positive and negative emotions and within negative emotions) after the 30 minute delayed recall were not confirmed. As shown in Figure 109 (below) fewer Korsakoff patients had negative accuracy indices, and their values were more modest than in the case of *anger* and *fear* stories.

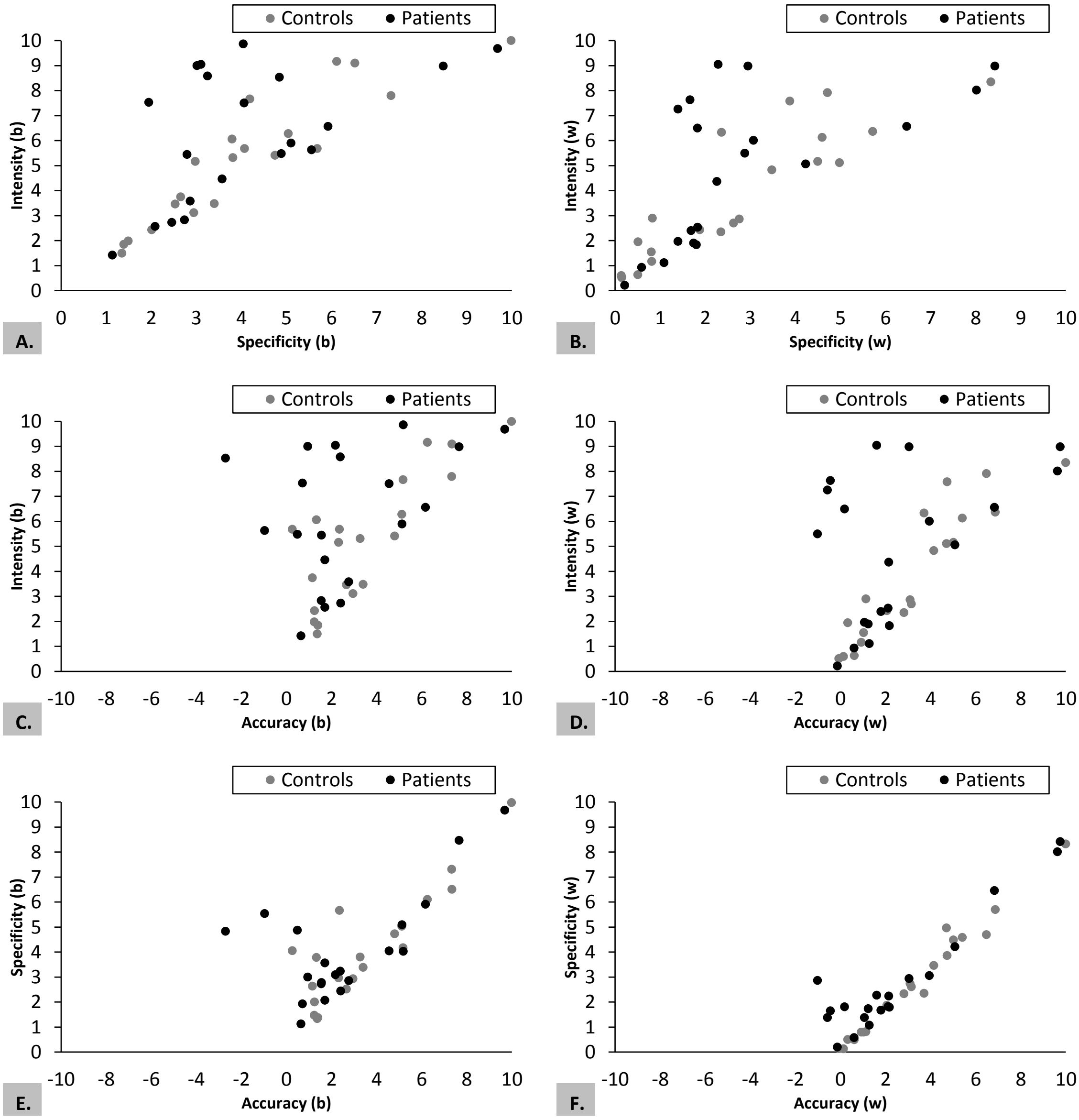

Figure 109. The average intensity, specificity and accuracy between positive and negative emotions (A., C., and E) and within negative emotions (B., D., and F.) for Korsakoff patients and elderly controls after the presentation and recall of the *sadness* story.

Although not statistically significant for the group analysis, two Korsakoff patients had a negative emotional accuracy following the presentation and recall of the *sadness* stories.

The emotional re-experience following the *sadness* story suggests that the Korsakoff patients and elderly controls experienced similarly intense, specific, and accurate emotions following the presentation, immediate and delayed recall. Only two Korsakoff patients reported higher rating of *happiness* than *sadness*, but the magnitude of differences was not enough to indicate a difference between patients and control participants.

4.5.4 The intensity, specificity and accuracy of the affective re-experience of the Korsakoff patients and elderly controls after the *happiness* story

Figure 110 (below) shows the index scores for the intensity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. A 2x6 mixed-factorial ANOVA performed on the indices of the intensity between positive and negative emotions failed to confirm a significant effect of G*roup* ($F(1,36)=1.03$, $p=.316$, $\eta_p^2=.028$), or *Time*Group* interaction ($F(1,36)=.44$, $p=.511$, $\eta_p^2=.012$, LB *df*). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions after 30 minutes Delayed Unaided Recall, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm a significant difference ($t(37)=-1.33$, $p=.192$).

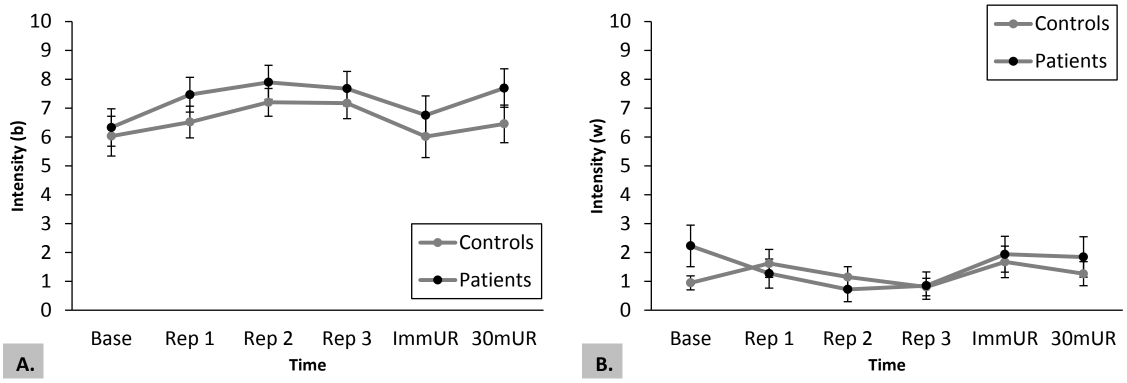

Figure 110. The intensity between positive and negative emotions (A.) and the intensity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *happiness* story.
There were no differences between the intensity of emotional experience of the Korsakoff patients and the control participants.

A similar 2x6 mixed-factorial ANOVA tested the differences between the intensity within negative emotions for the two groups. The results showed no effect of G*roup* (*F(*1,36)=.24, *p*=.624, η_p^2=.007), or *Time*Group* interaction (*F*(3.79,136.48)=1.33, *p*=.256, η_p^2=.036, HF *df*). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions at Baseline, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to confirm a significant difference (*t*(38)=-1.69, *p*=.099).

Figure 111 (below) illustrates the specificity between positive and negative emotions (A.) and within negative emotions (B.) for the two groups of participants. Possible differences in the intensity between positive and negative emotions of Korsakoff patients and elderly controls were compared using a 2x6 mixed-factorial ANOVA. The results failed to confirm a significant effect of G*roup* (*F(*1,36)=.45, *p*=.506, η_p^2=.012), or *Time*Group* interaction (*F*(1,36)=.79, *p*=.380, η_p^2=.021, LB *df*) for the specificity between positive and negative emotions.

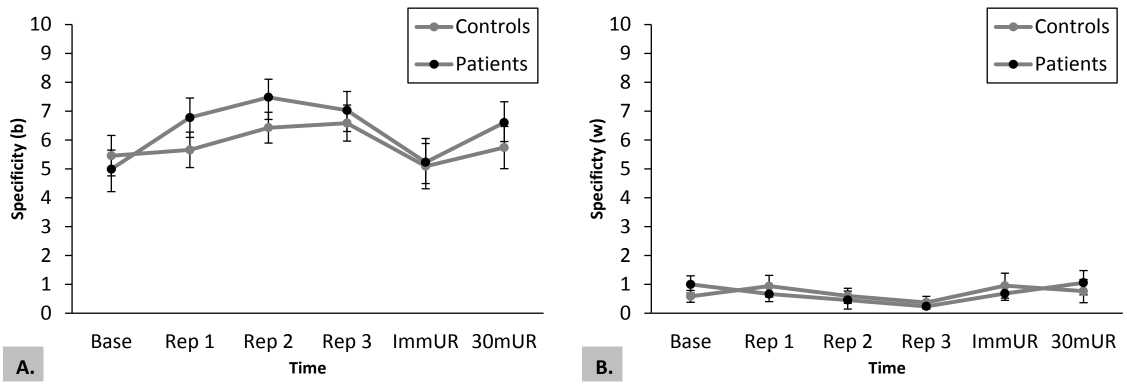

Figure 111. The specificity between positive and negative emotions (A.) and the specificity within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *happiness* story.

There were no differences in the specificity of the emotional experience (between positive and negative emotions, or within negative emotions) for the Korsakoff patients and control participants.

A 2x6 mixed-factorial ANOVA assessed the differences between the specificity within negative emotions for the two groups. The results failed to confirm an effect of G*roup* ($F(1,36)<.01$, $p=.964$, $\eta_p^2<.001$), or *Time*Group* interaction ($F(1,36)=.51$, $p=.482$, $\eta_p^2=.014$, LB *df*).

Figure 112 (below) shows the index scores for the accuracy between positive and negative emotions (A.) for the two groups of participants. A 2x6 mixed-factorial ANOVA failed to confirm a significant effect of G*roup* ($F(1,36)=.07$, $p=.793$, $\eta_p^2=.002$), or *Time*Group* interaction ($F(1,36)=1.19$, $p=.282$, $\eta_p^2=.032$, LB *df*). To confirm that the results were not compromised by the six levels of the *Time* factor and associated α level correction, a separate independent-samples t-test was carried out for the intensity between positive and negative emotions at Baseline, where the Mean Difference between the Korsakoff patients' and control participants' scores was highest. The *t*-test failed to report a significant difference between the two groups ($t(38)=1.36$, $p=.181$).

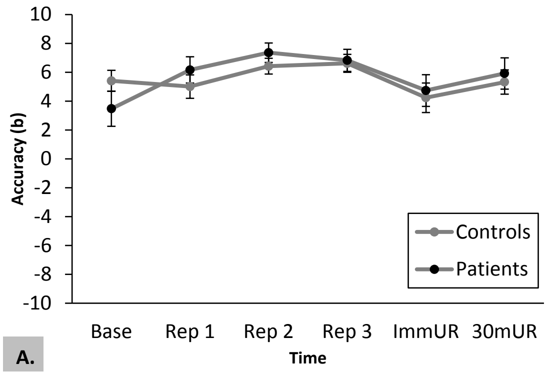

Figure 112. The accuracy between positive and negative emotions for Korsakoff patients and elderly controls after the presentation and recall of the *happiness* story. There were no differences between the accuracy of the emotional experience between the Korsakoff patients and the control participants.

In conclusion, following the presentation and recall of the *happiness* story, Korsakoff patients and elderly control participants reported similar emotional intensity, specificity and accuracy. The previously reported differences in the accuracy of the emotional after the 30 minutes delay for the negative emotions (in particular *anger*) were not observed for *happiness*. Moreover, a detailed inspection of the accuracy scores (see Figure 113 below) showed that only one Korsakoff patient and one control participant recorded negative accuracy scores, indicating that the intensity of one of the negative emotions was marginally higher than *happiness* following the recall of the story. The magnitude of the effect was negligeable and unable to cause a group effect.

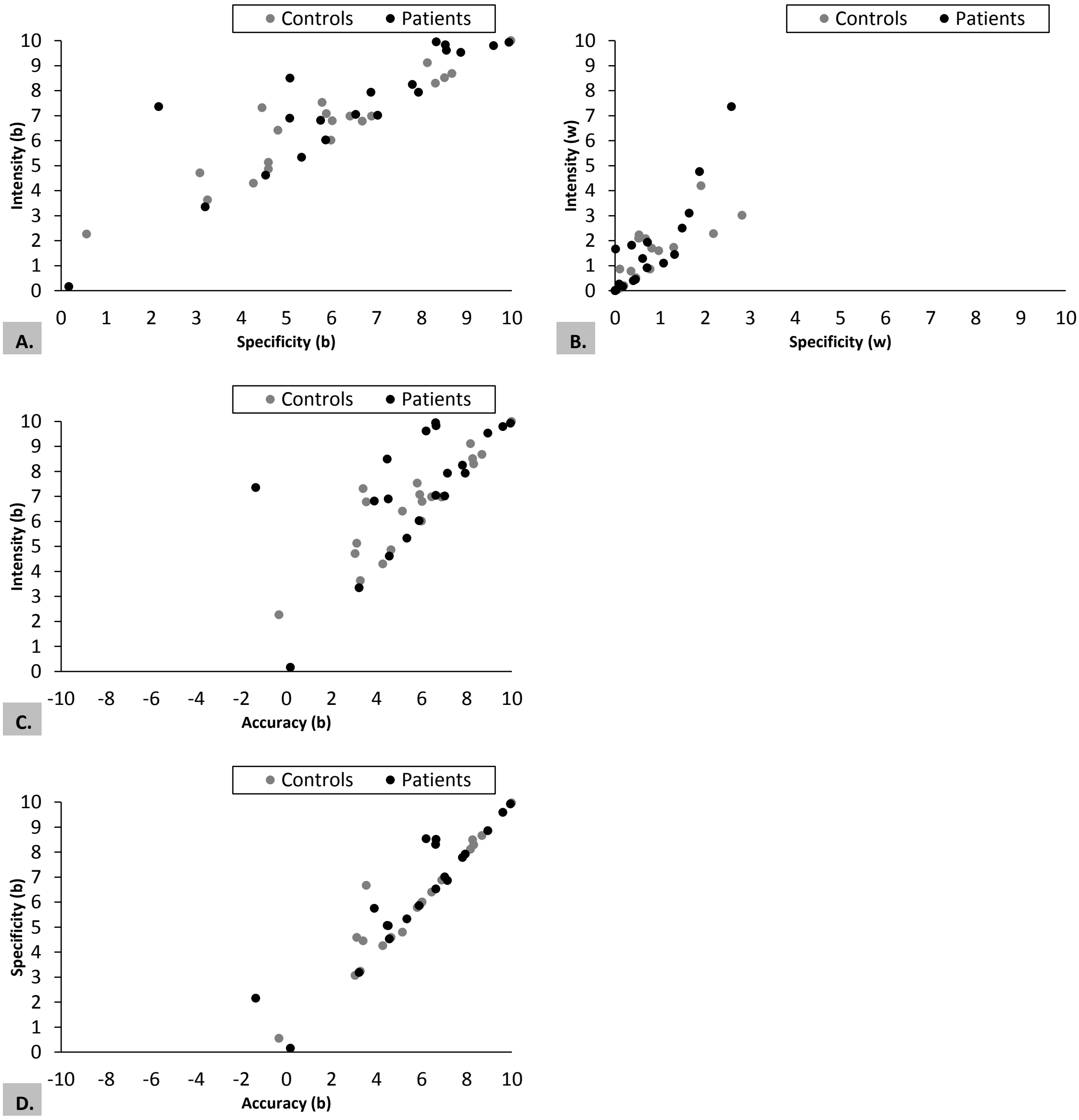

Figure 113. The average intensity, specificity and accuracy between positive and negative emotions (A., C., and D.) and within negative emotions (B.) for Korsakoff patients and elderly controls after the presentation and recall of the *happiness* story.

Only one Korsakoff patient and one control participant had negative emotional accuracy scores following the presentation and recall of the *happiness* story.

The emotional re-experience following the *happiness* story suggests that the Korsakoff patients and elderly controls experienced similarly intense, specific, and accurate emotions as the control participants. Transgressions from the generally high emotional accuracy were only rare exceptions, and of modest magnitudes, unable to influence a group effect. Thus, the Korsakoff patients were just as able to re-experience positive emotions following the presentation and recall of the *happiness* story as were the control participants.

4.5.5 Conclusions on the intensity, specificity and accuracy of the affective re-experience of the Korsakoff patients and elderly controls

The analysis of the intensity, specificity, and accuracy indices revealed a limited number of differences between the Korsakoff patients and elderly controls, summarised in Table 12 below. The anger story produced a unique finding, when a number of Korsakoff patients had a negative emotion accuracy after the 30 minute delay. This was due to patients reporting higher levels of *happiness*, when attempting to recall the anger after 30 minutes. The same findings, but with a lesser magnitude (fewer patients, and lesser negative accuracy) was found for *fear* and to an even lesser extent for the *sadness* story. However, the results were significant only for the *anger* story.

Table 12.

Summary of the comparison between the intensity, specificity and accuracy of the Korsakoff patients and elderly controls. (ns – not significant)

	Anger	Fear	Sadness	Happiness
Intensity (b)	ns	Korsakoff > Control (30minUR)	ns	ns
Intensity (w)	ns	ns	ns	ns
Specificity (b)	ns	Control > Korsakoff (Baseline)	ns	ns
Specificity (w)	ns	Korsakoff > Control (Baseline)	ns	ns
Accuracy (b)	Korsakoff<Control (30minUR)	ns	ns	ns

Accuracy (w)	Korsakoff<Control (30minUR)	ns	ns	ns

The intensity between positive and negative emotions was higher for Korsakoff patients following the presentation and recall of the *fear* story. However, the higher intensity was not accompanied by a higher specificity or emotional accuracy. The finding that the specificity of the Korsakoff patients was different from that of the control participants at Baseline, during the presentation of the *fear* story is probably a sampling variation, and did not seem to relate with or influence any other effects. The *sadness* and *happiness* stories caused a similarly intense, specific and accurate emotional experience for Korsakoff patients and control participants.

4.6 Discussion

The study of discrete emotions is a growing area of research with at least four basic emotions being elicited and studied independently. However, the targeted elicitation of discrete emotion produces the co-activation of other basic emotions at various levels of intensity. The separate measure of the intensity of discrete emotions creates the challenges of finding a method to summarise: (1) the overall intensity of the affective experience; (2) the degree to which a single basic emotion reflects the affective experience (specificity); and (3) the degree to which the experience of a certain target emotion dominates the emotional response (accuracy). The present paper presented a presently unique method of computing a separate index for each of the three constructs (intensity, specificity, and accuracy) separately for negative emotions (anger, fear, and sadness) – thus describing negative affect and for both positive and negative emotions (i.e., anger, fear, sadness, and happiness) – representing the entire spectrum of basic emotions, as it is currently supported by an overwhelming body of literature. Positive affect if currently underpinned by a single basic emotion (happiness), so a separate set of indices are unnecessary.

The intensity index provides a summary of the overall intensity of negative affect and of the overall affective experience. The index reflects the maximum intensity of the basic emotions. Other attempts (PANAS-X, Watson & Clark, 1994; PANAS, Watson, Clark & Tellegen, 1988) have proposed using the average of a set of independent measures of a larger set of emotions to calculate the intensity of positive and negative affect. This approach doesn't benefit a discrete set of basic emotions, whose measures are theorised to represent each emotion construct fully. For example, when intensity measures of rage, frustration, annoyance, resentment, fury, and others, are thought to represent distinct aspects of a construct (i.e., anger), the average of these measures can approximate the overall intensity of anger. However, extrapolating this method to negative affect, or to the overall affective experience would disagree with a fundamental finding of discrete basic emotions, that they each can fully represent the affective experience. If an average method would be used, then the intensity of an affective experience where someone feels moderately angry, afraid and sad at the same time, would be the same as the intensity of another affective experience when somebody feels extremely angry, but not at all sad, or afraid. This would clearly misrepresent the ability of anger to describe the affective experience entirely. The method proposed in the present paper argues that the overall intensity of affect should be considered as the maximum intensity of basic emotions. In the example above, the first affective experience would be of moderate intensity (although muddled between different basic emotions – see below for a discussion of specificity), and the second affective experience would be of extreme (or very high) intensity, and at the same time very precise in the type of emotion experienced (i.e., anger).

The specificity index describes the degree to which a single discrete basic emotion represents the affective experience. The maximum level of specificity for an affective experience is reached when only a single basic emotion is elicited at the maximum level of intensity, and thus, the intensity of all the other basic emotions is nil. The lowest level of specificity is achieved in situations when all basic emotions are at the same level intensity, regardless of the level. For example, an affective experience characterised by very high levels of anger, fear, and sadness would have the same specificity as an experience described by very low levels of the three emotions (provided that the absolute differences between emotions is the same). Thus, specificity alone cannot fully describe the affective experience, but only the *selectivity* of the affective experience. An intensity adjusted specificity index described in the present paper takes into account both the specificity and intensity of the affective experience.

The accuracy index reflects the degree to which a certain discrete target emotion is being experienced at higher levels of intensity than any other (non-target) basic emotion. Although mostly similar, the concept of emotional accuracy differs from emotional specificity in one important aspect: it refers to a predefined target emotion, intended to be elicited by the experimental paradigm, or expected to be experienced in a certain situation, while emotion specificity refers to whichever basic emotion is dominant (i.e., most intense) at a particular time. Thus, while the specificity index always refers to the most intense basic emotion, without providing any information about which discrete emotion it is, the accuracy index refers precisely to a pre-identified discrete emotion, but which may not always be the most intense (see below the discussion for when emotional accuracy takes negative values). The accuracy index (similar with specificity) is always less than, or equal to emotional intensity. This means that an affective experience must first have intensity before it can reach a certain level of accuracy. However, no other information can be implied from the accuracy index about the emotional intensity. Similarly with the specificity index, this limitation is resolved by calculating the intensity adjusted accuracy index.

This presently unique method of calculating affective intensity, specificity and accuracy has two key methodological features. Firstly, it summarises the affective experience on a scale with the same magnitude as the intensities of basic emotions – the commonly used range from zero to 1. The indices for intensity and specificity take positive values only, similarly with the intensities of basic emotions. The accuracy index takes values on a symmetrical interval around zero (from –10 to 10). Negative values are obtained in situations when a target discrete emotions was not elicited at higher levels of intensity than the other non-target emotions. This would amount to a failure in eliciting the target emotion discretely (as other emotions dominate the affective experience), and thus a negative value of the accuracy index seems most informative. Furthermore, the method can be easily adjusted to accommodate other scale (e.g., zero to 100), should the benefit of using other ranges be established.

Secondly, the present method is easily expanded from its current form to a potentially limitless number of discrete basic emotions. The concepts of intensity, specificity and accuracy prevail the exact number and choice of basic emotions. In their current form, the intensity, specificity and accuracy indices are computed for negative and overall affect from the individual intensity ratings of three (i.e., *anger*, *fear*, and *sadness*) and four basic emotions, respectively (adding *happiness* to the previous three). This was determined by the currently overwhelming empirical evidence (Bloch, Lemeignan, & Aguilera, 1991; Cacioppo, Berntson, Klein, & Poehlmann, 1997; Collet, Vernet-Maurym, Delhomme, & Dittmar, 1997; Lench, Flores, & Bench, 2011; Rainville, Bechara, Naqvi, & Damasio, 2006; Stephens, Christie, & Friedman, 2010; Tettamanti, Rognoni, Cafiero, Costa, Galati, & Perani, 2012; Vytal & Hamann, 2010) that the present four discrete emotions indeed meet the standard of basic affective states. However, future investigations may potentially reveal sufficient evidence to consider other emotion states as basic forms of affect, such as *disgust* (see Vytal & Hamman, 2010), and also, perhaps, other discrete positive emotions alongside *happiness*. Such findings would only reinforce the importance and application of the current concepts of intensity, specificity, and accuracy, and would potentially extend them to positive affect. The computational formulae for the respective indices could be easily derived from the ones presented in the current model.

A final consideration should be given to the fact that the intensity, specificity, and accuracy of the affective experience are potentially affected by various underlying traits or emotion processes unique to every individual. Thus, their index would be best used in repeated measures designs, in order to control for individual differences. Difference in emotional intensity, specificity, or accuracy between people (or groups of people) in response to the same stimulus (or situation), as well as different patterns between individual basic emotions could reflect affective and cognitive neural processing differences. As this paper introduces the concepts and formalises the method for calculating the three concepts, further studies need to establish the factors that influence and correlate with the intensity, specificity and accuracy of the affective experience.

In conclusion, the present paper presented the concepts of affective intensity, specificity, and accuracy for negative and overall affect together with a method to calculate their respective values from the intensity measures of four discrete basic emotions (*anger*, *fear*, *sadness*, and *happiness*). A simulation of the possible values taken by the specificity and accuracy indices was included. The study of basic emotions requires the means to calculate the degree to which the emotional experience has a specific discrete flavour, or is made up of multiple emotions. Moreover, emotion elicitation paradigms targeting a certain basic emotion need to assess the degree to which the targeted emotion has been elicited at superior levels of intensity to other non-target emotions. The present paper presented the only method to date which allows to calculate precisely these concepts. Notably, the method allows for the integration of other basic emotions beyond the current four with slight arithmetic adjustments. Further research is required to better understand the determinants and covariates of the affective intensity, specificity and accuracy, for each discrete emotion.

Chapter 5. Final discussion and conclusions

Final discussion and conclusions

The present thesis aimed to expand for the first time the study of emotional memory in amnesia to the level of four discrete classes of emotions (anger, fear, sadness, and happiness). The first objective was to investigate the possible hierarchical organisation of affect, which would bring together the long established but seemingly divergent findings supporting the dimensional and categorical theories of emotions. The stability of valence – a long established dimension of emotional experience was compared with the stability of emotion categories, in situations eliciting discretely each of the four basic classes of affect. The empirical question (addressed in Chapter 2) was whether the valence of an affectively conditioned stimulus can be re-experienced for longer than its discrete category. This was be the first direct investigation of the stability of affective valence and discrete emotions over time.

A second objective of the thesis was to investigate which aspects of an emotional event need to be recalled in order to elicit the original discrete emotions. Specifically, in Chapter 2, an affective conditioning paradigm was used to test the emotional re-experience of both neutral and emotional material, over time, following the presentation and episodic recall of four sets of stories generating discretely each of the four basic emotions (anger, fear, happiness, and sadness).

Thirdly, the thesis examined for the first time the re-experience of the four discrete classes of emotions in amnesic (Korsakoff's syndrome) patients and the differences compared to neurologically normal controls. The relationship between episodic recall and the experience of each of the four discrete emotion classes was also addressed in Chapter 3, while the relationship between core executive functions and the intensity of the emotional re-experience of the four distinct basic emotions was also explored in Chapter 3.

Finally, in light of the previous findings and supported by the rich data on emotion experience collected during the project, the thesis introduced the concepts of affective intensity, specificity and accuracy, and presented a computational method for calculating the respective indices using the individual intensities of the most common four basic emotions (anger, fear, sadness, and happiness), both for negative and overall affect. The conceptual and procedural definitions of the indices were presented in Chapter 4, while a first application of the indices on the datasets collected during the previous two studies and the first novel findings using this set of indices were also presented in Chapter 4.

5.1 Summary of main findings

The most notable finding reported in the present thesis (see Chapter 3) refers to the preserved ability of amnesic (Korsakoff's syndrome) patients to re-experience discretely each of four discrete classes of emotions (anger, fear, sadness and happiness) at similar levels of intensity as neurologically normal controls, despite a substantial memory impairment. Furthermore, even those patients who could not recall anything from the emotional stimulus, reported experiencing the target emotion discretely, at significantly high levels of intensity. Although the ability of amnesic patients to reliably re-experience past emotions without being able to reproduce the events that initially triggered these emotions has been well documented in the past (Chapelle, Philippot, & van der Linden, 2007), this was the first report that emotional memory encodes and reactivates individual basic emotions (anger, fear, sadness, and happiness), and not just for *generic* positive or negative affect. Moreover, previous suggestions (Feinstein, Duff, & Tranel, 2010) that, perhaps, certain classes of emotions (e.g., sadness) could be more durable in the case of amnesics than neurologically normal controls were not supported by the present findings. Thus, a greater ability of affective systems was revealed, to accurately encode and reactivate specific classes of emotions with limited or even with no input at all from episodic memory systems.

As the ability to re-experience discrete classes of emotions was preserved in profoundly amnesic patients, the immediate question to ask was which variables can predict the intensity of the emotional memory for discrete emotions. In light of the previous findings, it was unsurprising that there was no relationship between episodic memory ability and the intensity with which the four discrete classes of affect are re-experienced. The literature suggested that other cognitive functions could be likely factors to affect the re-experience of discrete emotions. Chapter 3 showed that the intensities of fear, sadness, and happiness were consistently associated with executive functions, such as, cognitive flexibility, response inhibition and non-verbal fluency, and Processing Speed, and Performance IQ from WAIS. In the present context, the results failed to find a relationship between the intensity of anger and any executive functions, and only showed an association with the Verbal Comprehension task from Wechsler Adult Intelligence Test. Although the statistically significant results are encouraging, the findings are a first attempt to expand the previous literature reporting that emotion regulatory processes rely on prefrontal cortex based executive control.

The unimpaired re-experience of discrete emotions for Korsakoff's syndrome patients is even more significant in light of the results reported in Chapter 2. Amnesic patients have previously been shown to re-experience the correct positive or negative valence of forgotten past events, but the ability to re-experience discrete emotions was never addressed.

Firstly, discrete emotion categories are a more vulnerable form of emotional experience than affective valence, as shown in the first report of a direct comparison between the dimensional structure of affect (represented by valence) and the categorical structure (represented by the four classes of discrete emotions: anger, fear, sadness, and happiness). In terms of the structure of the affective experience, this finding apparently supports the classical dimensional theory of emotions (Russell & Barrett, 1999), at least for the valence dimension. However, the finding is perhaps better explained in the context of the hierarchical theory of emotions (Tellegen et al., 1999) and similar reports from the affective neuroscience (Panksepp, 2004), that emotion valence is a more primordial form of emotional experience than discrete emotions. Thus, despite the unique behavioural and neuroanatomical correlates of discrete emotions, they seem to require, over time, more intense forms of emotion elicitation (e.g., detailed episodic recall) than are needed for the re-experience of affective valence. Furthermore, this indicates that affective valence is the last form of affect that is retained and re-experienced when the potency of a past emotional stimulus has faded, or in the absence of further integration of more complex cognitive material (e.g., episodic recall and executive processing).

A direct implication of this finding (and of the hierarchical account) is that is helps bring together two large bodies of the affective science literature which divergently argued that the affective experience is best described either by a series of bipolar dimensions (e.g., valence, and others), or distinct emotion classes (e.g., anger, fear, sadness, happiness, etc.). The present evidence suggests that perhaps the answer to the question “What is the structure of affect?” is that it consists of *both* a dimensional and categorical organisation. The dimensional organisation (according to either a positive or negative valence) is a general, fundamental, archaic, and most durable form of affect. The categorical organisation is a behaviourally and neuroanatomically discrete organisation into at least four classes of affect (anger, fear, sadness, and happiness), that are more emotionally specific in the short term, but that also are more vulnerable to automatic emotion regulatory processes, and thus, less stable over time.

The second finding reported in the present thesis (Chapter 2) that makes the re-experience of discrete emotions in amnesia even more unlikely, comes from a neurologically normal sample of undergraduate students. The semantically neutral material (story beginnings) associated with the emotional story *endings* (eliciting basic emotions discretely) is not enough to re-experience the original emotion, even when the event is known, but not consciously recalled and vocalised. However, the active recollection of the emotionally specific material, invariably elicits the correct target emotion, and notably, at similar levels of intensity across discrete emotions. The emotional experience following the active episodic recall of the eliciting event retains its initial affective class specificity, for each of the four basic emotions (anger, fear, sadness, and happiness). Thus, the process of formal detailed recall is central for a full and emotionally discrete affective re-experience.

In a wider context, this finding suggests that *reducing* or *enhancing* the active recollection of a past emotional event affects in a similar direction the magnitude of the affective re-experience. The present evidence provides support to similar reports from the emotion disorders and the emotional well-being literature that affective processes can be readily up- or down-regulated by increasing or reducing the magnitude of episodic recall.

Finally, the thesis introduced the concepts of affective intensity, specificity and accuracy, both for negative and overall affect, based on the experience of discrete classes of emotions (anger, fear, sadness, and happiness), and presented a flexible computational model which can be easily adapted to accommodate possible other classes of emotions. The importance of the model is that it allows the direct investigation of the degree to which a single discrete emotion is experienced and differentiates between situations when the discrete emotional experience corresponds (or not) to the affect class targeted by the emotion elicitation paradigm. A simulation of the domains and codomains of the equations used to calculate the indices is presented. A first exploratory application of the indices revealed systematically that *happiness* is *less* specifically (but not less intensely) re-experienced following a brief interference of a negative emotion. And in certain situations (for episodic memory impaired Korsakoff patients), certain classes of negative emotions (anger, fear, but not sadness) are *more* discretely (but not more intensely) re-experienced after a brief interference of a happy moment.

This is a first report of such an emotional interference effect produced consistently for *happiness*, and in an opposite direction for certain classes of negative emotions, experienced by an amnesic population. The novel indices of affective intensity, specificity, and accuracy allowed the calculation of such an effect. These preliminary findings are consistent and expand previous reports (Feinstein et al., 2010; Guzman-Velez et al., 2014) that negative emotions have a potentially greater and more enduring selective relevance when episodic information is no longer available.

Although the present findings seem to be best explained by the hierarchical model of affect, they raise interesting observations and research questions in the context of the constructivist model of emotions (Barrett, 2012; Barrett et al., 2007). The finding reported in the present thesis most closely linked with the concept of core affect and the psychological construction of emotions is that the re-experience of discrete emotions is more vulnerable (over time) than the re-experience of affective valence (see Chapter 2). Firstly, the pleasure-displeasure dimension of the affective re-experience following the presentation of the story *stems*, was reliably evidenced by the emotion self-report ratings of the student sample, after 7 days from the initial presentation. This finding can be associated with the concept of *core affect*, whose experience is viewed as the most fundamental conceptualisation of affect (Russell, 2003). Secondly, the discrete re-experience of the target emotions following the presentation of the story *stems* after 30 minutes, but not after 7 days, suggests that the processes of psychological construction can manifest in the absence of the conscious and explicit recollection of the eliciting stimuli, but only for relatively short periods of time. The variable nature of the re-experience of emotions is fully acknowledged by the psychological constructivist model, as each emotional experience (and indeed re-experience) is unique. Thus, only efforts to consciously explain, classify, (possibly justify) and certainly communicate the emotional experience determine the use of socially acceptable and established emotion labels (anger, fear, sadness, happiness). Indeed, the processes that allowed participants to report highly specific discrete emotions, consistent with the emotional experience following the story *endings*, after 3o minutes, and not after 7 days may have been cognitive rather than biological. The prime candidates for the psychological processes accessed to recreate the specific emotional reports after 30 minutes are semantic memory processes, or automatic associations between stimuli (story *stems*) and the emotion measures (the ratings of emotions). In light of this account, participants may have either implicitly or explicitly retained and recalled their ratings of the associated story *endings* and reproduce them following the story *stems* after 30 minutes. However, a week later, their initial ratings may not have been readily and accurately remembered, other than the fact that they were definitely not happy stories/situations. There is a considerable conceptual overlap between semantic processes (e.g., Was this a anger story, or a fear, sadness, happiness story?), episodic processes (e.g., Which parts of this story would make me feel angry, or afraid, sad or happy?), and emotion memory processes (e.g., How does this story *stem* actually make me feel in the present?), and isolating one set of processes (e.g., emotional memory) from the others is more challenging using self-report measures of emotions. Experimental manipulations (e.g., specific orienting tasks, dissimulation of experimental goals) and analysis techniques (e.g., inter-participant variability) can help to some extend limit the risk of measurement artefacts and increase the confidence in the findings. However, the use of multiple concomitant measures of affect (especially implicit measures of physiology and functional neuroimaging) can provide the strongest indication of which processes are involved in the emotional re-experience following the presentation of the *contexts* (i.e., story *stems*) surrounding memories that elicit highly specific and discrete emotional states.

The Korsakoff patients' discrete re-experience of the four target emotions, following a severely (albeit not completely) impaired recall of the eliciting stimuli suggests that the psychological construction of the affective experience could be decoupled, at least in part, from episodic memory systems. Following their poor performance on the free recall task, amnesic patients integrated limited information about the episodic experience, associations between the different elements of the stories and the categorisation of the pattern of elements into discrete classes of affect. As the episodic material reproduced was significantly reduced (and in few, distinct cases nil), different processes were required to generate the emotional ratings. The surprising finding is that the specificity of the emotional experience remained unchanged (for all four discrete emotions) during the initial three presentations, as well as immediately after interference and after the 30 minutes delayed recall. The robustness of the psychological construction of each of the four discrete emotions suggests that either the processes of the emotional experience were very strongly and reliably inter-related, or perhaps other competing cognitive processes acted as a substitute. Although the episodic memory of the Korsakoff patients was overall severely impaired, most patients correctly recalled a small number of details from each story, while some were unable to recall anything. However, the emotional experience was not related to the number of episodic details recalled, and, notably, some of the patients unable to recall anything from the stories reported high levels of the target emotion. Thus, associations between limited cues from the stories led to the accurate and discrete re-experience of the target emotions.

Despite their different formulation, the hierarchical theory of affect (Tellegen, Watson, & Clark, 1999) and the constructivist view of emotions (Barrett, 2012) share many conceptual elements. Firstly, both accounts acknowledge that affective valence, (i.e., positive and negative affect) is a fundamental dimension of the emotional experience, and as shown in Chapter 2 appears to be the most stable form of affect over time. Secondly, both accounts recognise that discrete emotion classes are a secondary form of emotional experience, crucial to the conscious, subjective conceptualisation of the emotional experience. The processes underpinning the experience of discrete emotions are still debated in the literature, and the two accounts take different views in this respect; the hierarchical theory proposes biological factors, while the constructivist view suggests psychological process. Nonetheless, the ability to re-experience or at least to subjectively identify the re-experience of discrete classes of affect seems to be limited over time in comparison with the re-experience of affective valence. Furthermore, episodic memory processes (when impaired) can be successfully substituted in the attempt to instantiate the experience of discrete emotions, as was reported by the Korsakoff patients (Chapter 3).

5.2 Limitations of findings

The present thesis provided the first direct evidence that affective valence and discrete emotion classes can both contribute simultaneously to defining the structure of affect, with valence being a more enduring and stable form of affect, while discrete emotions require a stronger form of emotion elicitation in order to be re-experienced fully. Secondly, the thesis expanded the investigation of emotional memory in amnesia to a specific set of four discrete emotions (anger, fear, sadness, and happiness), and showed that amnesic (Korsakoff's syndrome) patients can experience discretely each of the four classes of affect even when they can remember very little, or indeed almost nothing at all from the emotion eliciting event. A possible relationship between the amount of episodic recall and the intensity of the emotional re-experience was shown to be non-existent. A possible relationship was revealed between core executive functions and the intensity with which certain discrete emotions were experienced. Finally, a series of novel indices was introduced which are able to summarise and describe the affective experience in ways not possible with traditional measures of emotions.

5.2.1 Self-reports of emotional experience

The self-report measures of emotions are generally regarded as the most efficient forms of assessing the affective experience, and are widely employed in experimental and clinical work. They provide great flexibility regarding the choice of emotions and are particularly preferred for the study of discrete classes of emotions, where alternative types of measures (physiological, neuroimaging, behavioural) do not provide (or provide only a limited) specificity. The basic premise of emotion self-reports is that people know their own emotional states best. However, data from self-reports are not always straightforward to interpret. Numerous socio-psychological factors can influence the validity of a response. These include the ability of a respondent to articulate his or her deeper thoughts or feelings; the motivation of the respondent to respond fully; the urge to respond in socially desirable ways; and biases introduced by the construction of the questioning sequences, etc.

The validity of self-report measures relies on two fundamental assumptions, that participants are (1) *able*, and (2) *willing* to observe and report their own emotions. Although self-report measures provide a valuable opportunity to collect information about the affective experience in an integrated and standardised format, they only assess the explicit forms of emotional expression, accessible to conscious experience, and do not provide any information regarding the implicit forms of affect. Nonetheless, the subjective form of the emotional experience, of which people are conscious and aware, forms an important part of the affective life and its assessment is uniquely served by self-reports measures, as long as the fundamental assumptions of *ability* and *willingness* are met.

Firstly, a valid use of self-report measures of emotions requires that participants possess the ability to monitor, assess, and integrate information about their own emotions. Such abilities rely heavily on intact executive and limbic system functioning. Thus, when used to assess the emotional experience of neurological patients, lesion screening and neuropsychological testing are essential.

The second issue of *willingness* is an important concern for all forms of subjective self-report measures, namely that participants’ response might be influenced by factors not contained by the variable under investigation. The most frequently discussed response set is that of social desirability (Diener, Smith & Fujita, 1995). Attempts to limit such effect often dissimulate the true goal of the study until the end of the study (as was the case in the current investigation).

A different potential limitation of self-report measures of emotions concerns the effects of repeated assessments. The repeated use of emotion self-reports during an experimental paradigm raises concerns regarding *measurement independence*. This is a form of stereotypic responding (Stone, 1995), which is observed when participants settle into a response profile that does not change over time. The effect is usually reflected in the standard deviations of the self-report measures across assessment occasions. The stereotypic responding relies on participants remembering their previous ratings, and the artefact can affect neurologically normal as well as amnesic participants, since the semantic memory systems necessary for this response set are intact in both groups. Self-report measures using Liker-type scales are particularly vulnerable (as participants often tend to remember the phrasing of their initial rating, e.g., “moderate”, or “very high”, etc.). Visual analogue scales (as used in the present investigations) offer more protection against this artefact, as participants are not given a verbal anchor for their responses. Complex visual information involving proportions from the end of the scales are usually more difficult to encode and retrieve. Moreover, using a set of discrete emotions, presented in an unpredictable order, further disrupts the memory effects.

In conclusion, the use of emotion self-reports in the present studies provided an efficient form of collecting information about participants’ experience of discrete emotions, at key moments during the experimental paradigm. Methodological decisions regarding the orienting task of the emotion elicitation paradigm, and emotional assessment have helped to dissimulate the true nature of the study and reduce demand characteristics. The choice of visual analogue scales (instead of classical Likert scales), and the presentation of the measured of the four discrete emotions in a counterbalanced and unpredictable order helped to reduce any memory effects that participants might show, especially in the case of Korsakoff patients, whose reliance on semantic information to make sense of situations they no longer remember is well documented.

However, the lack of multiple methods of assessing emotional experience remains an important limitation of the studies. The decision not to include physiological and neuroimaging measures was guided by their low sensitivity for the four discrete emotions investigated, and practical aspects of conducting the field work (especially involving the Korsakoff patients). Future studies could re-examine the findings reported in the present studies by employing different measures of emotional experience, in particular assessing the physiology and neural activity associated with the affective re-experience.

5.2.2 The structure of affect

The fundamental structure of affect is an essential aspect of understanding the emotional experience, and the on-going debate between the two most influential theories of emotions is still in need of a resolution, and most likely a reconciliation of positions. The hierarchical theory of emotions offers such a solution, and the findings reported in the present thesis contribute in a direct way to supporting this approach. However, further evidence is needed to inform the wider aspects of the theory and integrate the multitude of findings subscribed to each of the two original theories (dimensional and categorical).

As a first investigation of its kind, the present thesis employed only behavioural, self-report measures of emotions. This choice was justified by the fact that a novel set of stimuli were needed to address the specific research questions of the thesis, and they required an initial validation. Moreover, the novel research questions addressed in the thesis were substantially distant from the established findings that they needed a first layer of evidence before more costly investigative techniques could be justified. The neuroscientific evidence is by far the most influential and informative form of evidence in the field of affective science. Thus, further studies using neuroimaging techniques can further expand present findings.

5.2.3 Discrete emotions in amnesia

Studies of neurological patients most commonly involve neuroimaging data and lesion analysis. However, previous brain scans of the patients reported in this thesis were not available (if they were ever taken), and logistical related to the geographical distance of patients from Bangor University meant that dedicated neuroanatomical and functional MRI scanning of patients was impractical. This prevented an analysis of the range and severity of brain lesions/atrophy, and would have been particularly useful, since Korsakoff patients showed comparatively poorer executive function scores than neurologically normal, age-matched controls. However, it is not uncommon for early investigations to employ methodologically efficient tools, to test new phenomena, before a wider range of approaches is used. The present investigation of emotional memory for discrete classes of emotions in amnesia relied on behavioural self-report measures and free recall of emotions. These were enough to confirm a poor episodic memory of patients, while the majority of patients showed an emotional response to the experimental stimuli similar with those of control patients (despite the significant episodic memory deficit). The behavioural reports of episodic memory and emotional re-experience were consistent with the clinical diagnosis, the treatment and the care received by all patients for Korsakoff's syndrome. Furthermore, neuroimaging scans of Korsakoff's syndrome patients are not always revealing, and are not routinely employed in diagnosis (NICE, 2014).

5.3 Directions for future research

The present thesis revealed fundamental aspects of the ability to re-experience emotions both in the presence and absence of episodic recall. The experience of affective valence was found to be more durable than that of discrete emotion classes, which showed that perhaps valence (a long-recognised dimension of affect) is a stronger, more fundamental form of affect than discrete emotion categories. However, both neurologically normal and amnesic (Korsakoff's syndrome patients) were able to re-experience discretely all four classes of emotions (anger, fear, sadness, and happiness, as executive function, and not episodic memory seemed to be related to the intensity of the affective re-experience.

Importantly, further questions about emotional re-experience (emotional memory) remain unanswered. Firstly, the contribution of executive functions to emotional memory needs to be explored in more detail, potentially in more neurological studies with patients with different aetiologies of the amnesic syndrome. An immediate direction would be to replicate current findings regarding the ability to re-experience of discrete emotions, and the interference of positive and negative classes of emotions is replicated when episodic memory systems are permanently inaccessible. Moreover, a particularly intriguing extension of the present work would address the same question when episodic memory systems are only temporarily switched off, as it he case for patients diagnosed with Transient Global Amnesia (TGA). Certain obvious ethical issues would need to be addressed first, but logistical concerns regarding the speed of administration and the use of quick and reliable measures of emotions should be appeased by the success of the methodology and tools used in the present work. Secondly, future research would benefit from employing neuroimaging techniques to expose which brain areas are involved in the re-experience of emotions, and the extent to which they differ from the system already identified to be employed in the processing and experience of discrete emotions. Thirdly, as there is already considerable evidence that negative discrete emotions share substantial neuroanatomical pathways (Vytal & Hamman, 2010; Vytal & Hamann, 2012), the question remains if those areas and networks can describe negative and positive affect with subordinate and unique neuroanatomic structures corresponding to discrete negative and positive emotions.

A promising outcome of the thesis is the proposition of a new set of indices to describe the emotional experience: the intensity, specificity, and accuracy of affect. The use of these composite indices could replace entirely the classical ratings of discrete emotions from which they are calculated and can be used to investigate all forms of emotional experience. As a first step to establish the new indices as routine measures of emotional experience, they would need to be associated with a specific neuroanatomy. Indeed, the neuroscientific evidence provides the fundamental neuroanatomic correlates of cognitive functions, processes, or constructs. If discrete emotion states indeed exist (and the neuroscience literature has provided substantial evidence that they do), then it makes sense to discuss about the overall intensity, specificity and accuracy of affect. However, empirical evidence should show that the overall intensity of affect corresponds to the maximum intensity of the four discrete emotions by identifying a corresponding pattern in the cortical and subcortical blood flow activity to known emotion processing structures. Similarly, after measuring individual discrete emotions when only one emotion is of interest, one would think that the specificity of the affective experience is indeed an essential construct. However, for specificity to be a potent tool for the investigation of affect, the index should correlate consistently with a selective neural pathway. The regions most probable to capture the construct of specificity could be the unique areas associated with each discrete emotion which should show a proportionately more intense hemodynamic response for emotional experiences with a higher specificity index. A curious alternative would be for a unique brain area or structure ("the specificity centre") to activate proportionately with the specificity of the affective experience, regardless of dominant discrete emotion, while the known unique brain regions that correlate with that discrete emotion to indicate which emotion class it is.

Further removed from the evidence presented in this thesis is the question regarding the organisation or the structure of affect. In this respect, one has to wonder whether the right questions have been asked. Specifically, is valence the only fundamental dimension of affect, or are any of the other dimensions relevant to the experience of emotions? If other such dimensions can be identified, then how do they relate (in a subordinate or superordinate fashion) with discrete emotions and valence. Convenient possibilities are offered by the literature on the dimensional theories of emotions. Perhaps the most intriguing hypothesis to be tested was proposed by Lövheim (2012), who suggested that the levels of monoamine neurotransmitters traditionally involved in emotion experience (dopamine, noradrenaline, serotonin) might represent underlying dimensions of the experience of discrete emotions. Conversely, a second line of enquiry can address the question if the study of discrete emotions can reliably extend to other classes of affect? Currently, the neuroscientific evidence suggest the strongest candidate might be the emotion of disgust (Hamman, 2012).

5.4 A final thought

Discrete emotions offer an unsurpassed means of understanding the uberty of the affective experience and should be used more widely. The present thesis has shown that amnesic (Korsakoff's syndrome) patients are able to experience and reliably report at least four discrete emotions with a high level of specificity, similarly with neurologically normal controls. However, a wider range of clinical populations can potentially present unique insights about their own emotional experience, if specific emotions are targeted and elicited discretely, while, importantly, measuring the experience of all basic emotions. This can open the door to further understanding of discrete emotions, and their role in shaping the affective experience – which is arguably the next frontier in the field of affective neuroscience.

As shown in the present work, the available instruments to measure discrete emotions can be used effectively, even for a high number of administrations in a single session. Other tools, especially assessing the brain activity and physiology associated with the specific re-experience of discrete emotions (the neuro-correlates of affective specificity) could greatly expand our current understanding of affect, and further inform the development of future investigations. Notably, this thesis has presented novel ways to analyse and interpret the ratings of individual discrete emotions, which look most likely to reveal new and far-reaching aspects of the affective experience.

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Appendices

Appendix A. Research ethics and research governance approvals (School of Psychology, Bangor University)

Marian Andrei Stanciu

From:	Charlotte Jane Pollock
Sent:	05 October 2011 17:04
To:	Marian Andrei Stanciu
Subject:	Ethics Application Approved

Dear Marian Andrei,

2011-3621 Stability of Discrete Emotions in Amnesia

Your research proposal number 2011-3621 has been reviewed by the School of Psychology Ethics and Research Committee and the committee are now able to confirm ethical and governance approval for the above research on the basis described in the application form, protocol and supporting documentation. This approval lasts for a maximum of three years from this date.

Ethical approval is granted for the study as it was explicitly described in the application

If you wish to make any non-trivial modifications to the research project, please submit an amendment form to the committee, and copies of any of the original documents reviewed which have been altered as a result of the amendment. Please also inform the committee immediately if participants experience any unanticipated harm as a result of taking part in your research, or if any adverse reactions are reported in subsequent literature using the same technique elsewhere.

.

Governance approval is granted for the study as it was explicitly described in the application and we are happy to confirm that this study is now covered by the University's indemnity policy.

If any new researchers join the study, or any changes are made to the way the study is funded, or changes that alter the risks associated with the study, then please submit an amendment form to the committee.

Yours sincerely

Everil McQuarrie

1

Marian Andrei Stanciu

From:	Charlotte Jane Pollock
Sent:	07 November 2011 12:43
To:	Marian Andrei Stanciu
Subject:	Ethics Application Approved

Dear Marian Andrei,

2011-3621-A3483 Amendment to Stability of Discrete Emotions in Amnesia

Your research proposal number 2011-3621-A3483 has been reviewed by the School of Psychology Ethics and Research Committee and the committee are now able to confirm ethical and governance approval for the above research on the basis described in the application form, protocol and supporting documentation. This approval lasts for a maximum of three years from this date.

Ethical approval is granted for the study as it was explicitly described in the application

If you wish to make any non-trivial modifications to the research project, please submit an amendment form to the committee, and copies of any of the original documents reviewed which have been altered as a result of the amendment. Please also inform the committee immediately if participants experience any unanticipated harm as a result of taking part in your research, or if any adverse reactions are reported in subsequent literature using the same technique elsewhere.

.

Governance approval is granted for the study as it was explicitly described in the application and we are happy to confirm that this study is now covered by the University's indemnity policy.

If any new researchers join the study, or any changes are made to the way the study is funded, or changes that alter the risks associated with the study, then please submit an amendment form to the committee.

Yours sincerely

Everil McQuarrie

1

Marian Andrei Stanciu

From:	Charlotte Jane Pollock
Sent:	04 July 2012 10:12
To:	Marian Andrei Stanciu
Subject:	Ethics Application Approved

Dear Marian Andrei,

2011-3621-A5542 Amendment to Stability of Discrete Emotions in Amnesia

Your research proposal number 2011-3621-A5542 has been reviewed by the School of Psychology Ethics and Research Committee and the committee are now able to confirm ethical and governance approval for the above research on the basis described in the application form, protocol and supporting documentation. This approval lasts for a maximum of three years from this date.

Ethical approval is granted for the study as it was explicitly described in the application

If you wish to make any non-trivial modifications to the research project, please submit an amendment form to the committee, and copies of any of the original documents reviewed which have been altered as a result of the amendment. Please also inform the committee immediately if participants experience any unanticipated harm as a result of taking part in your research, or if any adverse reactions are reported in subsequent literature using the same technique elsewhere.
.

Governance approval is granted for the study as it was explicitly described in the application and we are happy to confirm that this study is now covered by the University's indemnity policy.

If any new researchers join the study, or any changes are made to the way the study is funded, or changes that alter the risks associated with the study, then please submit an amendment form to the committee.

Yours sincerely

Everil McQuarrie

--

Marian Andrei Stanciu

From:	Charlotte Jane Pollock
Sent:	14 September 2012 14:38
To:	Marian Andrei Stanciu
Subject:	Ethics Application Approved

Dear Marian Andrei,

2011-3621-A5861 Amendment to Stability of Discrete Emotions in Amnesia

Your research proposal number 2011-3621-A5861 has been reviewed by the School of Psychology Ethics and Research Committee and the committee are now able to confirm ethical and governance approval for the above research on the basis described in the application form, protocol and supporting documentation. This approval lasts for a maximum of three years from this date.

Ethical approval is granted for the study as it was explicitly described in the application

If you wish to make any non-trivial modifications to the research project, please submit an amendment form to the committee, and copies of any of the original documents reviewed which have been altered as a result of the amendment. Please also inform the committee immediately if participants experience any unanticipated harm as a result of taking part in your research, or if any adverse reactions are reported in subsequent literature using the same technique elsewhere.

.

Governance approval is granted for the study as it was explicitly described in the application and we are happy to confirm that this study is now covered by the University's indemnity policy.

If any new researchers join the study, or any changes are made to the way the study is funded, or changes that alter the risks associated with the study, then please submit an amendment form to the committee.

Yours sincerely

Everil McQuarrie

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Appendix B. Appendix A. Research ethics and research governance approvals (School of Psychology, Bangor University)

GIG CYMRU NHS WALES | Bwrdd Iechyd Prifysgol Betsi Cadwaladr University Health Board

Panel Arolygu Mewnol Y&D - Y Gorllewin
R&D Internal Review Panel - West

Betsi Cadwaladr University Health Board
Ysbyty Gwynedd
Clinical Academic Office
Bangor, Gwynedd
LL57 2PW

Chairman/Cadeirydd – Dr. Richard Tranter, MBChB, MRCPsych, PhD
Email: rossela.roberts@wales.nhs.uk
angela.filippi@wales.nhs.uk
sion.lewis@wales.nhs.uk
Tel/Fax: 01248 384 877

Mr Marian Andrei Stanciu
PhD Student
School of Psychology
Brigantia Building
Bangor University
LL57 2AS

25 January 2012

Dear Mr Stanciu

Re: Research Project Review

Stanciu 11/WA/0347 The stability of basic discrete emotions across time in the absence of episodic information recall

Documents reviewed:	Version	Date
NHS R&D Form – 85619/262820/14/548	-	12/10/2011
NHS SSI Form – 85619/264649/6/372/134175/227852	-	07/11/2011
Protocol	2.0	14/12/2011
Summary/Synopsis Protocol Flowchart (Session 1 & 2-5)	1.0	20/06/2011
Letter from Sponsor: School of Psychology, Bangor University – Approval from Neurology and Neuroimaging Expert Group	-	29/07/2011
Letter from Sponsor: School of Psychology, Bangor University – Approval from Ethics and Research Governance Committee	-	05/10/2011
Evidence of insurance or indemnity	UMAL	01/08/2011
Investigator CV PhD student (M.A. Stanciu)	-	04/11/2011
Academic Supervisor CV (Prof O. Turnbull)	-	04/09/2011
Letter of invitation to participant: Patients	-	20/06/2011
Letter of invitation to participant: Patients – Welsh	1.0	20/06/2011
Letter of invitation to participant: Controls	1.0	20/06/2011
Letter of invitation to participant: Controls – Welsh	1.0	20/06/2011
Participant Information Sheet : Neurological Participants	2.0	28/11/2011
Participant Information Sheet: Neurological Participants - Welsh	1.0	20/06/2011
Participant Information Sheet: Controls	2.0	28/11/2011
Participant Information Sheet: Controls – Welsh	1.0	20/06/2011
Participant Information Sheet: Anatomical MRI scan	1.0	20/06/2011
Participant Information Sheet: Anatomical MRI scan – Welsh	1.0	20/06/2011
Participant Consent Form: Experimental paradigm	1.0	20/06/2011
Participant Consent Form: Experimental paradigm – Welsh	1.0	20/06/2011
Participant Consent Form: Anatomical MRI scan	1.0	20/06/2011
Participant Consent Form: Anatomical MRI scan – Welsh	1.0	20/06/2011
Informed Consent Form – Neurological Participants	2.0	28/11/2011
Consent Form – Controls	2.0	28/11/2011
GP/Consultant Information Sheets	1.0	20/06/2011
GP/Consultant Information Sheets – Welsh	1.0	20/06/2011
Debrief Sheet	1.0	20/06/2011
Debrief Sheet – Welsh	1.0	20/06/2011
Other: Empirical assessment of capacity to consent	1.0	20/06/2011
Questionnaire: Rey Auditory Verbal Learning Test	-	-
Questionnaire: Hospital Anxiety and Depression Scale	-	-

Questionnaire : Mini Mental State Examination	-	-
Questionnaire: Wechsler Memory Scale III – Logical Memory	-	-
Questionnaire: Wechsler Memory Scale III – Forward and Backward Digit	-	-
Questionnaire: Wechsler Memory Scale III – Verbal Paired Associates	-	-
Questionnaire: Wechsler Memory Scale III – Word List	-	-
Questionnaire: Delis Kaplan Verbal Fluency Test	-	-
Questionnaire: Delis Kaplan Trail Making Test	-	-
Questionnaire: Token Test	-	-
Questionnaire : Visual Analogues Mood Scales	-	-
Questionnaire: Word Recognition Task	1.0	20/06/2011
Questionnaire: Subjective ratings of the Stories	1.0	20/06/2011
Questionnaire: Emotion induction stimuli – Emotional Stories	1.0	20/06/2011
Questionnaire: Interference Stories	1.0	20/06/2011
NHS R&D Checklist	-	-
NHS SSI Checklist	-	-
CV of CI (M A Stanciu)	1	14/11/2011
CV of Academic Supervisor (O Turnbull)	1	04/09/2011

The above research project was reviewed at the meeting of the Internal Review Panel held on 01 December 2011. Thank you for responding to the Committee's request for further information.

The Chairman considered the response on behalf of the Committee and is satisfied with the scientific validity of the project, the risk assessment, the review of the NHS cost and resource implications and all other research management issues pertaining to the revised application.

I have pleasure in confirming that the Internal Review Panel is pleased to grant approval to proceed at Betsi Cadwaladr University Health Board sites as described in the application.

The study should not commence until the Ethics Committee reviewing the research has confirmed final ethical approval - favourable opinion.

All research conducted at the Betsi Cadwaladr University Health Board sites must comply with the Research Governance Framework for Health and Social Care in Wales (August 2009).
An electronic link to this document is provided on the BCUHB R&D WebPages.

Alternatively, you may obtain a paper copy of this document via the R&D Office.
Attached you will find a set of approval conditions outlining your responsibilities during the course of this research. Failure to comply with the approval conditions will result in the withdrawal of the approval to conduct this research in the Betsi Cadwaladr University Health Board.

If you would like further information on any other points covered by this letter please do not hesitate to contact me. On behalf of the Committee, may I take this opportunity to wish you every success with your research.

Yours sincerely

p Dr Richard Tranter MBChB, MRCPsych, PhD
Consultant Psychiatrist
Chairman Internal Review Panel
Assistant Director of R&D

Bwrdd Iechyd Prifysgol
Betsi Cadwaladr
University Health Board

Panel Arolygu Mewnol Y&D - Y Gorllewin
R&D Internal Review Panel - West

Betsi Cadwaladr University Health Board
Ysbyty Gwynedd
Clinical Academic Office
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Mr Marian Andrei Stanciu
PhD Student
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Chairman/Cadeirydd – Dr. Richard Tranter, MBChB, MRCPsych, PhD
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2 December 2011

Subject:	NISCHR PCP - 85619 – Valid Application
BCUHB – R&D Ref:	Stanciu 11/WA/0347

Dear Mr Stanciu

Re: The stability of basic discrete emotions across time in the absence of episodic information recall (85619) – Governance checks complete not satisfied

Unfortunately, we have been unable to satisfy all the governance checks for your study. Below are the details of the governance check(s) that we have been unable to satisfy:

Emergency / Backup / Support arrangements assessed
The Committee discussed whether appropriate emergency, support and back up arrangements are in place to deal with identified risks concerning procedures within the study. The following issues were raised:
The Committee requested that the investigators detail the procedure for accidental disclosure which may occur during the interview process.

Protocol Assessment
The Committee considered whether the objectives, design, methodology, statistical considerations (or other methods of data analysis) and the organisation of the study are appropriately described in the protocol.
The following issues were raised:
The Committee requested that the investigators liaise with Yvonne Sylvestre (NWORTH) to clarify the contingencies that will affect their statistical analysis. The Committee noted that the protocol design may benefit from service user involvement.

Principal Investigator (PI) / research team Human Resources arrangements in place
The Committee discussed whether the appropriate Human Resources (HR) systems are in place to ensure appropriate management and supervision of researchers.
The following issues were raised:
The CI is awaiting an honorary contract with BCUHB

Research Ethics Committee favourable opinion received
The Committee considered whether the applicant has provided a copy of the Favourable opinion letter issued by the Ethics Committee for the study.
The following issues were raised:
The study is awaiting Ethical Approval.

If you are able to provide additional information or further clarification to resolve these issues, we will review the relevant Local governance checks again.

If you have any further questions please contact us and we will be able to answer your queries and advise you on how to proceed. Our e-mail addresses for any additional information / documents is Angela.Filippi@wales.nhs.uk or Sion.Lewis@wales.nhs.uk

Kind regards

Dr. Rossela Roberts, MICR, CSci
Clinical Governance Officer (R&D/Ethics)

Bwrdd Iechyd Prifysgol
Betsi Cadwaladr
University Health Board

Panel Arolygu Mewnol Y&D - Y Gorllewin
R&D Internal Review Panel - West

Betsi Cadwaladr University Health Board
Ysbyty Gwynedd
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Mrs Alwen Nicholson
Principal Pharmacist
Pharmacy
Ysbyty Gwynedd
Bangor
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Chairman/Cadeirydd – Dr. Richard Tranter, MBChB, MRCPsych, PhD
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sion.lewis@wales.nhs.uk
Tel/Fax: 01248 384 877

02 March 2012

Dear Mrs Nicholson,

Re: Research Project Review

Nicholson An evaluation of the training preparedness for medicines-based calculations in health care professionals and undergraduate students in BCUHB West

Documents reviewed:	Version	Date
Protocol	2.0	21/12/2011
Cover Letter (Email)	-	20/12/2011

Thank you for your application, notifying the Internal Review Panel of the above study.
As this is a study that falls under the category '**Service Evaluation**' it would not require formal application for R&D approval.

The study was considered and acknowledged at the meeting of the Committee held on 01 March 2012.

The Committee is satisfied with the scientific validity of the project, the risk assessment, the review of the NHS costs and resource implications and all other research management issues pertaining to the review of the application.

All research conducted at the Betsi Cadwaladr University Health Board sites must comply with the Research Governance Framework for Health and Social Care in Wales (August 2009).
An electronic link to this document is provided on the R&D WebPages. Alternatively, you may obtain a paper copy of this document via the R&D Office.

If you would like further information on any other points covered by this letter please do not hesitate to contact me. On behalf of the Committee, may I take this opportunity to wish you every success with your research.

Yours sincerely

Dr Richard Tranter MBChB, MRCPsych, PhD
Consultant Psychiatrist
Chairman Internal Review Panel
Assistant Director of R&D

North Wales Research Ethics Committee - West
Bangor

Clinical Academic Office
Ysbyty Gwynedd Hospital
Betsi Cadwaladr University Health Board
Bangor
Gwynedd
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Tel/Fax: 01248 -384.877

File Copy

Mr. Marian Andrei Stanciu
PhD Student
School of Psychology, Bangor University
Brigantia Building, Penrallt Road,
Bangor, Gwynedd
LL57 2AS

08 November 2011

Dear Mr. Stanciu,

Full title of study:	**The stability of basic discrete emotions across time in the absence of episodic information recall**
REC reference number:	**11/WA/0347**

Thank you for your application for ethical review, which was received on 07 November 2011. I can confirm that the application is valid and will be reviewed by the Committee at the meeting on 17 November 2011.

Meeting arrangements

The meeting will be held in the Llewelyn Room, Ysbyty Gwynedd Hospital, Bangor, Gwynedd, on 17 November 2011. The Committee would find it helpful if you could attend the meeting to respond to any questions from members. Other key investigators and a representative of the sponsor are also welcome to attend. This may avoid the need to request further information after the meeting and enable the Committee to make a decision on the application more quickly.

If you have a disability and need any practical support when attending the REC meeting you may wish to contact the REC office so appropriate arrangements can be made if necessary.

If you are unable to attend the meeting the Committee will review the application in your absence.

The review of the application has been scheduled for 5.30 pm. Would you please let me know whether or not you would be available to attend at this time. Please note that it is difficult to be precise about the timing as it will depend on the progress of the meeting. We would kindly ask you to be prepared to wait beyond the allocated time if necessary.

If you cannot attend, it would be helpful if you could be available on the telephone at the time of the review.

Meetings are occasionally attended by observers, who will have no vested interest in the applications under review or take any part in discussion. All observers are required to sign a confidentiality agreement.

11/WA/0347 Page 2 of 3

Documents received

The documents to be reviewed are as follows:

Document	Version	Date
REC application (Submission 85619/262801/1/633)		07 November 2011
Protocol	1.0	20 June 2011
Summary/Synopsis Protocol Flowchart (Session 1 & 2-5)	1.0	20 June 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Neurology and Neuroimaging Expert Group		29 July 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Ethics and Research Governance Committee		05 October 2011
Evidence of insurance or indemnity	UMAL	01 August 2011
Investigator CV PhD student (M.A. Stanciu)		04 November 2011
Academic Supervisor CV (Prof O. Turnbull)		04 September 2011
Letter of invitation to participant: Patients		20 June 2011
Letter of invitation to participant: Patients Welsh Language translation	1.0	20 June 2011
Letter of invitation to participant: Controls	1.0	20 June 2011
Letter of invitation to participant: Controls Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Neurological Participants	1.0	20 June 2011
Participant Information Sheet: Neurological Participants Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Neurologically Normal Participants	1.0	20 June 2011
Participant Information Sheet: Neurologically Normal Participants Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Anatomical MRI scan	1.0	20 June 2011
Participant Information Sheet: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
Participant Consent Form: Experimental paradigm	1.0	20 June 2011
Participant Consent Form: Experimental paradigm Welsh Language translation	1.0	20 June 2011
Participant Consent Form: Anatomical MRI scan	1.0	20 June 2011
Participant Consent Form: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
GP/Consultant Information Sheets	1.0	20 June 2011
GP/Consultant Information Sheets Welsh Language translation	1.0	20 June 2011
Debrief Sheet	1.0	20 June 2011
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Other: Empirical assessment of capacity to consent	1.0	20 June 2011
Questionnaire: Rey Auditory Verbal Learning Test		
Questionnaire: Hospital Anxiety and Depression Scale		
Questionnaire: Mini Mental State Examination		
Questionnaire: Wechsler Memory Scale III - Logical Memory		
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Questionnaire: Delis Kaplan Trail Making Test		
Questionnaire: Token Test		
Questionnaire: Visual Analogues Mood Scales		
Questionnaire: Word Recognition Task	1.0	20 June 2011
Questionnaire: Subjective ratings of the Stories	1.0	20 June 2011
Questionnaire: Emotion induction stimuli - Emotional Stories	1.0	20 June 2011
Questionnaire: Interference Stories	1.0	20 June 2011

No changes may be made to the application before the meeting.
If you envisage that changes might be required, we would advise you to withdraw the application and re-submit it.

Notification of the Committee's decision

You will receive written notification of the outcome of the review within 10 working days of the meeting. The Committee will issue a final ethical opinion on the application within a maximum of 60 days from 07 November 2011, excluding any time taken by you to respond fully to one request for further information or clarification after the meeting.

Site-specific assessments

NHS sites
Site-specific assessment (SSA) for any site within the National Health Service (NHS) or Health and Social Care (HSC) in Northern Ireland will form part of the research governance review. The Site-Specific Information (SSI) Form for the site should be included with the application for R&D approval.
If the REC gives a favourable opinion, this will apply to any NHS/HSC site on condition that management permission is obtained from the host organisation prior to the research starting at the site.There is no need to submit the SSI Form to the local REC.

Non-NHS sites
The site-specific assessment for School of Psychology, Bangor University will be carried out by this Committee at the same time as the ethical review.
No further documents need to be submitted. The main purpose of the SSA is to assess the suitability of the local Principal Investigator, site and facilities.

R&D approval

You should seek approval from the R&D office for the relevant care organisation to conduct this research at a NHS site. The R&D approval process may take place at the same time as the ethical review. Final R&D approval will not be confirmed until after a favourable ethical opinion has been given.
Any researchers and local research collaborators who intend to participate in this study at other NHS sites should also apply for R&D approval from the relevant care organisation. You should advise researchers and local collaborators accordingly.
Guidance on applying for R&D approval is available at http://www.rdforum.nhs.uk/rdform.

Communication with other bodies

All correspondence from the REC about the application will be copied to the research sponsor and to the R&D office for [name of care organisation at lead site. It will be your responsibility to ensure that other investigators, research collaborators and NHS care organisation(s) involved in the study are kept informed of the progress of the review, as necessary.

11/WA/0347	**Please quote this number on all correspondence**

Yours sincerely
Rossela Roberts

Dr Rossela Roberts
Committee Co-ordinator
Email: rossela.roberts@wales.nhs.uk

Enclosure: *Further information about REC membership and meeting arrangements*

Copy to: *Sponsor: Dr Charles Leek, Bangor University, School of Psychology, Bangor University*
Academic Supervisor: Prof Oliver Turnbull, School of Psychology, Bangor University
R&D Office: Betsi Cadwaladr University Health Board

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North Wales Research Ethics Committee - West
Bangor

Clinical Academic Office
Ysbyty Gwynedd Hospital
Betsi Cadwaladr University Health Board
Bangor, Gwynedd
LL57 2PW

Tel/Fax: 01248 -384.877

Mr Marian Andrei Stanciu
PhD Student
School of Psychology
Brigantia Building
Penrallt Road,
Bangor, Gwynedd
LL57 2AS

21 November 2011

Dear Mr Stanciu,

Study Title: **The stability of basic discrete emotions across time in the absence of episodic information recall**
REC reference number: **11/WA/0347**

The Research Ethics Committee reviewed the above application at the meeting held on 17 November 2011. Thank you for attending to discuss the study.

Documents reviewed

The documents reviewed at the meeting were:

Document	*Version*	*Date*
REC application (Submission 85619/262801/1/633)		07 November 2011
Protocol	1.0	20 June 2011
Summary/Synopsis Protocol Flowchart (Session 1 & 2-5)	1.0	20 June 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Neurology and Neuroimaging Expert Group		29 July 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Ethics and Research Governance Committee		05 October 2011
Evidence of insurance or indemnity	UMAL	01 August 2011
Investigator CV PhD student (M.A. Stanciu)		04 November 2011
Academic Supervisor CV (Prof O. Turnbull)		04 September 2011
Letter of invitation to participant: Patients		20 June 2011
Letter of invitation to participant: Patients Welsh Language translation	1.0	20 June 2011
Letter of invitation to participant: Controls	1.0	20 June 2011
Letter of invitation to participant: Controls Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Neurological Participants	1.0	20 June 2011
Participant Information Sheet: Neurological Participants Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Neurologically Normal Participants	1.0	20 June 2011
Participant Information Sheet: Neurologically Normal Participants Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Anatomical MRI scan	1.0	20 June 2011
Participant Information Sheet: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
Participant Consent Form: Experimental paradigm	1.0	20 June 2011

Participant Consent Form: Experimental paradigm Welsh Language translation	1.0	20 June 2011
Participant Consent Form: Anatomical MRI scan	1.0	20 June 2011
Participant Consent Form: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
GP/Consultant Information Sheets	1.0	20 June 2011
GP/Consultant Information Sheets Welsh Language translation	1.0	20 June 2011
Debrief Sheet	1.0	20 June 2011
Debrief Sheet Welsh Language translation	1.0	20 June 2011
Other: Empirical assessment of capacity to consent	1.0	20 June 2011
Questionnaire: Rey Auditory Verbal Learning Test		
Questionnaire: Hospital Anxiety and Depression Scale		
Questionnaire: Mini Mental State Examination		
Questionnaire: Wechsler Memory Scale III - Logical Memory		
Questionnaire: Wechsler Memory Scale III - Forward and Backward Digit		
Questionnaire: Wechsler Memory Scale III - Verbal Paired Associates		
Questionnaire: Wechsler Memory Scale III - Word List		
Questionnaire: Delis Kaplan Verbal Fluency Test		
Questionnaire: Delis Kaplan Trail Making Test		
Questionnaire: Token Test		
Questionnaire: Visual Analogues Mood Scales		
Questionnaire: Word Recognition Task	1.0	20 June 2011
Questionnaire: Subjective ratings of the Stories	1.0	20 June 2011
Questionnaire: Emotion induction stimuli - Emotional Stories	1.0	20 June 2011
Questionnaire: Interference Stories	1.0	20 June 2011

Provisional opinion

Ethical issues raised by the Committee in private discussion, together with responses given by the researcher when invited into the meeting

Social or scientific value; scientific design and conduct of the study
1. The Committee noted that the statistical analysis plan presented in the application form is different from the one listed in the protocol (standard ANOVA vs single case ANOVA Crawford, Garthwaite & Howell)
You clarified that 2 different types of analysis will be performed, depending on the number of participants: if the team managed to recruit the 20 participants proposed in the application then 2 groups will be compared; if less participants are recruited, then the analysis will be comparing the performance of single patients against the control sample, to ensure that the significance of findings will not be reliant on sample size.
2. The Committee noted that the project will require an opportunistic sampling and queried whether the groups from which participants are to be recruited are self-limiting.
You clarified that Dr. Coetzer (NWBIS) will be the main clinician screening and recruiting participants for this study and he suggested that this would be an achievable sample size.

3. The Committee requested a clarification on what are the specific indications for proposing that the participants undergo MRI scanning?
You clarified that this had been suggested by the neurologists: the majority of potential patients have had an MRI scan and would not require a repeated scan, but new patients who have not had a scan done may benefit from the provision of a high performance scan.
A further query was raised regarding the action to be taken if an abnormality will be detected. Professor Turnbull clarified that abnormal results are dealt in accordance to the strict protocol instituted by the School of Psychology and participants will be referred back to the referring neurologist. The Committee concluded that the research design and the proposed analysis were deemed suitable for answering the research question. No further ethical issues were raised.

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Favourable risk benefit ratio; anticipated benefits/risks for research participants
The Committee discussed the anticipated benefits and potential risks to participants and were satisfied that the applicant has suitably identified the risks and benefits and highlighted them in the information given to participants. The Committee queried the support mechanism available to participants if a major emotional response to stories is elicited. Professor Turnbull clarified that he will be present at these sessions to intervene if required and if the need should arise, participants will be referred back to their clinician. It is appreciated that this is a fine line investigation as banal stories will not elicit a reply, however, the stimulus story will not be personal to the participant but very much like listening to a story/watching a film about other people.
No further ethical issues were raised

Care and protection of research participants; respect for participants' welfare & dignity; data protection and participants' confidentiality
1. The Committee requested a clarification of the requirement to access the medical records. Professor Turnbull clarified that this is required to identify possible confounders or exclusions, such as psychiatric history, etc. Patients are screened by the neurologist but once the participant agrees to take part additional information may be required. Consent to access the medical record will be explicitly sought from patients.
2. The Committee discussed the potential risk of incidental disclosures (sub-optimal care, malpractice or abuse, risk to self and others) and the statutory requirement to break confidentiality and concluded that the risk of incidental disclosure is unlikely and no specific mechanism needs to be put in place. However, as Professor Turnbull stated that this eventuality could not be entirely ruled out, especially if the story reminds them of something that took place earlier in their lives, the Committee requested that the limits of confidentiality are discussed in the Participant Information Sheet.
3. The Committee discussed where and for how long will data be stored, and clarified who will have access to the data. It was noted that it is proposed to store the original audio recordings for 5 years. You clarified that recordings will be stored in an anonymised format (file names with audio recording only contain age and gender - no personal identifiable information) and will only available to the research team; this is required by the BPS guidelines part of the audit of research probity mechanism.
No further ethical issues were raised

Informed Consent process
It was noted that an empirical assessment of capacity to consent is conducted by the referring clinician and repeated prior to each session. You clarified that the first line screening (assessment of capacity) is conducted by the neurologist but subsequent assessments are envisaged as a contingency measure, should there be a doubt of the patient's loss of capacity occurring between the time of the referral and consent. The Committee raised a further query regarding the consent process to be repeated before each session: as patients are amnesic and may not remember to what they consented in the previous session; and if they do not have the ability to retain information should this have been an MCA application? Professor Turnbull clarified that by virtue of the lesion site this type of patient tends to be intact in terms of making executive decisions. You added that written consent is taken only once at the beginning of the study, but verbal consent procedures are repeated at every session, as a mechanism to discuss the requirements of the specific phase of the study and to give participants the right to withdraw. If a patient is deemed to lack capacity s/het will not be included in the study. The Committee noted that written informed consent is taken as part of a process - with participants having adequate time to consider the information, and opportunity to ask questions. The information is clear to what the participant consents and there is no inducement or coercion. No further ethical issues were raised.

Adequacy and completeness of Participant Information
The Committee agreed that generally the procedures described in the protocol have been addressed in the Information Sheet, but felt that some corrections are needed:
1. The Committee noted that the Participant Information Sheet and Consent Form do not follow the standard format recommended by NRES and as such it lacks the structure and clarity given by the format. The information given to participants needs to be simplified and lay language used throughout. In its current form, the Participant Information Sheet lacks information (e.g. the paragraph 'Why have I been chosen'), it is too wordy and technical (e. g. phrases such as 'dysexecutive syndrome' are not lay) and contains unnecessary information (such as the exclusion criteria).

2. The Committee requested the Participant Information Sheet provides a clarification on the amount paid to participants as it is inconsistent in the information provided in the protocol.
3. The Committee noted that the extra time involved in the study for the carer - which would be needed for a participant in supported accommodation - should be detailed in the information sheets.
4. The Committee noted that the Information Sheet for 'neurologically normal participants' should be referred to as the Information sheet for 'Controls'
5. The Participant Information Sheet for Controls should clarify where the testing will be undertaken, i.e. participant's own home or School of Psychology.
6. The limits of confidentiality need to be discussed and the statutory requirement to break confidentiality in case of incidental disclosures of malpractice or abuse is elaborated upon in the Information Sheets (for both patients and controls)
7. The Committee noted that the Consent Form for Controls has been adapted from the Consent Form for Patients and some paragraphs have not been revised (e.g. states that they can withdraw without their 'health care' being affected)
8. The Committee noted that in the Welsh language version the document titles are not translated adequately (there is no differentiation between Patients and Controls)

Suitability of the applicant and facilities; community considerations
1. The Committee noted that your CV does not clarify the experience of the student with this group of patients. Professor Turnbull clarified that he will be present at each session to ensure that the student is adequately supervised.
2. A further query was raised regarding the role of the MSc students.
You clarified that the MSc students will collect data for the control group and will have access to anonymised data for analysis.
The Committee concluded that this is a suitable arrangement. The local facilities and arrangements are also suitable and community issues have been considered.
The Committee carried out an SSA for non NHS site (School of Psychology, Bangor University at the same time as the ethical review. A "no objection" decision has been raised for all sites.
No further ethical issues were raised.

General comments/ missing information/ typographical errors/ application errors
No comments were made

On the basis of the information provided, the Committee was satisfied with the following aspects of the research:

- *Social or scientific value; scientific design and conduct of the study*
- Independent review
- Fair participant selection
- Favourable risk benefit ratio; anticipated benefits/ risks for research participants
- Care and protection of research participants; respect for participants' welfare & dignity; data protection & participant's confidentiality
- Informed Consent process
- Suitability of the Applicant and Supporting Staff

The Committee identified issues with the following aspects of the research:

- Adequacy and completeness of Participant Information

The Committee would be content to give a favourable ethical opinion of the research, subject to receiving a complete response to the request for further information set out below.

The Committee delegated authority to confirm its final opinion on the application to the Chair.

Further information or clarification required

The Committee requested the following information before confirming its final opinion:

- In the Participant Information Sheet and Consent Forms

The Committee agreed that generally the procedures described in the protocol have been addressed in the Information Sheet, but felt that some corrections are needed:

1. The Committee requested that Information Sheets and Consent Forms are re-written in the standard format. Guidance on Information Sheets and Consent Forms is available on the NRES website at http://www.nres.npsa.nhs.uk/applications/guidance/consent-guidance-and-forms/?esctl1417026_entryid62=67013
The information given to participants needs to be simplified and lay language used throughout.

2. The Committee requested the Participant Information Sheet provides a clarification on the amount paid to participants.

3. The Committee requested that the extra time for the carer involved in the study is detailed in the information sheets.

4. The Committee requested that that the Information Sheet for 'neurologically normal participants' should be referred to as the Information sheet for 'Controls'

5. The Participant Information Sheet for Controls should clarify where the testing will be undertaken (i.e. participant's own home or School of Psychology)
6. The limits of confidentiality need to be discussed and the statutory requirement to break confidentiality in case of incidental disclosures of malpractice or abuse is elaborated upon in the Information Sheets (for both patients and controls)

7. The Committee requested that that the Consent Form for Controls is revised to eliminate paragraph that are not applicable.

8.The amended Participant Information Sheets and Consent Forms need translating and the Welsh language version made available to participants.

If you would find it helpful to discuss any of the matters raised above or seek further clarification from a member of the Committee, you are welcome to contact Dr Rossela Roberts, Committee Coordinator, at the address listed in the letter head.

When submitting your response to the Committee, please send revised documentation where appropriate underlining or otherwise highlighting the changes you have made and giving revised version numbers and dates.

If the committee has asked for clarification or changes to any answers given in the application form, please do not submit a revised copy of the application form; these can be addressed in a covering letter to the REC.

The Committee will confirm the final ethical opinion within a maximum of 60 days from the date of initial receipt of the application, excluding the time taken by you to respond fully to the above points. A response should be submitted by no later than 20 March 2012.

Membership of the Committee

The members of the Committee who were present at the meeting are listed on the attached sheet.
It was noted that absent members have not submitted written comments.
No declarations of interest have been made in relation to this application.

11/WA/0347 Page 6 of 7

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

11/WA/0347	**Please quote this number on all correspondence**

Yours sincerely

Rossela Roberts

PP **Mr David Owen**
Chairman

Email: rossela.roberts@wales.nhs.uk

Enclosures: *List of names and professions of members who were present at the meeting and those who submitted written comments.*

Copy to: *Sponsor: Dr Charles Leek, Bangor University, School of Psychology, Bangor University*
Academic Supervisor: Prof Oliver Turnbull, School of Psychology, Bangor University
R&D Office: Betsi Cadwaladr University Health Board

North Wales Research Ethics Committee - West

Attendance at Committee meeting on 17 November 2011

Committee Members

Name	*Profession*	*Capacity*	*Present*
Dr. Karen Addy	Clinical Psychologist	Expert	Yes
Dr. Swapna Alexander	Consultant Physician	Expert	Yes
Mrs. Kathryn Chester	Research Nurse	Expert	Yes
Dr. Christine Clark	Consultant Obstetrician & Gynaecologist	Expert	No
Mr. Derek James Crawford	Consultant Surgeon (Vice-Chairman)	Expert	Yes
Mrs. Gwen Dale-Jones	PA (retired)	Lay +	Yes
Mr. Hywel Lloyd Davies	Solicitor (Alternate Vice-Chairman)	Lay +	No
Mr. Henry Alan Owen Hughes	Pharmacy Professional Services Lead	Expert	Yes
Mr. Clive Robert Jenkins	Consultant GCP Auditor	Lay	Yes
Ms. Gillian Jones	Information Governance Manager	Lay	Yes
Dr. Mark Lord	Consultant Pathologist	Expert	Yes
Mr. David Owen	Retired Chief Constable (Chairman)	Lay +	Yes
Mr. Paramasivam Sathyamoorthy	Consultant Orthopaedic Surgeon	Expert	No
Dr. Thanthullu Vasu	Consultant Anaesthetist	Expert	Yes
Mr. Christopher John Whitaker	Statistician	Lay	Yes
Dr. Philip Wayman White	General Practitioner	Expert	Yes

Deputy Members

Name	*Profession*	*Capacity*	*Present*
Mrs. Rebecca Burns	Research Nurse (deputy to Mrs. Chester)	Expert	No
Dr. Michael Cronin	Consultant Paediatrician (deputy to Dr. Clark)	Expert	Yes
Mrs. Mair Rhiannon Martin	Pharmacist (deputy to Mr. Hughes)	Expert	No

In attendance

Name	*Position (or reason for attending)*
Dr. Rossela Roberts	Committee Coordinator
Miss Angela Filippi	Assistant Coordinator

Observer

Name	*Position (or reason for attending)*
Dr Corinne Scott	Research Ethics Operational Manager (NISCHR)

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North Wales Research Ethics Committee - West
Bangor

Clinical Academic Office
Ysbyty Gwynedd Hospital
Betsi Cadwaladr University Health Board
Bangor, Gwynedd
LL57 2PW

Tel/Fax: 01248 -384.877

Mr Marian Andrei Stanciu
PhD Student
School of Psychology
Brigantia Building
Penrallt Road,
Bangor, Gwynedd
LL57 2AS

06 December 2011

Dear Mr Stanciu,

Study Title:	**The stability of basic discrete emotions across time in the absence of episodic information recall**
REC reference number:	**11/WA/0347**

Thank you for your letter of 05 December 2011, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chairman.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation [as revised], subject to the conditions specified below.

Ethical review of research sites

NHS sites
The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS sites
Notification(s) of no objection have been received from local assessors for the non-NHS site(s) listed in the table below, following site-specific assessment (SSA).

I am pleased to confirm that the favourable opinion applies to the following research site(s), subject to site management permission being obtained prior to the start of the study at the site (see under 'Conditions of the favourable opinion below').

Research Site	Principal Investigator / Local Collaborator
School of Psychology, Bangor University	Mr Marian Andrei Stanciu

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
REC application (Submission 85619/262801/1/633)		07 November 2011
Protocol	1.0	20 June 2011
Summary/Synopsis Protocol Flowchart (Session 1 & 2-5)	1.0	20 June 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Neurology and Neuroimaging Expert Group		29 July 2011
Letter from Sponsor: School of Psychology, Bangor University Approval from Ethics and Research Governance Committee		05 October 2011
Evidence of insurance or indemnity	UMAL	01 August 2011
Investigator CV PhD student (M.A. Stanciu)		04 November 2011
Academic Supervisor CV (Prof O. Turnbull)		04 September 2011
Letter of invitation to participant: Patients		20 June 2011
Letter of invitation to participant: Patients Welsh Language translation	1.0	20 June 2011
Letter of invitation to participant: Controls	1.0	20 June 2011
Letter of invitation to participant: Controls Welsh Language translation	1.0	20 June 2011
Participant Information Sheet: Neurological participants	2	28 November 2011
Participant Information Sheet: Controls	2	28 November 2011
Participant Information Sheet: Anatomical MRI scan	1.0	20 June 2011
Participant Information Sheet: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
Participant Consent Form: Neurological Participants	2	28 November 2011
Participant Consent Form: Controls	2	28 November 2011
Participant Consent Form: Anatomical MRI scan	1.0	20 June 2011

Participant Consent Form: Anatomical MRI scan Welsh Language translation	1.0	20 June 2011
GP/Consultant Information Sheets	1.0	20 June 2011
GP/Consultant Information Sheets Welsh Language translation	1.0	20 June 2011
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Questionnaire: Wechsler Memory Scale III - Logical Memory		
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Questionnaire: Token Test		
Questionnaire: Visual Analogues Mood Scales		
Questionnaire: Word Recognition Task	1.0	20 June 2011
Questionnaire: Subjective ratings of the Stories	1.0	20 June 2011
Questionnaire: Emotion induction stimuli - Emotional Stories	1.0	20 June 2011
Questionnaire: Interference Stories	1.0	20 June 2011
Response to Request for Further Information		05 December 2011

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

Further information is available at National Research Ethics Service website > After Review

11/WA/0347	**Please quote this number on all correspondence**

Yours sincerely

Rossela Roberts

Mr David Owen
Chairman

Email: rossela.roberts@wales.nhs.uk

Enclosures: *"After ethical review – guidance for researchers"*

Copy to: *Sponsor: Dr Charles Leek, Bangor University, School of Psychology, Bangor University*

Academic Supervisor: Prof Oliver Turnbull, School of Psychology, Bangor University

R&D Office: Betsi Cadwaladr University Health Board

NHS
National Research Ethics Service

RESEARCH IN HUMAN SUBJECTS OTHER THAN CLINICAL TRIALS OF INVESTIGATIONAL MEDICINAL PRODUCTS

After ethical review – guidance for sponsors and investigators

This document sets out important guidance for sponsors and investigators on the conduct and management of research with a favourable opinion from a NHS Research Ethics Committee. Please read the guidance carefully. A failure to follow the guidance could lead to the committee reviewing its opinion on the research.

1. Further communications with the Research Ethics Committee

1.1 Further communications during the research with the Research Ethics Committee that gave the favourable ethical opinion (hereafter referred to in this document as "the Committee") are the personal responsibility of the Chief Investigator.

2. Commencement of the research

2.1 It is assumed that the research will commence within 12 months of the date of the favourable ethical opinion.

2.2 The research must not commence at any site until the local Principal Investigator (PI) or research collaborator has obtained management permission or approval from the organisation with responsibility for the research participants at the site.

2.3 Should the research not commence within 12 months, the Chief Investigator should give a written explanation for the delay

2.4 Should the research not commence within 24 months, the Committee may review its opinion.

3. Duration of ethical approval

3.1 The favourable opinion for the research generally applies for the duration of the research. If it is proposed to extend the duration of the study as specified in the application form, the Committee should be notified.

SL-AR2 After ethical review - research other than CTIMPs
Version 5.0 September 2011

3.2 Where the research involves the use of "relevant material" for the purposes of the Human Tissue Act 2004, authority to hold the material under the terms of the ethical approval applies until the end of the period declared in the application and approved by the Committee.

4. Progress reports

4.1 Research Ethics Committees are expected to keep a favourable opinion under review in the light of progress reports and any developments in the study. The Chief Investigator should submit a progress report to the Committee 12 months after the date on which the favourable opinion was given. Annual progress reports should be submitted thereafter.

4.2 Progress reports should be in the format prescribed by NRES and published on the website (see www.nres.npsa.nhs.uk/applicants/after-ethical-review/).

4.3 The Chief Investigator may be requested to attend a meeting of the Committee or Sub-Committee to discuss the progress of the research.

5. Amendments

5.1 If it is proposed to make a substantial amendment to the research, the Chief Investigator should submit a notice of amendment to the Committee.

5.2 A substantial amendment is any amendment to the terms of the application for ethical review, or to the protocol or other supporting documentation approved by the Committee that is likely to affect to a significant degree:

(a) the safety or physical or mental integrity of the trial participants
(b) the scientific value of the trial
(c) the conduct or management of the trial.

5.3 Notices of amendment should be in the format prescribed by NRES and published on the website, and should be personally signed by the Chief Investigator. The agreement of the sponsor should be sought before submitting the notice of amendment.

5.4 A substantial amendment should not be implemented until a favourable ethical opinion has been given by the Committee, unless the changes to the research are urgent safety measures (see section 7). The Committee is required to give an opinion within 35 days of the date of receiving a valid notice of amendment.

5.5 Amendments that are not substantial amendments ("minor amendments") may be made at any time and do not need to be notified to the Committee.

6. Changes to sites

Management permission (all studies)

6.1 For all studies, management permission should be obtained from the host organisation where it is proposed to:

- include a new site in the research, not included in the list of proposed research sites in the original REC application
- appoint a new PI or Local Collaborator at a research site
- make any other significant change to the conduct or management of a research site.

In the case of any new NHS site, the Site-Specific Information (SSI) Form should be submitted to the R&D office for review as part of the R&D application.

Site-specific assessment (where required)

6.2 The following guidance applies only to studies requiring site-specific assessment (SSA) as part of ethical review.

6.3 In the case of *NHS/HSC sites*, SSA responsibilities are undertaken on behalf of the REC by the relevant R&D office as part of the research governance review. The Committee's favourable opinion for the study will apply to any new sites and other changes at sites provided that management permission is obtained. There is no need to notify the Committee (or any other REC) about new sites or other changes, or to provide a copy of the SSI Form.

6.4 Changes at *non-NHS sites* require review by the local REC responsible for site-specific assessment (SSA REC). Please submit the SSI Form (or revised SSI Form as appropriate) to the SSA REC together with relevant supporting documentation. The SSA REC will advise the main REC whether it has any objection to the new site/PI or other change. The main REC will notify the Chief Investigator and sponsor of its opinion within a maximum of 35 days from the date on which a valid SSA application has been received by the SSA REC.

Studies not requiring SSA

6.5 For studies designated by the Committee as not requiring SSA, there is no requirement to notify the Committee of the inclusion of new sites or other changes at sites, either for NHS or non-NHS sites. However, management permission should still be obtained from the responsible host organisation (see 6.1 above).

7. Urgent safety measures

7.1 The sponsor or the Chief Investigator, or the local Principal Investigator at a trial site, may take appropriate urgent safety measures in order to protect research participants against any immediate hazard to their health or safety.

7.2 The Committee must be notified within three days that such measures have been taken, the reasons why and the plan for further action.

8. Serious Adverse Events

8.1 A Serious Adverse Event (SAE) is an untoward occurrence that:

(a) results in death
(b) is life-threatening
(c) requires hospitalisation or prolongation of existing hospitalisation
(d) results in persistent or significant disability or incapacity
(e) consists of a congenital anomaly or birth defect
(f) is otherwise considered medically significant by the investigator.

8.2 A SAE occurring to a research participant should be reported to the Committee where in the opinion of the Chief Investigator the event was related to administration of any of the research procedures, and was an unexpected occurrence.

8.3 Reports of SAEs should be provided to the Committee within 15 days of the Chief Investigator becoming aware of the event, in the format prescribed by NRES and published on the website.

8.4 The Chief Investigator may be requested to attend a meeting of the Committee or Sub-Committee to discuss any concerns about the health or safety of research subjects.

8.5 Reports should not be sent to other RECs in the case of multi-site studies.

9. Conclusion or early termination of the research

9.1 The Chief Investigator should notify the Committee in writing that the research has ended within 90 days of its conclusion. The conclusion of the research is defined as the final date or event specified in the protocol, not the completion of data analysis or publication of the results.

9.2 If the research is terminated early, the Chief Investigator should notify the Committee within 15 days of the date of termination. An explanation of the reasons for early termination should be given.

9.3 Reports of conclusion or early termination should be submitted in the form prescribed by NRES and published on the website.

10. <u>Final report</u>

10.1 A summary of the final report on the research should be provided to the Committee within 12 months of the conclusion of the study. This should include information on whether the study achieved its objectives, the main findings, and arrangements for publication or dissemination of the research including any feedback to participants.

11. <u>Review of ethical opinion</u>

11.1 The Committee may review its opinion at any time in the light of any relevant information it receives.

11.2 The Chief Investigator may at any time request that the Committee reviews its opinion, or seek advice from the Committee on any ethical issue relating to the research.

NISCHR

Gwasanaeth Moeseg Ymchwil | RES | Research Ethics Service

Mr Marian Andrei Stanciu
PhD Student
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Brigantia Building, Penrallt Road
Bangor,
LL57 2AS
m.a.stanciu@bangor.ac.uk

19 December 2012

Dear Mr Stanciu,

Study title:	**The stability of basic discrete emotions across time in the absence of episodic information recall**
REC reference:	**11/WA/0347**
SSA reference:	**12/EM/0465**
IRAS project ID:	**85619**

The REC gave a favourable ethical opinion to this study on 06 December 2011.

A notification has been received from local assessor, following site-specific assessment. On behalf of the Committee, I am pleased to confirm the extension of the favourable opinion to the new site and investigator listed below:

Research Site	Principal Investigator / Local Collaborator
Victoria Care Home	Mr Marian Andrei Stanciu

The favourable opinion is subject to management permission or approval being obtained from the host organisation prior to the start of the study at the site concerned.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

11/WA/0347	**Please quote this number on all correspondence**

Yours sincerely

Rossela Roberts

Dr Rossela Roberts
Committee Co-ordinator

E-mail: rossela.roberts@wales.nhs.uk

GIG CYMRU NHS WALES | Bwrdd Iechyd Addysgu Powys | Powys Teaching Health Board

Cynhelir Cydweithrediad Gwyddor Iechyd Academaidd y Sefydliad Cenedlaethol ar gyfer Ymchwil Gofal Cymdeithasol ac Iechyd gan Fwrdd Addysgu Iechyd Powys

The National Institute for Social Care and Health Research Academic Health Science Collaboration is hosted by Powys Teaching Health Board

Ariennir gan Lywodraeth Cymru | Funded by Welsh Government

Copy: Sponsor: Professor Charles Leek
School of Psychology, Bangor University
Brigantia Building, Penrallt Road
Bangor,
LL57 2AS e.c.leek@bangor.ac.uk

Academic Supervisor: Prof Oliver Turnbull
School of Psychology, Bangor University
Brigantia Building, Penrallt Road
Bangor,
LL57 2AS o.turnbull@bangor.ac.uk

R&D Office: Mr Sion Lewis
Clinical Academic Office
Betsi Cadwaladr University Health Board
Ysbyty Gwynedd
Bangor, LL57 2PW sion.lewis@wales.nhs.uk

File Copy

North Wales Research Ethics Committee - West

Bangor
Clinical Academic Office
Ysbyty Gwynedd Hospital
Betsi Cadwaladr University Health Board
Bangor
Gwynedd
LL57 2PW
Tel/Fax: 01248 384 877

Mr Marian Andrei Stanciu
PhD Student
School of Psychology, Bangor University
Brigantia Building
Penrallt Road, Bangor, Gwynedd
LL57 2AS

23 February 2012

Dear Mr Stanciu

Study title:	**The stability of basic discrete emotions across time in the absence of episodic information recall**
REC reference:	**11/WA/0347**
Amendment number:	**AM01**
Amendment date:	**23 February 2012**

Thank you for your letter of 23 February 2012, notifying the Committee of the above amendment. The amendment has been considered by the Chair.

The Committee does not consider this to be a "substantial amendment" as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

Documents received
The documents received were as follows:

Document	Version	Date
Notification of a Minor Amendment		23 February 2012
Participant Information Sheet: Controls	2	28 November 2011

Statement of compliance
The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

11/WA/0347:	**Please quote this number on all correspondence**

Yours sincerely

Angela Filippi
Committee Co-ordinator

E-mail: angela.filippi@wales.nhs.uk

Copy to: *Sponsor: Dr Charles Leek, School of Psychology, Bangor University*
R&D office for Betsi Cadwaladr University Health Board

Bwrdd Iechyd Prifysgol
Betsi Cadwaladr
University Health Board

Panel Arolygu Mewnol Y&D - Y Gorllewin
R&D Internal Review Panel - West

Betsi Cadwaladr University Health Board
Ysbyty Gwynedd
Clinical Academic Office
Bangor, Gwynedd
LL57 2PW

Chairman/Cadeirydd - Dr. Mike C Jackson, CPsychol, DClinPsych, DPhil
Email: rossela.roberts@wales.nhs.uk
wendy.scrase2@wales.nhs.uk
sion.lewis@wales.nhs.uk
Tel/Fax: 01248 384 877

Mr Marian Andrei Stanciu
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Brigantia University
Penrallt Road
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m.a.stanciu@bangor.ac.uk

08 February 2013

Dear Mr Stanciu

Re: Substantial Amendment AM01 dated 03/01/2013

Study Title	Stability of discrete emotions in amnesia
R&D reference	Stanciu 11/WA/0347
IRAS reference	85619

The above amendment was reviewed at the meeting of the R&D Internal Review Panel held on 07 February 2013

Documents reviewed:	Version	Date
Notice of Substantial Amendment	-	03/01/2013

The Committee discussed the amendment and is satisfied with the scientific justification for this amendment, the risk assessment, the review of the NHS cost and resource implications and all other research management issues pertaining to the amendment.

I have pleasure in confirming that the R&D Internal Review Panel - West is pleased to grant approval to continue at all BCUHB sites as described in the application. The amendment does not affect local management approval previously given to this research.

The Panel has agreed to fund the additional costs incurred (£ 3,695) to enable the project to finalise the pilot 'pathway to portfolio' phase.

Please liaise with the University's finance office to ensure that the R&D funding will only be used for direct costs (both pay and non-pay) and will not cover University overheads.

You will need to arrange with the University's finance office to raise an invoice addressed to the R&D office at the address in the letterhead of this letter (clearly identifying the study reference number). Please liaise with Sion Lewis in the R&D office for a requisition/purchase order number.

As part of the regular monitoring undertaken by the Internal Review Panel you will be required to complete a short progress report. This will be requested on an annual basis. However, please contact me sooner should you need to report any particular successes or problems concerning your research. Whilst BCUHB is keen to reduce the burden of paperwork for researchers failure to produce a report may result in withdrawal of approval.

All research conducted at the Betsi Cadwaladr University Health Board sites must comply with the Research Governance Framework for Health and Social Care in Wales (August 2009). An electronic link to this document is provided on the BCUHB R&D WebPages. Alternatively, you may obtain a paper copy of this document via the R&D Office.

On behalf of the Committee, may I take this opportunity to wish you every success with your research.

Yours sincerely,

Rossela Roberts

Dr. Rossela Roberts, MICR, CSci
Clinical Governance Officer (R&D/Ethics)

Copy to:	Sponsor:	Charles Leek School of Psychology Brigantia Building Penrallt Road Bangor LL57 2AS	e.c.leek@bangor.ac,uk
Academic Supervisor:		Professor Oliver Turnbull School of Psychology Brigantia Building Penrallt Road Bangor LL57 2AS	o.turnbull@bangor.ac.uk
	Finance Office:	Mr Alon Williams School of Psychology Brigantia Building Penrallt Road Bangor LL57 2AS	pss02b@bangor.ac.uk

Marian Andrei Stanciu

From: Rossela Roberts (BCUHB - R & D) <Rossela.Roberts@wales.nhs.uk>
Sent: 02 July 2012 13:53
To: Marian Andrei Stanciu
Subject: RE: MSc students sitting in patients' testing sessions (REC reference number: 11/WA/0347)

Dear Andrei,
As the students are not investigators (collaborators at best) in this study and would not take active part in the testing/intervention - I can confirm that this would not constitute a substantial amendment and there is no need to obtain an ethical opinion from the Research Ethics Committee or the R&D Committee. Please ensure though that patients are in full agreement to the students being present in the room and given them the opportunity to object to the students' presence if they do not feel comfortable with it.
Also, as discussed, please ensure that the names of the students are added to the project on the School of Psychology Ethics and Governance Review system.

Kind regards,
Rossela

Dr. Rossela Roberts, MICR, CSci
Swyddog Rheolaeth Glinigol (YaD/Moeseg)
Clinical Governance Officer (R&D/Ethics)
Bwrdd Iechyd Prifysgol Betsi Cadwaladr University Health Board
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tel/fax: 01248 - 38 (4877)
e-mail: rossela.roberts@wales.nhs.uk

Bwrdd Iechyd Prifysgol Betsi Cadwaladr yw enw gweithredol Bwrdd Iechyd Lleol Prifysgol Betsi Cadwaladr
Betsi Cadwaladr University Health Board is the operational name of Betsi Cadwaladr University Local Health Board

-----Original Message-----
From: Stanciu,Marian Andrei [mailto:m.a.stanciu@bangor.ac.uk]
Sent: 02 July 2012 13:48
To: Rossela Roberts (BCUHB - R & D)
Subject: MSc students sitting in patients' testing sessions (REC reference number: 11/WA/0347)

Hi Rossela,

I have 5 MSc students on the Clinical Neuropsychology course working with me on the project (11/WA/0347), collecting data for the control group. They are all CRB checked and included in the application, but only I have a Research Passport, because I am the only one testing the patients.

Bob Rafal and Oliver Turnbull were wondering if I had to put in an amendment to the ethics application to have the students sitting in with me during patients' testing. The students would not be interacting with

1

patients at any point, as I will be conducting the session, but they
will only being present in the room, somewhere in the background.

Would I need a supplementary approval from the REC / R&D committees for
this?

Thank you very much,
Andrei

****

Andrei Stanciu
PhD Student
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LL57 2AS

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Fax: +44 (0)1248 382599

On 06/12/2011 09:33, Rossela Roberts (BCUHB - R & D) wrote:
> Dear Andrei,
> Please find attached the letter of favourable ethical opinion (original in the post)
> Best wishes,
> Rossela
>
>
> -----Original Message-----
> From: Stanciu,Marian Andrei [mailto:m.a.stanciu@bangor.ac.uk]
> Sent: 05 December 2011 10:36
> To: Rossela Roberts (BCUHB - R& D)
> Subject: Re: ethical review (REC reference number: 11/WA/0347)
>
> Dear Rossela,
>
>
> Please find attached the updated participants documents: Information
> Sheet and Consent Forms for Patients and Controls (version 2.0,
> 28/11/2011) and two brief comments regarding the ethics review meeting /
> application (at the end of the email).
>
> The Committee's requests have been addressed as follows:
>
> 1. The Information Sheet and Consent form have been re-written in the
> standard format. The Information Sheet has been simplified and lay
> language has been used throughout.
>
> 2. The amount paid to participants has been corrected in the Information
> Sheet. (see the paragraph titled "Will I receive compensation?" on page 2).
>
> 3. The extra time for the patient's carer has been detailed in the
> Information Sheet for Neurological Participants (see the paragraph

2

> titled "What happens during the study?" on page 1).
>
> 4. The title of the Information Sheet for Neurologically Normal
> Participants has been corrected to Information Sheet for Controls.
>
> 5. The Information Sheet for Controls has been corrected and now
> clarifies that control participants will be tested in the School of
> Psychology laboratory (see the paragraph titled "What happens during the
> study?" on page 1).
>
> 6. The limits of confidentiality have been discussed in the both
> Information Sheets for controls and patients (see the paragraph entitled
> "Are there any limits to confidentiality?" on page 2 of both documents).
>
> 7. The Consent Form for Controls has been revised to exclude the
> irrelevant information regarding medical care not being affected.
>
> 8. The Information Sheets and Consent Forms for patients and controls
> have been submitted to the Translation Unit of Bangor University for
> translation into Welsh. Both versions will be made available to
> participants.
>
>
>
> Together with the above changes I would like to mention two other issues:
>
> 1. In the meeting review document issued on 21/11/2011, in the paragraph
> "Suitability of the applicant and facilities; community considerations",
> at pct. 1 it is mentioned that Prof. Turnbull will be present at each
> testing session. I would like to very briefly clarify to the Committee
> what was meant in the meeting with regards to this issue. Prof. Turnbull
> will be present at the initial testing sessions, until he is confident
> that the Principal Investigator is able to manage the demands of patient
> assessment (i.e., interaction with the patient, delivery of the
> assessment protocol, and administration of the neuropsychological
> assessment tests).
>
> 2. Regarding the testing of controls, our minimum suggestion was to test
> 20 participants. However, we now have the possibility to increase the
> power of the analysis and would like to raise the number of controls to
> 60. This would allow us to better identify differences in the single
> case study versus control group comparisons. The number of patients
> recruited will remain unchanged.
>
> Please do let me know whether the above points need to be formalised any
> further.
>
>
> Thank you very much for all your help!
>
>
> Best regards,
> Andrei
>
>
>

3

> **********************
> Andrei Stanciu
> PhD Student
> School of Psychology
> Bangor University
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> Penrallt Road
> Bangor
> Gwynedd
> LL57 2AS
>
> Tel: +44 (0)1248 382943
> Fax: +44 (0)1248 382599
>
> On 21/11/2011 17:02, Rossela Roberts (BCUHB - R& D) wrote:
>> Dear Oliver, Dear Andrei,
>>
>> Thank you for attending the ethics committee to speak to this submission.
>>
>> Please find attached the letter of provisional opinion following the
>> review. (original in the post)
>>
>> Should you require further information or clarifications please do not
>> hesitate to contact me.
>>
>> Best wishes,
>>
>> Rossela
>>
>> --
>> Dr. Rossela Roberts, MICR, CSci
>>
>> Swyddog Rheolaeth Glinigol (YaD/Moeseg)
>>
>> Clinical Governance Officer (R&D/Ethics)
>>
>> Bwrdd Iechyd Prifysgol Betsi Cadwaladr University Health Board
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>> tel/fax: 01248 - 38 (4877)
>> e-mail: rossela.roberts@wales.nhs.uk
>> <blocked::mailto:rossela.roberts@wales.nhs.uk>
>>
>> **
>>
>> *Bwrdd Iechyd Prifysgol Betsi Cadwaladr yw enw gweithredol Bwrdd Iechyd
>> Lleol Prifysgol Betsi Cadwaladr*
>>
>> *Betsi Cadwaladr University Health Board is the operational name of
>> Betsi Cadwaladr University Local Health Board*
>>
>> --
>>

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>> Cymraeg
>>
>> *Rhybudd Ebost (2010) - **Bwrdd Iechyd Prifysgol Betsi Cadwaladr***
>>
>> Fe'ch cynghorir i ddarllen rhybydd ebost Bwrdd Iechyd Prifysgol Betsi
>> Cadwaladr (a'i argraffu er mwyn cyfeirio ato yn y dyfodol). Gellir dod o
>> hyd iddo yn y lleoliad canlynol
>>
>> http://www.wales.nhs.uk/sitesplus/861/tudalen/47230
>>
>> English
>>
>> *Betsi Cadwaladr University Health Board - Email Notice (2010)*
>>
>> You are advised to read (and print for future reference) the Betsi
>> Cadwaladr University Health Board e-mail notice which can be found at
>> this location
>>
>> http://www.wales.nhs.uk/sitesplus/861/page/47229
>>
>> Betsi Cadwaladr University Health Board is the operational name of Betsi
>> Cadwaladr University Local Health Board
>>
>

--
Rhif Elusen Gofrestredig / Registered Charity No. 1141565

Cymraeg

Rhybudd Ebost (2010) - Bwrdd Iechyd Prifysgol Betsi Cadwaladr

Fe'ch cynghorir i ddarllen rhybydd ebost Bwrdd Iechyd Prifysgol Betsi Cadwaladr (a'i argraffu er mwyn cyfeirio ato yn y dyfodol). Gellir dod o hyd iddo yn y lleoliad canlynol

http://www.wales.nhs.uk/sitesplus/861/tudalen/47230

English

Betsi Cadwaladr University Health Board - Email Notice (2010)

You are advised to read (and print for future reference) the Betsi Cadwaladr University Health Board e-mail notice which can be found at this location

http://www.wales.nhs.uk/sitesplus/861/page/47229

Betsi Cadwaladr University Health Board is the operational name of Betsi Cadwaladr University Local Health Board

Email secured by Check Point

6

Andrei Stanciu
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Fax: +44 (0)1248 382599

Dear Andrei,

Re: Stability of discrete emotions in amnesia

We are very pleased to collaborate with you on the above project, by inviting some of our service users to take part in the study and by accommodating the testing sessions on our premises. This will hopefully contribute to a better understanding of alcohol related brain injuries that cause memory problems.

We understand that you will be visiting our alcohol related brain injury service starting in November 2012 to conduct the above study. The experimental paradigm will be based on four emotional stories and a set of established neuropsychological assessments.

Upon your arrival at our centre, we will ensure that you are fully inducted into the health and safety aspects of your stay with us, including the fire procedure, confidentiality and infection control. You will also be supported by a designated member of staff whilst you are with us, so that any questions or queries can be dealt with in a timely manner.

Yours sincerely,

K East

Karen East

Head of Clinical Governance

Dukeries Healthcare

Appendix C. Participant documents

Ysgol Seicoleg
Prifysgol Bangor

Adeilad Brigantia, Ffordd Penrallt
Bangor, Gwynedd LL57 2AS

Ffôn: (01248) 382211 - Ffacs: (01248) 382599
e-bost: psychology@bangor.ac.uk
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PRIFYSGOL BANGOR UNIVERSITY 1884

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www.psychology.bangor.ac.uk

Taflen Wybodaeth i Gleifion Niwrolegol

Teitl yr Astudiaeth
Ymchwiliad i'r Emosiynau Sylfaenol a'r Cof

Ymchwilwyr
Yr Athro Oliver Turnbull – PhD, Athro Niwroseicoleg, Prifysgol Bangor
Andrei Stanciu – Myfyriwr PhD, Ysgol Seicoleg, Prifysgol Bangor

Hayley Butler, Haifa Almutari, Matthew McMahon, Molly Harper, Myria Tryfonos
– myfyrwyr Meistr, Ysgol Seicoleg, Prifysgol Bangor

Mae gwahoddiad ichi gymryd rhan mewn astudiaeth ymchwil. Cyn ichi benderfynu p'un a hoffech gymryd rhan neu beidio, mae'n bwysig eich bod yn deall y rheswm am wneud yr ymchwil a'r hyn y bydd yn ei olygu. Cymerwch amser i ddarllen y wybodaeth isod yn ofalus.

Beth yw pwrpas yr astudiaeth?
Amcan yr astudiaeth bresennol yw ymchwilio i'r modd y mae pobl yn cofio storïau sy'n ysgogi teimlad. Mae'r astudiaeth hon yn unigryw am ei bod yn ymchwilio i fwy o emosiynau nag ymchwil flaenorol. Yn y dyfodol, gyda chymorth yr astudiaeth hon, efallai y bydd modd i glinigwyr a chwnselwyr ymdrin â phroblemau emosiynol pobl yn fwy penodol, hyd yn oed pan na allant gofio achos eu teimladau negyddol.

Pam rwyf wedi cael gwahoddiad?
Rydych wedi cael gwahoddiad i gymryd rhan yn yr astudiaeth hon am eich bod yn cael anhawster i gofio rhai manylion am ddigwyddiadau bob dydd. Rydym yn gwahodd 20 o bobl sydd â phroblemau ar y cof a 60 o gyfranogwyr eraill i gymryd rhan yn yr astudiaeth hon.

A oes raid imi gymryd rhan?
Mater i chi yw penderfynu ymuno â'r astudiaeth. Os cytunwch i gymryd rhan, byddwn yn gofyn ichi lofnodi ffurflen gydsynio. Mae gennych hawl i dynnu'n ôl ar unrhyw adeg, hyd yn oed ar ôl i'r astudiaeth ddechrau, a heb roi rheswm. Ni fydd hyn yn effeithio ar y gofal a gewch.

Beth sy'n digwydd yn ystod yr astudiaeth?
Byddwch yn cymryd rhan mewn pum sesiwn o ddwyawr yr un. Mae modd cynnal y rhain naill ai yn eich cartref neu mewn labordy pwrpasol yn yr Ysgol Seicoleg, Prifysgol Bangor. P'un a fyddoch yn penderfynu cymryd rhan yn yr astudiaeth yn eich cartref neu yn yr Ysgol Seicoleg, bydd angen i'ch gofalwr fod ar gael tra pery'r sesiwn brofi. Yn y sesiynau, byddwch yn gwrando ar hanesion byrion a'u galw i gof. Cyn ac ar ôl pob hanesyn, gofynnir ichi lenwi dau holiadur byr ar sut rydych yn teimlo, beth rydych yn ei gofio, a gwneud rhai profion ysgrifbin a phapur. Cymerir recordiadau sain yn ystod y tasgau cofio, fel na fydd yn rhaid ichi ysgrifennu eich atebion.

A yw'r astudiaeth yn cynnwys unrhyw sganio ar yr ymennydd?

Os nad ydych erioed wedi cael sgan manwl ar eich ymennydd, efallai y cewch wahoddiad i gael sgan MRI yn Uned Ddelweddu Prifysgol Bangor. Nid yw'r sgan hwn yn cynnwys unrhyw ymbelydredd, chwistrelliadau, cyffuriau, llawdriniaeth na thriniaeth arbrofol arall, ac ni fydd chwaith yn ymyrryd ag unrhyw feddyginiaeth na therapi arall y byddoch yn ei chael. Cewch fwy o wybodaeth os byddwn yn eich gwahodd i gael sgan.

A oes unrhyw risgiau o gymryd rhan yn yr astudiaeth?

Nid yw'r mesuriad hwn yn boenus nac yn beryglus o gwbl. Fodd bynnag, os cewch fod yr astudiaeth yn peri gofid ichi, gellwch roi'r gorau iddi, heb roi unrhyw resymau na chael unrhyw gosb.

Beth yw'r buddion?

Nid oes buddion uniongyrchol i chi am gymryd rhan yn yr astudiaeth. Fodd bynnag, bydd eich cyfranogiad yn gymorth o ran deall sut y mae pobl â phroblemau ar y cof yn profi emosiynau.

A fyddaf yn derbyn iawndal?

Os penderfynwch gymryd rhan, byddwch yn cael £10 yr awr (£20 am bob un o'r pum sesiwn), ynghyd ag unrhyw gostau teithio i'r Ysgol Seicoleg ac yn ôl.

Sut y sicrheir cyfrinachedd?

Byddwn yn trin yr holl ddata a gesglir yn yr astudiaeth fel pe bai'n llwyr gyfrinachol. Bydd eich data chi'n cael cod rhifol unigryw. Ni chynhwysir unrhyw wybodaeth arall a allai arwain at eich adnabod (e.e., enw, oed, etc.) yn y data sydd i'w storio. Bydd yr un peth yn wir ynglŷn â'r recordiadau sain. Byddwn yn archifo'r holl holiaduron am 5 mlynedd, ac wedyn cânt eu dinistrio mewn modd cyfrinachol. Efallai y caiff y wybodaeth o'r astudiaeth ei chyhoeddi mewn papurau gwyddonol, neu ei chyflwyno mewn cynadleddau gwyddonol, ond ni ddatgelir eich enw'n gyhoeddus.

A oes unrhyw gyfyngiadau o ran cyfrinachedd?

Mewn rhai achosion, mae'n ofynnol inni dorri cyfrinachedd. Mae'r rhain yn cynnwys adroddiadau ar gam-drin (e.e. cam-drin corfforol neu esgeulustod). Ar ben hynny, os datgelwch eich bod yn bwriadu eich niweidio eich hun neu niweidio pobl eraill, mae'n ofynnol inni hysbysu'r awdurdodau cyfreithiol am hyn a chymryd rhagofalon priodol.

Beth os bydd gennyf gwestiynau eraill?

Rydym yn croesawu'r cyfle i ateb unrhyw gwestiwn a fo gennych ynglŷn ag unrhyw agwedd ar yr astudiaeth hon neu'ch rhan chi ynddi. Gellwch gysylltu â'r Prif Ymchwilydd: Andrei Stanciu (ffôn: 01248 38 29 43, e-bost: m.a.stanciu@bangor.ac.uk), neu'r Athro Oliver Turnbull (e-bost: o.turnbull@bangor.ac.uk).

Beth os bydd gennyf gŵyn?

Os bydd gennych unrhyw gwynion ynglŷn â'r modd y gwneir yr ymchwil hon, dylech gyfeirio'r rhain at Mr. Hefin Francis, Rheolwr yr Ysgol, Ysgol Seicoleg, Prifysgol Bangor, Bangor Gwynedd, LL57 2AS, e-bost: h.francis@bangor.ac.uk, ffôn: 01248 38 83 39.

DIOLCH AM YSTYRIED Y MATER.

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Prifysgol Bangor

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Information Sheet for Neurological Participants

Study Title
Investigation of Basic Emotions and Memory.

Investigators
Prof. Oliver Turnbull – Ph.D., Professor of Neuropsychology, Bangor University.
Andrei Stanciu – PhD student, School of Psychology, Bangor University.

Hayley Butler, Haifa Almutari, Matthew McMahon, Molly Harper, Myria Tryfonos – Masters students, School of Psychology, Bangor University.

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?
The aim of the present study is to investigate how people remember emotional stories. This study is unique because it investigates more emotions than previous research. In future, with the help of this study, clinicians and counsellors may be able to address people's emotional problems more specifically even when the cause of their negative emotions cannot be remembered.

Why have I been invited?
You have been invited to take part in this study because you have difficulty in remembering some details of everyday events. We are inviting 20 people with memory problems, and 60 other participants to take part in this study.

Do I have to take part?
It is up to you to decide to join the study. If you agree to take part, we will ask you to sign a consent form. You are free to withdraw at any time, even after the study has started, and without giving a reason. This will not affect the care you receive.

What happens during the study?
You will take part in five sessions, each of two hours. These can take place either at your home, or in a dedicated laboratory at the School of Psychology, Bangor University. Whether you decide to take part in the study in your home, or in the School of Psychology, your carer will need to be available for the duration of the testing session. In the sessions, you will listen to short stories and recall them. Before and after each story, you will be asked to fill in two short questionnaires about how you are feeling, what you remember and some pen-

and-paper tests. Audio recordings will be taken during the memory tasks, so that you will not have to write your answers.

Does the study involve any brain scanning?

If you have never had a detailed brain scan, you may be invited for an MRI scan at the Imaging Unit of Bangor University. The scan does not involve any radiation, injections, drugs, surgery or other experimental treatment, and will in no way interfere with any medication or other therapy. More information will be provided if you are invited for a scan.

Are there any risks of taking part in the study?

This measure is not painful or dangerous in any way. However, if you find the study distressing you can stop, without giving any reasons, and without incurring any penalty.

What are the benefits?

There are no direct benefits to you for participating in the study. However, your participation will be helpful in understanding how emotions are felt by people with memory problems.

Will I receive compensation?

If you should decide to participate, you will receive £10 per hour (£20 for each of the five sessions), plus any travel costs to and from the School of Psychology.

How is confidentiality ensured?

All data collected in the study will be treated with full confidentiality. Your data will receive a unique numeric code. No other identifying information (e.g., name, age, etc.) will be included in the stored data. The same will apply to the audio recordings. All questionnaires will be archived for 5 years, at which time they will be confidentially destroyed. The information in the study may be published in scientific papers, or presented at scientific conferences, but your name will not be made public.

Are there any limits of confidentiality?

There are some cases in which we are required to break confidentiality. These include reports of abuse (e.g., physical abuse or neglect. Also, if you disclose the intention or a plan to harm yourself or others, we are required to report this to the legal authorities and take appropriate precautions.

What if I have further questions?

We welcome the opportunity to answer any question you may have about any aspect of this study or about your participation. You can contact the Principal Investigator: Andrei Stanciu (tel: 01248 38 29 43, e.mail: m.a.stanciu@bangor.ac.uk), or Prof. Oliver Turnbull (e.mail: o.turnbull@bangor.ac.uk).

What if I have a complaint?

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Bangor University, LL57 2AS, e-mail: h.francis@bangor.ac.uk, tel: 01248 38 83 39.

THANK YOU FOR YOUR CONSIDERATION.

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You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?
The aim of the present study is to investigate how people remember emotional stories. This study is unique because it investigates more emotions than previous research. In future, with the help of this study, clinicians and counsellors may be able to address people's emotional problems more specifically even when the cause of their negative emotions cannot be remembered.

Why have I been invited?
You have been invited to take part in this study because you have expressed an interest in taking part in psychological research conducted at the School of Psychology of Bangor University. We are inviting 20 people with memory problems, and 60 non-amnesic participants to take part in this study.

Do I have to take part?
It is up to you to decide to join the study. If you agree to take part, we will ask you to sign a consent form. You are free to withdraw at any time, even after the study has started, and without giving a reason.

What happens during the study?
You will take part in four sessions, each of two hours. These will take place in a dedicated laboratory at the School of Psychology, Bangor University. In the sessions, you will listen to short stories and recall them. Before and after each story, you will be asked to fill in two short questionnaires about how you are feeling, what you remember and some pen-and-paper tests. Audio recordings will be taken during the memory tasks, so that you will not have to write your answers.

Are there any risks of taking part in the study?

This measure is not painful or dangerous in any way. However, if you find the study distressing you can stop, without giving any reasons, and without incurring any penalty.

What are the benefits?

There are no direct benefits to you for participating in the study. However, your participation will be helpful in understanding how emotions are related to memory.

Will I receive compensation?

If you should decide to participate, you will receive £6 per hour (£12 for each of the first three sessions) and £14 for the last (fourth) session.

How is confidentiality ensured?

All data collected in the study will be treated with full confidentiality. Your data will receive a unique numeric code. No other identifying information (e.g., name, age, etc.) will be included in the stored data. The same will apply to the audio recordings. All questionnaires will be archived for 5 years, at which time they will be confidentially destroyed. The information in the study may be published in scientific papers, or presented at scientific conferences, but your name will not be made public.

Are there any limits of confidentiality?

There are some cases in which we are required to break confidentiality. These include reports of abuse (e.g., physical abuse or neglect. Also, if you disclose the intention or a plan to harm yourself or others, we are required to report this to the legal authorities and take appropriate precautions.

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Taflen Wybodaeth ar gyfer y Grŵp Safonol

Teitl yr Astudiaeth
Ymchwiliad i'r Emosiynau Sylfaenol a'r Cof

Ymchwilwyr
Yr Athro Oliver Turnbull – PhD, Athro Niwroseicoleg, Prifysgol Bangor
Andrei Stanciu – Myfyriwr PhD, Ysgol Seicoleg, Prifysgol Bangor

Hayley Butler, Haifa Almutari, Matthew McMahon, Molly Harper, Myria Tryfonos
– myfyrwyr Meistr, Ysgol Seicoleg, Prifysgol Bangor

Mae gwahoddiad ichi gymryd rhan mewn astudiaeth ymchwil. Cyn ichi benderfynu p'un a hoffech gymryd rhan neu beidio, mae'n bwysig eich bod yn deall y rheswm am wneud yr ymchwil a'r hyn y bydd yn ei olygu. Cymerwch amser i ddarllen y wybodaeth isod yn ofalus.

Beth yw pwrpas yr astudiaeth?
Amcan yr astudiaeth bresennol yw ymchwilio i'r modd y mae pobl yn cofio storïau sy'n ysgogi teimlad. Mae'r astudiaeth hon yn unigryw am ei bod yn ymchwilio i fwy o emosiynau nag ymchwil flaenorol. Yn y dyfodol, gyda chymorth yr astudiaeth hon, efallai y bydd modd i glinigwyr a chwnselwyr ymdrin â phroblemau emosiynol pobl yn fwy penodol, hyd yn oed pan na allant gofio achos eu teimladau negyddol.

Pam rwyf wedi cael gwahoddiad?
Rydych wedi cael gwahoddiad i gymryd rhan yn yr astudiaeth hon am eich bod wedi mynegi diddordeb mewn cymryd rhan mewn ymchwil seicolegol a gynhelir yn yr Ysgol Seicoleg, Prifysgol Bangor. Rydym yn gwahodd 20 o bobl sydd â phroblemau ar y cof a 60 o gyfranogwyr heb amnesia i gymryd rhan yn yr astudiaeth hon.

A oes raid imi gymryd rhan?
Mater i chi yw penderfynu ymuno â'r astudiaeth. Os cytunwch i gymryd rhan, byddwn yn gofyn ichi lofnodi ffurflen gydsynio. Mae gennych hawl i dynnu'n ôl ar unrhyw adeg, hyd yn oed ar ôl i'r astudiaeth ddechrau, a heb roi rheswm.

Beth sy'n digwydd yn ystod yr astudiaeth?
Byddwch yn cymryd rhan mewn pum sesiwn o ddwyawr yr un. Cynhelir y rhain mewn labordy pwrpasol yn yr Ysgol Seicoleg, Prifysgol Bangor. Yn y sesiynau, byddwch yn gwrando ar hanesion byrion a'u galw i gof. Cyn ac ar ôl pob hanesyn, gofynnir ichi lenwi dau holiadur byr ar sut rydych yn teimlo, beth rydych yn ei gofio, a gwneud rhai profion ysgrifbin a phapur.

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Ffurflen gofyn am Gydsyniad Gwybodus gan Gyfranogwyr Niwrolegol

Teitl yr Astudiaeth
Ymchwiliad i'r Emosiynau Sylfaenol a'r Cof

Ymchwilwyr
Yr Athro Oliver Turnbull – PhD, Athro Niwroseicoleg, Prifysgol Bangor
Andrei Stanciu – Myfyriwr PhD, Ysgol Seicoleg, Prifysgol Bangor

Hayley Butler, Haifa Almutari, Matthew McMahon, Molly Harper, Myria Tryfonos
– myfyrwyr Meistr, Ysgol Seicoleg, Prifysgol Bangor

Hyn sydd i dystio fy mod i, ……………………………………………………., yn cytuno trwy hyn i gymryd rhan fel gwirfoddolwr yn yr astudiaeth bresennol.

- Rwyf wedi darllen a deall y Daflen Wybodaeth, fersiwn 2.0, ddyddiedig 28/11/2011, ar gyfer yr astudiaeth uchod. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

- Rwyf wedi trafod yr astudiaeth bresennol ac wedi cael digon o wybodaeth amdani. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

- Rwyf wedi cael atebion boddhaol i'm holl gwestiynau ynglŷn â'r astudiaeth bresennol. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

- Deallaf fy mod yn cyfranogi o'm gwirfodd, a bod gennyf hawl i roi'r gorau iddi ar unrhyw adeg, a heb roi unrhyw reswm. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

- Deallaf fod gennyf hawl i beidio ag ateb eitemau neu gwestiynau penodol mewn cyfweliadau neu ar holiaduron, ac y caf hepgor unrhyw rannau o'r astudiaeth. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

- Rhoddaf fy nghaniatâd i'r ymchwilwyr edrych ar rannau perthnasol o'm hanes meddygol ac ar sganiau fy ymennydd. ☐

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu rhoddwch "X" os anghytunwch)

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- Cytunaf i sesiynau'r astudiaeth gael eu recordio er hwyluso'r gwaith o gasglu data. Bydd recordiadau sain yn defnyddio cod rhifol, ac ni fyddant yn cynnwys fy enw i nac unrhyw wybodaeth bersonol arall, a chânt eu storio am 5 mlynedd ar ôl diwedd yr astudiaeth; yna, cânt eu dinistrio mewn modd cyfrinachol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych *yn cytuno, neu nodwch "X" os anghytunwch*)

- Deallaf y cedwir yr holl ddata a gesglir yn ystod yr astudiaeth, ac y cânt eu dadansoddi a'u cyhoeddi mewn modd llwyr gyfrinachol o ran fy manylion personol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde *os ydych yn cytuno, neu nodwch "X" os anghytunwch*)

- Gofynnwyd am fy nghaniatâd i gael crynodeb o ganlyniadau'r astudiaeth bresennol pan ddeuant i law.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

Llofnod y cyfranogwr ______________________________ Dyddiad ____________

Enw'r Cyfranogwr (mewn priflythrennau) ____

Yr wyf i, sydd â'm henw isod, wedi rhoi eglurhad llawn i'r cyfranogwr uchod ynglŷn â'r ymchwiliad.

Llofnod yr Ymchwilydd________________________________ Dyddiad ____________

Os bydd gennych unrhyw g*ŵynion ynglŷn â'r modd y gwneir yr ymchwil hon, dylech gyfeirio'r rhain* at Mr. Hefin Francis, Rheolwr yr Ysgol, Ysgol Seicoleg, Prifysgol Bangor, Bangor Gwynedd, LL57 2AS, e-bost: h.francis@bangor.ac.uk, ffôn: 01248 38 83 39. Yn achos Cleifion y Gwasanaeth Iechyd, dylech hefyd gyfeirio cwynion at Brif Weithredwr yr ymddiriedolaeth berthnasol.

02/12.6192-hs-app-f-neur

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Consent Form for Controls

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Investigation of Basic Emotions and Memory.

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Andrei Stanciu – PhD student, School of Psychology, Bangor University.

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– Masters students, School of Psychology, Bangor University.

This is to certify that I, ………………………………………………………., hereby agree to participate as a volunteer in the present study.

- I have read and understood the Information Sheet version 2.0, dated 28/11/2011, for the above study.
  (please *initial the box to the right if you agree, or mark an "X" if do not agree*) ☐
- I have discussed and received enough information about the present study.
  (please initial the box to the right if you agree, or mark an "X" if do not agree) ☐
- I have received satisfactory answers to all my questions about the present study.
  (please initial the box to the right if you agree, or mark an "X" if do not agree) ☐
- I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.
  (please *initial the box to the right if you agree, or mark an "X" if do not agree*) ☐
- I understand that I am free not to answer specific items or questions in interviews or on questionnaires, and that I can skip any parts of the study.
  (please *initial the box to the right if you agree, or mark an "X" if do not agree*) ☐
- I agree for study sessions to be audio-recorded in order to facilitate data collection. Audio recordings will use a numeric code and will not include my name or other personal information and will be stored for five years after the end of the study, at which time they will be confidentially destroyed.
  (please init*ial the box to the right if you agree, or mark an "X" if do not agree*) ☐

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- I understand that all data gathered during the study will be stored, analysed and published in a completely confidential manner with regard to my identity.

(please initial the box *to the right if you agree, or mark an "X" if do not agree*) ☐

- I have been asked for my permission to receive a summary of the results of the present study, when they become available.

(please *initial the box to the right if you agree, or mark an "X" if d*o not agree) ☐

- I have never had any neurological or psychiatric conditions.

(please *initial the box to the right if you agree, or mark an "X" if do not agree*) ☐

If you have been diagnosed and are currently undergoing treatment for any of the conditions listed at the question above, then please give details below and continue on a separate page if needed:

....

....

....

....

....

....

....

Participant Signature ______________________________ Date ____________

Participant Name (in capital letters) ____________________________________

I, the undersigned, have fully explained the investigation to the above participant.

Investigator Signature ______________________________ Date ____________

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Bangor University, LL57 2AS, e-mail: h.francis@ bangor.ac.uk, tel: 01248 38 83 39. In the case of Health Service Patients, complaints should in addition be addressed to Chief Executive of the relevant trust.

Date: 28/11/2011 Document Version: 2.0 2

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- I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.
  (please *initial the box to the right if you agree, or mark an "X" if do not agree*) ☐

- I understand that I am free not to answer specific items or questions in interviews or on questionnaires, and that I can skip any parts of the study without my medical care or legal rights being affected.
  (please initial the box to the right if you agree, or mark an *"X" if do not agree*) ☐

Date: 28/11/2011 Document Version: 2.0 1

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- I give my permission for relevant sections of my medical history and brain scans to be looked at by the investigators.

(please *initial the box to the right if you agree, or mark an "X" if do not agree*)

- I agree for study sessions to be audio-recorded in order to facilitate data collection. Audio recordings will use a numeric code and will not include my name or other personal information and will be stored for five years after the end of the study, at which time they will be confidentially destroyed.

(please *initial the box to the right if you agree, or mark an "X" if do not agree*)

- I understand that all data gathered during the study will be stored, analysed and published in a completely confidential manner with regard to my identity.

(please *initial the box to the right if you agree, or mark an "X" if do not agree*)

- I have been asked for my permission to receive a summary of the results of the present study, when they become available.

(please initial the box to the right *if you agree, or mark an "X" if do not agree*)

Participant Signature ______________________________ Date ____________

Participant Name (in capital letters) ____________________________________

I, the undersigned, have fully explained the investigation to the above participant.

Investigator Signature ______________________________ Date ____________

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Bangor University, LL57 2AS, e-mail: h.francis@ bangor.ac.uk, tel: 01248 38 83 39. In the case of Health Service Patients, complaints should in addition be addressed to Chief Executive of the relevant trust.

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Ffurflen Gydsynio ar gyfer y Grŵp Safonol

Teitl yr Astudiaeth
Ymchwiliad i'r Emosiynau Sylfaenol a'r Cof

Ymchwilwyr
Yr Athro Oliver Turnbull – PhD, Athro Niwroseicoleg, Prifysgol Bangor
Andrei Stanciu – Myfyriwr PhD, Ysgol Seicoleg, Prifysgol Bangor

Hayley Butler, Haifa Almutari, Matthew McMahon, Molly Harper, Myria Tryfonos – myfyrwyr Meistr, Ysgol Seicoleg, Prifysgol Bangor

Hyn sydd i dystio fy mod i, ……………………………………………………….., yn cytuno trwy hyn i gymryd rhan fel gwirfoddolwr yn yr astudiaeth bresennol.

- Rwyf wedi darllen a deall y Daflen Wybodaeth, fersiwn 2.0, ddyddiedig 28/11/2011, ar gyfer yr astudiaeth uchod.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Rwyf wedi trafod yr astudiaeth bresennol ac wedi cael digon o wybodaeth amdani.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Rwyf wedi cael atebion boddhaol i'm holl gwestiynau ynglŷn â'r astudiaeth bresennol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Deallaf fy mod yn cyfranogi o'm gwirfodd, a bod gennyf hawl i roi'r gorau iddi ar unrhyw adeg, a heb roi unrhyw reswm.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Deallaf fod gennyf hawl i beidio ag ateb eitemau neu gwestiynau penodol mewn cyfweliadau neu ar holiaduron, ac y caf hepgor unrhyw rannau o'r astudiaeth.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Cytunaf i sesiynau'r astudiaeth gael eu recordio er hwyluso'r gwaith o gasglu data. Bydd recordiadau sain yn defnyddio cod rhifol, ac ni fyddant yn cynnwys fy enw i nac unrhyw wybodaeth bersonol arall, a chânt eu storio am 5 mlynedd ar ôl diwedd yr astudiaeth; yna, cânt eu dinistrio mewn modd cyfrinachol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

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- Deallaf y cedwir yr holl ddata a gesglir yn ystod yr astudiaeth, ac y cânt eu dadansoddi a'u cyhoeddi mewn modd llwyr gyfrinachol o ran fy manylion personol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Gofynnwyd am fy nghaniatâd i gael crynodeb o ganlyniadau'r astudiaeth bresennol pan ddeuant i law.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

- Nid wyf erioed wedi dioddef gan unrhyw gyflyrau niwrolegol na seiciatryddol.

(rhowch lythrennau blaen eich enw yn y blwch ar y dde os ydych yn cytuno, neu nodwch "X" os anghytunwch)

*Os ydych wedi cael eich diagnosio ag unrhyw un o'r cyflyrau sydd wedi'u rhestru yn y cwestiwn uchod neu wrthi'n cael tri*niaeth tuag ato, rhowch fanylion isod a pharhewch ar dudalen ar wahân os oes angen:

……
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……
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……
……

Llofnod y cyfranogwr ________________________________ Dyddiad ____________

Enw'r Cyfranogwr (mewn priflythrennau) ________________________________

Yr wyf i, sydd â'm henw isod, wedi rhoi eglurhad llawn i'r cyfranogwr uchod ynglŷn â'r ymchwiliad.

Llofnod yr Ymchwilydd________________________________ Dyddiad ____________

Os bydd gennych unrhyw gwynion *ynglŷn â'r modd y gwneir yr ymchwil hon, dylech gyfeirio'r rhain* at Mr. Hefin Francis, Rheolwr yr Ysgol, Ysgol Seicoleg, Prifysgol Bangor, Bangor Gwynedd, LL57 2AS, e-bost: h.francis@bangor.ac, ffôn: 01248 38 83 39. Yn achos Cleifion y Gwasanaeth Iechyd, dylech hefyd gyfeirio cwynion at Brif Weithredwr yr ymddiriedolaeth berthnasol.

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Dyddiad: 28/11/2011 Dogfen Fersiwn: 2.0 2

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Taflen Ôl-gyfarwyddyd

Teitl yr astudiaeth	Ymchwilio i emosiynau a chof sylfaenol.
Beth mae'r astudiaeth yn ymchwilio iddo?	Nod yr astudiaeth yw darganfod sut mae gwahanol sefyllfaoedd ym mywydau pobl yn achosi emosiynau megis dicter, ofn, llawenydd a thristwch dros amser. Mae hyn yn bwysig oherwydd bod emosiynau pobl yn newid dros amser yn unol â'r manylion maent yn eu cofio. Hefyd caiff gwahanol emosiynau, er enghraifft llawenydd a thristwch, eu heffeithio'n wahanol yn dibynnu ar faint o wybodaeth mae pobl yn ei gofio. Yr astudiaeth hon yw'r gyntaf o'i math oherwydd ei bod yn archwilio emosiynau mwy sylfaenol nac astudiaethau blaenorol, ac mewn mwy o fanylder. Felly, yn y dyfodol, gyda chymorth yr astudiaeth hon, gallai clinigwyr a chynghorwyr fynd i'r afael â phroblemau emosiynol pobl mewn ffordd fwy penodol a gwella eu lles hyd yn oed os nad ydynt yn gallu cofio eu hemosiynau negyddol.
Beth yw'r drefn?	Er mwyn astudio effaith gwahanol sefyllfaoedd ar deimladau pobl, crëwyd y pedair stori a gyflwynwyd i chi yn yr astudiaeth hon. Nid yw'r pethau sy'n digwydd yn y straeon yn gysylltiedig â'ch bywyd personol o gwbl. Nod pob stori oedd gwneud i chi deimlo emosiwn gwahanol (dicter, ofn, llawenydd neu dristwch) ar lefel gymedrol. Roedd y straeon yn gwneud i rai pobl deimlo'r emosiwn disgwyliedig, ond ni effeithiwyd pawb yn yr un ffordd. Bydd eich data'n ddefnyddiol pa un a wnaethoch deimlo'r emosiwn disgwyliedig neu beidio. Roeddem eisiau gweld a oedd yr emosiynau roedd pobl yn eu teimlo ar ddechrau'r sesiwn yn newid pan oeddent yn meddwl am y stori ar unwaith ar ôl ei chlywed neu pan oeddent yn meddwl amdani'r ail dro, tua 20 munud i hanner awr wedyn. Yna roeddem eisiau gweld a oedd pobl yn cofio'r un faint o fanylion am bob stori dros amser. Roedd rhai pobl yn cofio rhai straeon yn well nag eraill tra nad oedd rhai pobl yn cofio dim o gwbl am ddim un o'r straeon. Eto, bydd eich data'n ddefnyddiol iawn i ni, ni waeth faint o wybodaeth roeddech yn ei chofio.
Pryd fydd canlyniadau'r astudiaeth yn hysbys?	Bydd yr astudiaeth yn dod i ben ar 30 Awst 2014 a dylai'r canlyniadau fod yn hysbys cyn hynny. Gwnawn anfon grynodeb o ganlyniadau'r astudiaeth atoch pan fyddent ar gael os rhowch ganiatâd i ni wneud hynny. Dylai canlyniadau rhannol fod ar gael cyn diwedd yr astudiaeth. Os oes gennych unrhyw gwestiynau cysylltwch â'r prif ymchwilydd: Andrei Stanciu ar 01248 38 2943, neu trwy e-bost: m.a.stanciu@bangor.ac.uk.
Beth os bydd gennyf gwyn?	Dylid anfon unrhyw gwynion ynghylch y ffordd y cynhaliwyd yr astudiaeth hon at Mr Hefin Francis, Rheolwr yr Ysgol Seicoleg, Prifysgol Bangor, LL57 2AS, e-bost: h.francis@bangor.ac.uk, ffôn: 01248 38 83 39.

Diolch yn fawr am gymryd rhan!

Date: 20/06/2011 Document Version: 1.0

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Debriefing Sheet

Study Title	Investigation of Basic Emotions and Memory.
What is the study investigating?	The aim of this study is to investigate how different situations in people's lives cause emotions such as anger, fear, happiness and sadness across time. This is important because people's emotions change differently over time according to the amount of details they can remember. Also, different emotions, for example happiness and sadness, are affected differently by the amount of information remembered. This investigation is the first of its kind, because it investigates more basic emotions than previous studies, and in a greater level of detail. Therefore, in future, with the help of this study, clinicians and counsellors could be able to address people's emotional problems more specifically and improve their wellbeing even when the cause of their negative emotions cannot be remembered.
How does the procedure work?	In order to investigate the effect of different situations on the way people feel, we created the four fictive stories that were presented to you in the study. The actions taking place in the stories are not related with your personal life in any way. Each story was aimed at making you feel a different emotion (anger, fear, happiness, or sadness) at a moderate level of intensity. The stories cause some people to experience the expected emotion, but not everybody is affected in the same way. Your data will be useful in the study regardless of whether you reported the expected emotion or not. We want to see whether the emotions people feel at the beginning of the testing session change after the immediate recollection of the story, or after the second recollection, which took place 20-30 minutes later. Next, we wanted to see if people remember a different amount of details from each story, across time. Some people remember some stories better than others, while other people don't remember anything from any of the stories. Again, regardless of the amount of information you remembered, your data will be very useful in the study.
When will the results of the study be known?	The results of the study should become available before August 30th, 2014, when the study will end. If you give us your permission, we will send you a summary of the study results when they are available. Partial results could become available before the end of the study. Should you have any further questions, you can contact the Principal Investigator: Andrei Stanciu on 01248 38 2943, by e-mail: m.a.stanciu@bangor.ac.uk.
What if I have a complaint?	Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Bangor University, LL57 2AS, e-mail: h.francis@bangor.ac.uk, tel: 01248 38 83 39.

Thank you for your participation!

Date: 20/06/2011 Document Version: 1.0

Appendix D. Emotional Stories (Chapters 2 and 3)

Session 1, Presentation.

Instruction for participants listening to both the stem (i.e., the first paragraph of the story), and the emotional ending (i.e., the last paragraph). Both parts of the story are read out to them in a neutral prosody.

> *Please listen to the following story and imagine that you are personally experiencing what is happening in the text.*

Session 1, Recall, and Session 2.

Instructions for participants during the recall procedure, when they are presented with the original story stems, and are asked to recall the story ending. The story stems are read out to them in a neutral prosody.

> *Please listen to the following story and try to reproduce out loud the rest of the story, including as many details as you can remember.*

Story Code Name: Workmate **Target emotion: Anger**

It was Friday night, after work, and a colleague invited me for a drink in a newly opened pub. The pub was relatively busy, as you would expect on an early Friday evening. A few lads were gathered around the pool table, while the shooter broke the balls. I sat down at one of the few available tables in the corner, and my colleague went to get the drinks.

My colleague returned to our table and asked me to take the drinks from him. I got up and before I had a chance to take the drinks, my colleague let go of them. The glasses smashed against the corner of the table and splattered over him and few of the people around him, but surprisingly missed me completely. My colleague started shouting at me and accusing me of deliberating dropping the drinks, supposedly as a failed joke. I couldn’t believe how ridiculous his claims were, yet he seemed to be very serious. The scene quickly escalated, when the pool player, who was close behind my colleague, turned around and said that a chip of the glass cut his hand and that he was bleeding, but his hands seemed to be just fine. The couple by the slot machine intervened too by saying they saw the situation quite clearly and that I had deliberately dropped the drinks. Surprisingly, people became even more agitated and aggressive towards me, and while some seemed to treat the situation as a mockery at my expense, others made more serious threats. Accusations, threats and insults were thrown at him from all directions, as if everybody had been waiting for an excuse to lash out.

Story Name: Workmate **Target emotion: Fear**

It was Friday night, after work, and a colleague invited me for a drink in a newly opened pub. The pub was relatively busy, as you would expect on an early Friday evening. A few lads were gathered around the pool table, while the shooter broke the balls. I sat down at one of the few available tables in the corner, and my colleague went to get the drinks.

A few moments later I heard a loud noise, and a lot of people bustling around the bar. Loud screams rose from the crowd as I saw my colleague set on fire, running towards our table. A giant flame expanded behind him and everybody started to panic, while trying to find the way out. The pool player with the cue stick still in his hand rushed to get out of the way, but caused my colleague to trip and fall right at my feet. I couldn't believe how quickly the fire had spread. It was now spreading up my clothes. I could feel them getting stuck to my skin. I tried to rush to the door, but everything was in the way. I couldn't touch anything; fire was everywhere. A young couple by the slot machine were trapped too and were trying to push the machine out of the way. When they succeeded, it fell onto a column, which collapsed, and a small part of the ceiling fell over me, completely blocking my exit. I was trapped and the smoke was getting so thick, that I couldn't breathe anymore.

Story Code Name: Workmate **Target emotion: Sadness**

It was Friday night, after work, and a colleague invited me for a drink in a newly opened pub. The pub was relatively busy, as you would expect on an early Friday evening. A few lads were gathered around the pool table, while the shooter broke the balls. I sat down at one of the few available tables in the corner, and my colleague went to get the drinks.

My colleague brought the drinks over and we started talking mostly about work. He was one of the friendliest and most helpful people at work. He had supported me through some of the hardest times and had proven to be the only one I could truly rely on at work. The pool player came to our table, and my colleague introduced him as a friend. Before he went back, the pool player whispered something in his friend's ear. My colleague looked at me for a second and then burst into tears. He went on to say that he was seriously ill, and that the doctors said to him there was nothing they could do. He said his prospects of recovery were terribly slim, and that his life was just a matter of waiting for the inevitable to happen. He had never talked about his health before, and I was only then realising that I was about to lose one of the dearest and most important people to me. From across the room a couple by the slot machine were calling my name. As they came over to join us, I was trying to think of something to say to introduce my colleague, but I simply couldn't move on from the terrible news I had just received.

Story Code Name: Workmate **Target emotion: Happiness**

It was Friday night, after work, and a colleague invited me for a drink in a newly opened pub. The pub was relatively busy, as you would expect on an early Friday evening. A few lads were gathered around the pool table, while the shooter broke the balls. I sat down at one of the few available tables in the corner, and my colleague went to get the drinks.

My colleague came back with the drinks and said he had a pleasant surprise for me. He told me how one of the people at work, from a more distant department, heard about me joining the team and wanted to meet me. My colleague called the pool player over, and as he turned around I could hardly believe my eyes. It was one of my best childhood friends. We grew up together, but when his family moved to another town we lost track of each other. He looked very much as I had imagined him to be. The same smile, the same hair, the same look, only a special gleam in his eyes now that he saw me. He called, from the across the room, a couple that were standing by the slot machine: his younger brother with his lovely partner. They sat down at our table and I still could not believe we were all finally reunited. They were all doing well and as the younger brother was soon getting married, they invited me to the wedding. There was a lot of excitement about the big event, we shared memories from our school years, laughed, and had a lovely time.

Story Code Name: Child **Target emotion: Anger**

It was a regular Tuesday morning. I had plenty of time on my hands and I decided to leave the house early. I noticed the traffic was particularly busy. Out in the street, I saw my neighbour, who stopped only for a second to say hello. He had his little boy with him. They were going out for the day, and they were in a big rush. The man suddenly remembered that he had forgotten something important back at the house and asked me if I could look after the boy, just for a minute, while he went to fetch it. Another neighbour's daughter was gliding along on her roller blades nearby.

The boy noticed a little kitten behind us and approached it, looking like he wanted to play with it. Before I had a chance to react, he grabbed the kitten by the tail, lifted it up in the air and kicked it very hard towards the traffic. The kitten landed in front of a speeding car, but very nearly managed to avoid being run over. I quickly pulled the little boy away, and told him never to do that again. I couldn't believe how such a nice little boy could be so cruel to an innocent being. The kitten was back on the pavement when I saw the roller-skater coming towards it and holding a water blaster. I thought to myself, "It's too cold to be playing with such a toy", but she stopped next to the trembling kitten, pointed the gun at it, started squirting, and chased it away. The kitten was running as fast as it could, crying desperately, but the roller-skater seemed to have no problem keeping close to it and aiming straight at it with the water gun. A few men working on a nearby scaffolding noticed the whole scene and started cheering, encouraging the roller-skater to keep chasing the kitten for their own entertainment.

Story Code Name: Child **Target emotion: Fear**

It was a regular Tuesday morning. I had plenty of time on my hands and I decided to leave the house early. I noticed the traffic was particularly busy. Out in the street, I saw my neighbour, who stopped only for a second to say hello. He had his little boy with him. They were going out for the day, and they were in a big rush. The man suddenly remembered that he had forgotten something important back at the house and asked me if I could look after the boy, just for a minute, while he went to fetch it. Another neighbour's daughter was gliding along on her roller blades nearby.

Once his father left, I noticed that the boy became a little fidgety. I tried to hold his hand, but he unexpectedly pulled away and started running across the busy street. I began to run after him as fast as I could, to catch him before anything happened. He went around a building and was out of my sight. As I turned the corner, I ran into the roller-skater, I knocked her over and she crashed into a scaffolding erected alongside the building, while I fell on the ground. I got up and realised I was seemingly alright, but I couldn't see my neighbour's little boy anywhere. The roller-skater was lying on her back, on the ground, in a small puddle of blood. She started screaming and looked like she couldn't move. I then noticed several heavy objects hanging precariously right above her, high up on the scaffolding. I was thinking I had to go look for the boy, who was left in my care, but I also felt responsible for knocking the girl over. I didn't want to move the girl, in case she had hit her back and moving her would risk further damaging her spine, but the heavy objects hanging right above her looked set to come crashing down at any moment.

Story Code Name: Child **Target emotion: Sadness**

It was a regular Tuesday morning. I had plenty of time on my hands and I decided to leave the house early. I noticed the traffic was particularly busy. Out in the street, I saw my neighbour, who stopped only for a second to say hello. He had his little boy with him. They were going out for the day, and they were in a big rush. The man suddenly remembered that he had forgotten something important back at the house and asked me if I could look after the boy, just for a minute, while he went to fetch it. Another neighbour's daughter was gliding along on her roller blades nearby.

Once his father left, I noticed that the little child was very quiet. I tried to talk to him, but he sat down on the ground and started to cry. I asked him what had happened but he wouldn't stop crying – shaking, weeping, and holding a toy to his chest. Moments later, the boy looked up at me. His big eyes full of tears seemed to want to say something: "Mommy died…. She died last night.", and he turned his face down again. He seemed completely overwhelmed with grief. Then, I heard a sharp scream behind me, turned around and saw the roller-skater going very fast. She couldn't control her speed and crashed into the scaffolding erected alongside a building. A few heavy objects fell on top of her from high up on the scaffolding. She looked pretty badly hurt, and started crying profusely. Several other girls on roller skates soon gathered around her, all wearing the same outfit, for the annual inline hockey competition, which was going to start later that day. The girls were all looking very distressed at their friend's suffering and the fact that they would not be able to take part in the competition. All I could hear were the little boy's uncontrolled weeps, as he muttered to himself incoherently.

Story Code Name: Child **Target emotion: Happiness**

It was a regular Tuesday morning. I had plenty of time on my hands and I decided to leave the house early. I noticed the traffic was particularly busy. Out in the street, I saw my neighbour, who stopped only for a second to say hello. He had his little boy with him. They were going out for the day, and they were in a big rush. The man suddenly remembered that he had forgotten something important back at the house and asked me if I could look after the boy, just for a minute, while he went to fetch it. Another neighbour’s daughter was gliding along on her roller blades nearby.

Once his father left, I became increasingly aware that the little child was totally adorable. He was singing a cute little song – clearly one of his favourites and was jumping around, holding my hand tightly. His joyous mood was completely contagious. The roller-skater came towards us holding a bunch of tiny dainty flowers in one hand. She stopped next to the little boy, took a few flowers and gave them to him. The boy stopped singing for a moment, accepted the gift delightedly and then gave her a big hug and a kiss. As she was getting ready to leave, the little boy stopped her, took her hand and said: “You are my best friend!” The roller-skater looked surprised and very impressed by the little boy’s affection. Good children are so wonderful. Behind me, a few men were taking down the scaffolding from a building. The construction work had caused inconvenience to everybody in the area, due to the noise and dust coming off from the site, but work was now finished and everybody could finally look forward to having some peace and quiet.

Story Code Name: Car **Target emotion: Anger**

One Saturday morning a friend asked me to go with him to a nearby town, where he had some business. He said he was driving us there and since I didn’t have any particular plans for that day I agreed to go with my friend. I was watching the traffic and meditating aimlessly, when I gradually noticed that another car kept overtaking us, getting in front of us out of sight, then dropping behind us, only to come back again and go past us, in the other lane.

My friend turned the car stereo on and put the music up very loud. It wasn’t so much the volume, as the poor quality of the sound, which was absolutely horrible. If he had only turned the volume down a little, I was sure the speakers would have sounded better. I asked him repeatedly to do so, but he was too taken up with the song to even pay attention to me. I started thinking that I was coming with him as a favour, in the first place, so a little more consideration would not have been too much to expect. Then moments later he pulled over at a small petrol station and quickly got out the car to go to the shop. Thankfully, the car stereo stopped, but then I noticed that we were parked too close to the entrance in the station blocking everybody else’s access. The other vehicle, that I had seen earlier on the road, was now behind us, wanting to enter the petrol station, sounding the horn and shouting at me to move the car. A truck stopped behind and joined him in aggressively sounding the horn and shouting at me to get out of the car and push it out of the way. I could not believe how unreasonable and rude they were all being.

Story Code Name: Car **Target emotion: Fear**

One Saturday morning a friend asked me to go with him to a nearby town, where he had some business. He said he was driving us there and since I didn't have any particular plans for that day I agreed to go with my friend. I was watching the traffic and meditating aimlessly, when I gradually noticed that another car kept overtaking us, getting in front of us out of sight, then dropping behind us, only to come back again and go past us, in the other lane.

Suddenly, I heard a bang coming from the front of the car, and I could tell that my friend had lost control of the vehicle. Seconds later our car abruptly swerved to the right and repeated attempts to stay in our lane made the car go left and right very forcefully. I didn't know for how long was my friend going to avoid a collision as nothing he was doing seemed to stop or balance the car and I expected us to crash very soon. We were going from side to side and the next second my head hit against the door window, shattering the glass. My head started feeling weird from the blow and even if I didn't know what had happened, I could sense it was something bad. I tried to move, but I couldn't, and I kept thinking of the blow to the head that I had just taken. I then noticed the other car in front of us stopping very quickly and I started to prepare for a very violent impact, but only to realise there was not much I could do about it. I started thinking that a collision with the other car would project us into the opposite lane of traffic, where a truck was coming in at full speed.

Story Code Name: Car **Target emotion: Sadness**

One Saturday morning a friend asked me to go with him to a nearby town, where he had some business. He said he was driving us there and since I didn't have any particular plans for that day I agreed to go with my friend. I was watching the traffic and meditating aimlessly, when I gradually noticed that another car kept overtaking us, getting in front of us out of sight, then dropping behind us, only to come back again and go past us, in the other lane.

The car engine suddenly died and my friend's repeated attempts to restart it failed, so we pulled safely off the road to have a look under the bonnet. The engine looked in a very bad state, and my friend said there was nothing we could do about it. He took his mobile phone out and tried to make a call, but the reception wasn't good where we were, so he started walking on the side of the road to look for better signal. He stopped next to a parked truck and seemed like he managed to get through to someone on the phone. I then noticed the other car coming from behind him, at full speed, heading towards the truck and hitting my friend full on. I ran to him but by the time I arrived, there was nothing I could do; my friend lied lifeless on the tarmac. I couldn't believe how a regular Saturday morning when I was supposed to help my friend on a short trip could have had such a tragic ending. I couldn't bring myself to doing anything, and the desolate scene in front of me was stuck in my mind forever.

Story Code Name: Car **Target emotion: Happiness**

One Saturday morning a friend asked me to go with him to a nearby town, where he had some business. He said he was driving us there and since I didn't have any particular plans for that day I agreed to go with my friend. I was watching the traffic and meditating aimlessly, when I gradually noticed that another car kept overtaking us, getting in front of us out of sight, then dropping behind us, only to come back again and go past us, in the other lane.

My friend then told me that he had won a customer competition and the prize consisted in an all-expenses paid holiday abroad for him and three other friends, and that he wanted me to come along with him. I could not believe what I was hearing, but he continued saying that we were actually going to meet with two other friends to tell them the news and discuss the trip. We arrived into town and stopped near a pub, where my friend parked behind a large truck. The other vehicle that I had seen earlier on the road pulled over as well. A cheerful looking man came down from the truck and approached our car, and so did the other driver. I only then recognised them both; they were two of our mutual friends and I suspected we were all there for the same reason. My friend was very pleased to see them both and they seemed very excited too. We all went inside the pub impressed about my friend's wonderful news, and determined to make the most of that great opportunity. We had never been on a holiday together, but it was something we had talked about many times, and we could finally do it without having to worry about costs.

Story Code Name: Dog **Target emotion: Anger**

I was walking back home through the central park, one late Monday afternoon. There were not many people out, but the weather was good. A dog was running around energetically, enjoying the fresh air. Overlooking the park were the university and two schools. Students could often be seen in the park, but not that day. I walked past a wandering undergraduate, who seemed to be the only other person out at the time.

The dog came running from behind, went past me, and headed straight towards a frail old lady walking very slowly, holding a white cane in one hand and a small handbag in the other. It soon got to her and it grabbed her cane and pulled it away from her, then turned back again and started growling and barking loudly, in a very aggressive tone. The lady looked desperate and didn’t seem to know what to do, as she started crying and looking very hesitantly for someone to help her. The student I had seen earlier went over to her, but instead of lending her a hand, he started laughing at what was happening and inciting the dog further. He seemed to be enjoying the whole situation and demanded more entertainment. The horrible scene soon got worse when a young teenager saw what was happening and went over as well. He approached the old lady from behind, plucked her handbag away from her, and started going through her things, pocketing what he found interesting and throwing back at her everything else. The old lady was crying and begging to be left alone, but the two boys’ laughter and excitement was covering her feeble weeps completely.

Story Code Name: Dog **Target emotion: Fear**

I was walking back home through the central park, one late Monday afternoon. There were not many people out, but the weather was good. A dog was running around energetically, enjoying the fresh air. Overlooking the park were the university and two schools. Students could often be seen in the park, but not that day. I walked past a wandering undergraduate, who seemed to be the only other person out at the time.

The dog quickly caught up with me and suddenly became very aggressive. I could hear it growling very tensely behind me and before I had a chance to turn and react, it seemed to attack me. Luckily, however, the student walking behind me came to the rescue and kicked the dog away before it could get to me. But the dog turned around and plunged at the student, planting his teeth deep into his calf. A teenager intervened to help the student, but he also got attacked by the dog, which eventually ran away, leaving the two lying on the ground, bleeding heavily. The teenager seemed to have fallen in an awkward position on the concrete path and was not moving much, despite looking like he was in an agonising pain. A man behind me was calling an ambulance, describing the wounds over the phone, and saying to everyone not to move the victims. I could see that the student and the teenager were losing a lot of blood quickly and all I could think about was that they could soon go into shock. There wasn’t anything I could have done, but something had to be done quickly.

Story Code Name: Dog **Target emotion: Sadness**

I was walking back home through the central park, one late Monday afternoon. There were not many people out, but the weather was good. A dog was running around energetically, enjoying the fresh air. Overlooking the park were the university and two schools. Students could often be seen in the park, but not that day. I walked past a wandering undergraduate, who seemed to be the only other person out at the time.

The dog ran in front of me and couched at my legs, looking very poorly. I took a sandwich out of my bag and put it down next to it, but the dog refused to have it. Its eyes were running abundantly and its movements were uncoordinated. I tried to think what to do, but before I knew it, the dog fell inert. Its eyes were still open, but they had a blank stare. A young teenager came running and calling for his dog. When he saw us, he rushed to me, took his dog in his arms, and started crying. He said his dog had wondered off when he let it loose. It had not been looking well all day and he thought a walk in the park would do it good. The student I had passed by turned up behind us and saw the young boy in tears holding his dead dog. He went up to him and said he had lost a puppy too that same day. He had the puppy in a leash when he suddenly ran into the slow moving traffic and was caught under the wheels of a bus. The boys looked each other in the eyes and started weeping uncontrollably.

Story Code Name: Dog **Target emotion: Happiness**

I was walking back home through the central park, one late Monday afternoon. There were not many people out, but the weather was good. A dog was running around energetically, enjoying the fresh air. Overlooking the park were the university and two schools. Students could often be seen in the park, but not that day. I walked past a wandering undergraduate, who seemed to be the only other person out at the time.

The dog started leaping around me in circles, waging its tail and looking very playful. I looked around for his owner, but I couldn’t see anyone. The dog kept following me, and I was enjoying his company, but I decided not to let it come with me for too long. The student I had seen earlier came up from behind me, stopped and took a sandwich out of his bag to feed the dog. I hadn’t realised how hungry it was, but I could tell by the sounds it was making how grateful it was for the free meal. The student said he had a dog too and he could tell this one was lost and missing its owner. We watched the hungry dog finish the sandwich, hoping that its owner will appear, and soon, a young teenager came running towards us, calling his dog. He picked the dog up, squeezed it affectively and started stroking it gently and talking to it. Then he turned to us and said he had been looking for his dog in and around the park for the last several hours and he thought he had lost it. The dog was wagging its tail ever stronger while the teenager attached its strap back on and started walking it home.

Appendix E. Emotional stories (Chapters 2 and 3) – recall scoring

TO – Target Object (the main character of the story)

PO – Primed Object (the second character in the story, mentioned/primed in the story stem)

UO – Unprimed Object (the third character in the story, not mentioned in the story stem)

Story Code Name: Workmate **Target emotion: Anger**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My colleague asked me	3		
to take *the drinks*	2		
My colleague let go of the drinks	3		
to soon	1		
The glasses **smashed *against the corner of the table***	3		
My colleague started shouting at me	3		
I **tried to explain *what had happened,***	3		
but *he* **wouldn't listen**.	2		
The pool player was behind my colleague		3	
The pool player **said** that		3	
the drinks **had spoilt *his clothes*** too		3	
I **couldn't believe *his claim*** because		3	
he **was standing *too far from the table***		3	
I **tried to apologise,**		2	
he **wouldn't listen *to me*** either.		3	
A young couple **were standing *by the fruit machines***			3
The young couple **came over**			2
The young couple **said** that			2
The young couple **saw** how			2
I **had dropped *the drinks***			3
deliberately			1
The young couple **offered *a drink***			3
to my colleague			1
The young couple left with my colleague			3

Story Name: Workmate **Target emotion: Fear**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My colleague was screaming	2		
I **turned around**	2		
My colleague was set on fire	2		
My colleague was running towards our table	3		
The fire **was spreading *to the people around him***	3		
The pool player **rushed to get out *of the pub***		3	
The pool player **pushed aside *a table***		3	
The table **overturned**		2	
The table **knocked over *a few chairs***		3	
The drinks ***on the table*** **spilt** ***on the floor***		4	
The drinks ***caught fire***		2	
The chairs tripped up my colleague		3	
My colleague fell down next to my feet	3		
My colleague caused	2		
the fire **to climb** ***up my clothes***	3		
A young couple **were trapped *by the fruit machines***			3
The young couple **were trying to push *the machines***			3
out of the way			1
The fruit machine **fell *onto a column***			3
The column **collapsed *in front of me***			3
The column **trapped *me***			3
The smoke **was getting very thick**			2
I **couldn't breathe anymore**			2

Story Code Name: Workmate **Target emotion: Sadness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My colleague said	2		
My colleague had a terminal illness	2		
My colleague had been to the hospital	3		
that day	1		
The doctors told my colleague	3		
My colleague hadn't long to live	3		
My colleague was very nice	2		
My colleague had supported me	3		
through some of the hardest times in my life	1		
The pool player **came *towards our table***,		3	
The pool player **walked *past me***		3	
The pool player looked similar to an old colleague of mine		3	
My old colleague had died when I was younger		3	
I remembered my old colleague's funeral		3	
I **remembered *the feeling***		3	
of losing a colleague		2	
A young couple **were standing *by the fruit machines***			3
The young couple **were calling *my name***			3
The young couple **were distant relatives**			2
I hadn't **seen *the couple***			3
in a long time			1
The young couple **were coming over**			3
I was preparing to introduce my colleague			3
I **couldn’t find the words.**			2

Story Code Name: Workmate **Target emotion: Happiness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My colleague had a pleasant surprise for me	3		
My colleague had met through his work	3		
somebody who **used to know** ***me,***	3		
My colleague talked with this mysterious person	3		
about me	1		
My colleague decided to get us together,	3		
as soon as possible.	1		
My colleague called the pool player over.	3		
The pool player was one of my closest childhood colleagues		2	
We **used to live** ***on the same street***		3	
his family **moved** ***to another town***		3	
we **lost track** ***of each other****.*		3	
The pool player **was very excited** ***to see me***		3	
The pool player **said**		2	
The pool player **had been hoping** ***for this moment***		3	
for a long time		1	
A young couple were standing ***by the fruit machines***			3
The young couple **came over** ***to our table***			3
The young couple **were his younger brother and his partner**			2
The young couple **were going to get married soon**,			2
The young couple **were very excited** ***about the wedding***			3
The young couple **invited** ***me***			3
to the wedding			1
I **accepted** ***the invitation***			3

Story Code Name: Child **Target emotion: Anger**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The boy **noticed *a little kitten***	3		
The boy **went up to *the kitten***	3		
I **told the boy *to be gentle with it,***	3		
The *kitten* **looked very feeble**	2		
The boy **grabbed *the kitten***	3		
by the tail	1		
The boy **kicked *the kitten***	3		
as hard as *he* **could**	2		
The roller-skater **was coming *towards us***		3	
The roller-skater **was holding *a water pistol***		3	
It **was too cold**		2	
to be playing *with such a toy*		2	
The roller-skater **stopped *next to the kitten***		3	
The roller-skater **sprayed *the kitten***		3	
with a powerful jet of cold water		1	
The roller-skater **chased *the kitten* away**		3	
A few men **were working *on a nearby scaffolding***			3
The men **noticed *the whole scene***			3
The men **encouraged *the roller-skater***			3
to keep chasing *the kitten*			2
for their own entertainment			1
I **tried to get**			2
the roller-skater **to stop chasing *the kitten,***			3
My voice **could not be heard *over the workmen's cheers***			3

Story Code Name: Child **Target emotion: Fear**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The boy **became fidgety**	2		
The boy **started running *across the busy street***	3		
I **chased *after him,***	3		
I **was trying to catch *him***	3		
before anything happened	1		
The boy **went *around a building.***	3		
I **ran *into the roller-skater,***		3	
The roller-skater **crashed *into a scaffolding***		3	
I **couldn't see *the boy***	3		
The roller-skater **was lying *on the ground,***		3	
Heavy objects **were hanging *above her,***			3
high up on the scaffolding			1
The impact **had brought *them***			3
even closer to the edge of the scaffolding board			1
I **didn't want**		2	
to move *the girl,*		2	
in case *she* **had hit *her back***		3	
A few tools **fell *on the ground***			3
not far from the roller-skater			1
The tools falling down **made *a horrible noise***			3
The heavy objects above her **looked set to come crashing down**			2
as the scaffolding **seemed to have lost *one of its supporting sole boards***			3
The boy **was gone**	2		
and *I* also **felt responsible** for		2	
the girl **being in danger.**		2	

Story Code Name: Child **Target emotion: Sadness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The boy **was very quiet**	2		
The boy **sat down *on the ground***	3		
The boy **started to cry**	2		
The boy **looked up *at me***	3		
The boy's nana **died *last night***	3		
The boy **was holding *a toy***	3		
to his chest	1		
The toy **was the last present *from nana***	3		
The roller-skater **was going very fast *towards the end opf the pavement***		3	
The roller-skater **fell *in an awkward position***		3	
The roller-skater **sprained *her ankle***		3	
The roller-skater outfit **said**		2	
The roller-skater **was taking part *in a hockey competition***		3	
later that day		1	
The roller-skater **was looking very distressed** because		2	
she **wouldn't be able to take part *in the competition.***		3	
A few men **were standing *on a scaffolding***			3
The men **were finishing *the work***			3
on the front wall			1
A few buckets of paint **fell *from high up on the scaffolding.***			3
The men **looked dejected** as			2
the thick blue paint **spilled down**			2
the paint **was spreading *along the entire front wall,***			3
Several week's work **was ruined *within minutes***			3

Story Code Name: Child **Target emotion: Happiness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
*The boy***was singing** ***one of his favourite songs***	3		
The boy **was jumping around**	2		
The boy **was holding** ***my hand***	3		
The roller-skater **came** ***towards us***		3	
The roller-skater **was holding** ***a bunch of flowers***		3	
The roller-skater **gave** ***a few flowers***		3	
to the boy		1	
The boy **gave** ***the roller-skater***	3		
a hug	1		
The boy **took** ***the roller-skater's hand***	3		
The boy **asked** ***the roller-skater***	3		
to be ***friends***	2		
The roller-skater **looked very impressed,**		2	
The roller-skater **played** ***a game***		3	
with the boy		1	
The roller-skater **was teaching** ***the boy***		3	
a new song		1	
*A few men***were taking down** ***the scaffolding***			3
from a historic building			1
The construction work **had caused** ***inconvenience*** due to			3
the noise and dust **had been comin** ***from the site, but***			3
People **could look forward to having** ***some peace and quiet***			3
Work **was finished**			2
A few people **were gathered** ***in the street***			3
to watch ***the impressive building***			2

Story Code Name: Car **Target emotion: Anger**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My cousin **put the music up** very loud	2		
The speakers **started sounding awful.**	2		
I **asked** ***him*** repeatedly	3		
to turn ***the music*** **down** a little,	2		
He **didn't pay attention** ***to me*** at all	3		
My cousin **pulled over** ***at a small petrol station***,	3		
My cousin **quickly got out** ***of the car***	3		
to go ***to the shop.***	2		
The other vehicle **was now behind us**		2	
The driver **was beeping** ***the horn***		3	
We **were parked** ***too close to the entrance of the service station***		3	
We **were blocking** ***everybody else's access.***		3	
The other driver **was shouting** ***at me***		3	
to move ***the car***		2	
I **couldn't do anything anyway**		2	
before my cousin **returned**		2	
A truck **stopped** ***behind the other car***			3
The lorry driver **started honking** ***the horn***			3
The lorry driver **was shouting** ***at me***			3
to push ***the car***			2
out of the way			1
I **tried to explain** that			2
my cousin **will be back** shortly			2
with the keys			1
The *lorry driver* **kept on shouting** ***at me***			3

Story Code Name: Car **Target emotion: Fear**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
A bang **came *from the front of the car***	3		
My cousin **had lost *control of the vehicle*.**	3		
The car **was swerving left and right** very forcefully.	2		
I **expected**	2		
we **would leave *the road*** very soon	3		
my head **hit *the side window***	3		
in an awkward position	1		
My head/ The impact **shattered *the glass***	3		
The other car in front of us **was stopping** very quickly		2	
I **tried to prepare *for a very violent impact*,**		3	
I **couldn't move.**		2	
The blow to the head **could be made worse *by another impact.***		3	
The car in front **had stopped completely.**		2	
There was no *way*		2	
to go *past it*		2	
We **had to stop**		2	
but *we* **couldn't**		2	
A collision **would project us *into the opposite lane of traffic***			3
A lorry **was coming *towards us***fast			3
The lorry **started breaking** violently			2
in order **to avoid *the same obstacle as the car in front of us***			2
The lorry **started skidding**			3
The lorry **turned sideways across the road,**			1
The lorry **was sliding *towards us***			3
The lorry **was taking up *both lanes of traffic***			3

Story Code Name: Car **Target emotion: Sadness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My cousin **told *me*** that	3		
we **were going *to my auntie's***	3		
My auntie **had asked**	2		
to see *me* urgently.	2		
*My auntie***had been very ill *for a while now.***	3		
I **hadn't spoken *to her*** recently	3		
We **had been very close**	2		
I **was her favourite nephew**	2		
The car I had seen earlier on the road **was already there**.		2	
The driver **was standing *by the door***		3	
The driver **came running *towards us***		3	
The driver **said**		2	
we **had arrived too late**.		2	
My auntie **had died *earlier that morning***		3	
The ambulance **was leaving**		2	
just as *he* **got *there.***		3	
A lorry driver **was parked *across the road***			3
from my auntie's house			1
The lorry *driver* **came *to us***			3
The lorry driver **had been with my auntie**			2
in her last moments			1
A few people **were with her *at her death bed,***			3
My auntie **didn't want**			2
to see *anybody else*			2
My auntie **was calling *for me***			3

Story Code Name: Car **Target emotion: Happiness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
My cousin **had won *a newspaper competition***	3		
The prize **was an all-expenses paid holiday, *for him and three other friends***	3		
My cousin **wanted *me***	3		
to come along *with him*	2		
We **were going to meet *with two other friends***	3		
to tell *them*	2		
the news	1		
We **stopped *near a pub,***	3		
The other vehicle **pulled over too**		2	
The driver **was cheerful**		2	
The driver **was one of our mutual friends**		2	
I **was very pleased**		2	
to see *him*		2	
We all **went *inside the pub*.**		3	
The friend **was congratulating *my cousin***		3	
The friend **gave *both of us***		3	
a small present		1	
A lorry was **parking *behind my cousin's car.***			3
The lorry driver **was one of my cousin's friends**			2
The lorry driver **joined us *inside the pub***			3
The lorry driver **said**			2
we **had never been on a holiday *together,*** but			3
we **had talked *about it*** many times.			3
we **could finally go*,* without**			2
worrying *about the costs*			2

Story Code Name: Dog **Target emotion: Anger**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
on the other side of the channel	1		
The dog **was headed *towards a frail old lady***	3		
The dog **grabbed *the lady's walking stick***	3		
The dog **pulled *the lady's walking stick* away from her**	3		
The dog **started growling** aggressively	2		
The lady **looked for**	2		
someone **to help *her***	3		
I **tried *to* draw *the student's attention***	3		
The student **was very close *to the old lady***		3	
The student **didn't lend *the old lady* a hand**		3	
The student **incited *the dog***		3	
The student **picked up *the stick***		3	
The student **pretended to give *the stick back***		3	
to the lady		1	
The student **was holding *the stick***		3	
out of her reach		1	
The teenager **approached *the lady***			3
from behind			1
The teenager **snatched *the lady's bag***			3
The teenager **started going *through the bag***			3
The teenager **was pocketing**			2
what *he* **found interesting**			2
The old lady **was begging *to be left alone,***			3
The lady's feeble cries **could hardly be heard *over the teenager's laughter***			3

Story Code Name: Dog **Target emotion: Fear**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The dog **caught up *with me***	3		
The dog **started growling**	2		
The dog **tried to grab *my leg***	3		
The dog **pulled back *half way through the attack***	3		
The dog **went *around my back***	3		
The dog **began a new attack**	3		
The dog's teeth **were inches *from my skin***	3		
The student walking **kicked *the dog* away** before		3	
the dog **could get *to me.***		3	
The dog **pounced *at the student***		3	
The dog **bit *the student***		3	
from his calf		1	
The student **was screaming**		2	
The student **was losing *a lot of blood***		3	
The student **could soon go into shock**		2	
A teenager **came**			2
to help *the student*			2
The teenager **got attacked *by the dog***			3
The teenager **was lying *on the concrete path***			3
A man behind me **was calling *an ambulance***			3
The man **was describing *the boy's wounds***			3
The man **was advising everyone**			2
not to move *him.*			2

Story Code Name: Dog **Target emotion: Sadness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The dog **came up *to me***	3		
The dog **crouched *at my feet***	3		
The dog **was looking very ill**	2		
I **gave *the dog***	3		
a sandwich *I* **had**	2		
in my bag	1		
The dog **laid *his head***	3		
on my feet	1		
The dog **died**	2		
The student **turned up *behind me***		3	
The student **said that**		2	
The student **had lost *a puppy***		3	
that same day		1	
*The puppy **was*** **playing *in the garden***		3	
The puppy **choked on something**		2	
The puppy **died** before		2	
the student **could take *him***		3	
to the vet's		1	
A young teenager **came running**			2
The teenager **was calling *his dog***			3
The teenager **said**			2
The dog **had not been looking well**			2
The teenager **thought**			2
A walk in the park **would do *the dog* good**			3
The teenager **picked up *the dead dog***			3
The teenager **started crying *uncontrollably***			3

Story Code Name: Dog **Target emotion: Happiness**

	TO Score Unit	PO Score Unit	UO Score Unit
	20	**20**	**20**
The dog **started leaping *around me***	3		
The dog **was wagging *its tail***	2		
The dog **was holding *a stick***	3		
in its mouth	1		
The dog **dropped *the stick***	3		
at my feet	1		
I **threw *the stick***	3		
The dog **caught *the stick acrobatically***	3		
in the air	1		
The student **came up *from behind me***		3	
The student **took *a sandwich***		3	
out of his bag		1	
to feed *the dog*		2	
The dog **ate *the sandwich***		3	
The student **said**		2	
the student **had a dog** too		2	
The student **said**		2	
the dog **looked lost**		2	
A young teenager **was running *towards us***			3
The teenager **was calling *his dog***			3
The teenager **picked up *the dog***			3
The teenager **said**			2
the teenager **had been looking *for the dog***			3
for the last several hours			1
The teenager **was very grateful *to you***			3
for having looked after *his dog*			2

Appendix F. Emotional stories (Chapters 4 and 5)

Phase 1, Iterations 1 to 3.

Instruction for participants during the presentation procedure:

> *Please listen to the following story and imagine that you are personally experiencing what is happening in the text.*

Instruction for participants during the recall procedure:

> *Please try to reproduce out loud the previous story, including as many details as you can remember.*

Phase 1, Interference.

Instruction for participants during the presentation procedure:

> *Please listen to the following new story and imagine that you are personally experiencing what is happening in the text.*

Instruction for participants during the recall procedure:

> *Please try to reproduce out loud the previous story, including as many details as you can remember.*

Phase 2, Immediate Recall.

Instructions for participants during the recall procedure:

> *Please try to reproduce out loud the earlier story that I read to you three times at the start of the session, including as many details as you can remember.*

Phase 3, Delayed Recall.

Instructions for participants during the recall procedure:

> *Please try to reproduce out loud the earlier story that I read to you three times at the start of the session, including as many details as you can remember.*

Target Story Name: WA **Target emotion: Anger**

You are meeting with a friend in a local pub, on a Saturday afternoon. The pub is busy. You sit down as a small table in the corner, while your friend goes to the bar and returns with the drinks. Your friend drops the drinks, while putting them on the table. The glasses smash and the drinks spill down your legs. Your friend is shouting at you, and blames you for dropping the drinks. A young woman was standing behind your friend. She was wearing a new blue dress, which was now stained. The woman accuses you of ruining her dress, even if you hadn't touched the drinks. You explain that you didn't do anything, but she throws her cocktail into your face. The woman leaves the pub quickly. Many people around you comment about the woman's dress. A young couple standing by the fruit machines come over and speak to your friend. The couple take your friend's side and shout insults at you for no reason. The pub's staff ask you to leave and ban you from the pub.

Interference Story Name: FH **Target emotion: Happiness**

You are in your local shop. You start talking and as you go up to the till, you decide to let him/her go first. Your friend pays for his shopping and buys a scratch-card. As you are paying for your own shopping, your friend starts laughing loudly and tells you that he/she has won £250,000. He/she says that you must go for a meal to celebrate. On the way to the restaurants, your friend decides to spend some of the money to go on a holiday, and invites you to come along, for free. When you get to the restaurant, you begin making plans about where you want to go.

Target Story Name: LF **Target emotion: Fear**

Your friend is giving you a lift to a nearby town in a small car. You get on the main road, which is busy. A loud explosion is coming from below the engine. The car is swerving sideways forcefully, and the driver loses control of the car. Your head hits the side window and shatters the glass. The broken glass gets in your eyes, and it hurts badly. The blue car in front of you stops. The car has a pink Baby on Board sign. Two young girls are playing on the back seat and turn their heads towards you. The brakes on your car stop working. You hit the car in front, which is pushed off the road. Loud screams are coming from the car in front. Your car stops, and the engine shuts off. Your friend can't restart the car. A blue lorry is coming from the other direction. The lorry brakes violently, turns on its side and heads for your car. Your car door is jammed closed and you are trapped inside the car.

Interference Story Name: HH **Target emotion: Happiness**

You are on an exotic holiday at the seaside. It is a hot sunny summer day and you sit in the shade, at a terrace by the sea, looking out into the horizon. A soft smile creeps across your face as you begin to eat your favourite flavour of ice cream. A soft wind is blowing from the sea, and you just make out the contour of a large white boat in the distance. Closer to shore, three yachts gracefully glide across the sea, while the sailors are waving at somebody on the shore. The waves are gently lapping on the pristine white beach in front of you. The sea is clear and calm. Your favourite music starts playing on the stereo in the background.

Target Story Name: DS **Target emotion: Sadness**

You are in a park. A white dog is running around. The dog is looking sick. The dog falls at your feet and dies. A teenager wearing a green top and grey trousers was running after the dog. He is the dog's owner. The teenager picks up the dead dog and strokes it. The teenager has been looking after the dog ever since his parents died, 9 years ago. The boy had no friends. His brother had died 4 years ago. The brother was a year older than him. His sister lives in a hospice, 360 miles away suffering from a terminal illness. She was admitted into hospital after his brother died. His sister was two years younger than the teenager. The boy was not able to see his sister since she fell ill. The boy shows you a picture with his dog and with his brother from when they were on a trip in the mountains. His brother fell off a cliff and could not be saved.

Interference Story Name: PH **Target emotion: Happiness**

As you walk across the park, you catch the eye of an attractive man / woman. She / he smiles widely as he passes. He / she reminds you of the first boy/girl you liked, when you were in school. He / She was tall and slender and had a beautiful face. You wondered if he/she could be the same person. A couple of seconds later, he/she calls your name from behind. He/she recognises you, and is very happy to see you. You go to a pub, to catch up on old times. He/she tells you how you haven't changed at all. After a couple of drinks, you make plans to meet again in a couple of days.

Target Story Name: SH **Target emotion: Happiness**

You are walking back home on a Friday afternoon. The streets are busy as many people are walking home from work. A man/woman is crossing the street in a hurry and calls your name. The man/woman is one of your closest childhood friends. You used to live next door to him/her, but after you turned 14, his/her family moved to a far-away town. You haven't seen him/her since he/she left. He/she is very excited to see you and says he/she has been hoping for this moment for a long time. He/she has moved recently into town. He/she lives near you, and invites you to visit him/her one weekend. Your friend's younger brother and his lovely partner join you. They are getting married, and are excited about the wedding. The wedding will be on a cruise ship, in four weeks and they are paying for all their guests' tickets and expenses. They invite you to the wedding and you gladly accept the invitation.

Interference Story Name: RS **Target emotion: Sadness**

It is Tuesday morning. You are free for a couple of hours, and so, you decide to go for a walk. While getting back, you see your neighbour’s young boy, who seems to be waiting for someone. The boy is quiet. He sits down on the ground and then starts to cry. Next, he looks up at you and says that his nana had died the previous night. You notice that the boy is holding a toy close to his chest. The boy tells you that his nana gave him that toy yesterday. Then, you hear something behind you. You turn around and see the roller-skater going fast towards the end of the pavement. She can’t control her speed, and falls in an awkward position, spraining her ankle badly. She was getting ready to take part in a competition later in the day. The roller-skater is looking very distressed because she wouldn’t be able to compete.

Appendix G. Emotional stories (Chapters 4 and 5) – recall scoring

The propositional analysis followed the detailed guidelines published by Turner and Greene (1977).

Target Story Name: WA **Target emotion: Anger**

Story Sentence	Proposition / Recall Unit	Valence	
You are meeting with a friend in a local pub, on a Saturday afternoon.	Meet, you friend	N	1
	qualify, pub, local	N	2
	Location: meet, pub	N	3
	Qualify: Saturday, afternoon	N	4
	Time: Meet, Saturday	N	5
The pub is busy.	qualify, pub, busy	N	6
You sit down as a small table in the corner,	Sit down, you, table	N	7
	qualify table, small	N	8
	location: table, corner	N	9
while your friend goes to the bar and returns with the drinks.	quality friend, your	N	10
	go, friend bar,	N	11
	return, friend, drinks	N	12
Your friend drops the drinks, while putting them on the table.	quality friend, your	E	13
	drop friend drinks	E	14
	put friend drinks on table	E	15
	Time: while, put, drop	E	16
The glasses smash and	Smash, glasses	E	17
the drinks spill down your legs.	quality of legs, your	E	18
	Spill drinks down pants	E	19
Your friend is shouting at you, and blames you for dropping the drinks.	Quality of friend, you	E	20
	shout, friend at you	E	21
	blame, friend, you	E	22
	drop drinks, you	E	23
	causality: because, drop, blame	E	24
A young woman was standing behind your friend	qualify friend, your	N	25
	qualify woman, young	N	26
	stand, woman, behind friend	N	27
She was wearing a new blue dress, which was now stained.	qualify, dress, new	N	28
	qualify dress, blue	N	29
	wear woman, dress	N	30
	qualify dress, stained	N	31
The woman accuses you of ruining her dress,	qualify dress, her	E	32
	ruin, you dress	E	33
	Accuse woman, ruin	E	34
even if you hadn't touched the drinks.	touch drinks you	E	35
	negate: touch	E	36
	Despite: negate, acuse	E	37

Target Story Name: WA **Target emotion: Anger**

Continued from previous page

Story Sentence	Proposition / Recall Unit	Valence	
You explain that you didn't do anything,	do you nothing	E	38
	explain you, do you	E	39
but she throws her cocktail into your face.	quality of, cocktail, her	E	40
	quality of face, your	E	41
	throw, she cocktail, face	E	42
The woman leaves the pub quickly.	leave woman, pub	N	43
	qualify, leave, quickly	N	44
Many people around you comment about the woman's dress.	number of, people, many	N	45
	qualify people, around you	N	46
	quality of dress, woman's	N	47
	Comment, people, dress	N	48
A young couple standing by the fruit machines come over	quality of, couple, young	N	49
	stand couple, fruit machines	N	50
	come over, couple	N	51
and speak to your friend.	Quality of, friend, your	N	52
	Speak couple, friend	N	53
The couple take your friend's side and shout insults at you for no reason.	Quality of friend, you	E	54
	Take side, couple, friend	E	55
	Shout, couple, insults, you, no reason	E	56
The pub's staff ask you to leave and ban you from the pub.	quality of staff, pubs	E	57
	leave you	E	58
	ask, staff, you, leave you	E	59
	ban, staff you, pub.	E	60

Target Story Name: LF **Target emotion: Fear**

Sentence	Proposition	Valence	
Your friend is giving you a lift to a nearby town in a small car.	Quality of, friend, your	N	1
	Quality of, nearby, town	N	2
	quality of car, small	N	3
	Gives lift, your friend, you, small car	N	4
	Location: nearby town	N	5
You get on the main road, which is busy.	Quality of road, main	N	6
	Get you, on the main road	N	7
	Quality of, main road, busy	N	8
A loud explosion is coming from below the engine.	quality of, explosion, loud	E	9
	Come loud explosion from the engine	E	10
The car is swerving sideways forcefully, and	Swerve sideways, car	E	11
	Qualify swerve, forcefully	E	12
the driver loses control of the car.	Lose control, driver, car	E	13
Your head hits the side window and shatters the glass.	quality of, head, your	E	14
	Hit, your head, side window	E	15
	Shatter, the glass	E	16
The broken glass gets in your eyes, and it hurts badly.	quality of eyes, your	E	17
	Get broken glass, in your eyes	E	18
	hurts, glass, you	E	19
	Qualify, hurts glass you, badly	E	20
The blue car in front of you stops.	quality of the car, blue	N	21
	quality of the car, in front	N	22
	Stop, car in front	N	23
The car has a pink Baby on Board sign.	Quality of sign, Baby on Board	N	24
	quality of sign, pink	N	25
	quality of the car, in front	N	26
Two young girls are playing on the back seat	quality of girls, young	N	27
	number of, girls, 2	N	28
	play, girls	N	29
	quality of, seat, back	N	30
	Location: play girls, back seat	N	31
and turn their heads towards you.	quality of heads, girls	N	32
	turn, girls heads towards you	N	33

Target Story Name: LF **Target emotion: Fear**

Continued from previous page

Sentence	Proposition	Valence	
The brakes on your car stop working.	Quality of car, your	E	34
	quality of brakes, car	E	35
	work, brakes	E	36
	negate: work brakes	E	37
You hit the car in front, which is pushed off the road	quality of the car, in front	E	38
	hit, you, car in front	E	39
	is pushed car in front, off the road	E	40
Loud screams are coming from the car in front.	quality of screams, loud	E	41
	quality of the car, in front	E	42
	come screams from the car	E	43
Your car stops, and the engine shuts off.	Quality of car, your	N	44
	be stopped, your car	N	45
	shut off, the engine	N	46
Your friend can't restart the car.	quality of friend, your	N	47
	restart, car, your friend	N	48
	negate: restart car	N	49
A blue lorry is coming from the other direction.	quality of lorry, blue	N	50
	quality of direction, other	N	51
	come lorry from the other direction	N	52
The lorry brakes violently,	Brake lorry	E	53
	Qualify brake lorry, violently	E	54
turns on its side and heads for your car	turn on side, lorry	E	55
	quality of car, your	E	56
	head for your car, lorry	E	57
Your car door is jammed closed and you are trapped inside the car.	quality of door, your	E	58
	Is jammed closed, your door	E	59
	are trapped inside the car you	E	60

Target Story Name: DS **Target emotion: Sadness**

Sentence	Proposition	Valence	
You are in a park.	you are	N	1
	Location: Park	N	2
A white dog is running around.	Quality of: dog, white	N	3
	Run around, dog	N	4
The dog is looking sick	Look, dog, sick	E	5
The dog falls at your feet	Fall, dog	E	6
	quality: feet, your	E	7
	Location: at your feet	E	8
and dies	die, dog	E	9
A teenager wearing a green top and gray trousers	Quality of: top, green	N	10
	Quality of: trousers, gray	N	11
	Wear, teenager, top and trousers	N	12
was running after the dog	Run, teenager, after dog	N	13
He is the dog's owner	Quality: owner, dog	N	14
	IS: Teenager, dog owner	N	15
The teenager picks up the dead dog	Pick up: teenager, dog	E	16
and strokes it.	Stroke: teenager, dog	E	17
The teenager has been looking after the dog	Look after: teenager, dog	E	18
	Quality of: parents, teenager's	E	19
	Die: teenager's parents	E	20
ever since his parents died, 9 years ago.	Time: Since, look after, Die	E	21
	Number of: years, 9	N	22
	Time: 9 years ago	N	23
The boy had no friends.	Have: boy, friends	E	24
	Negate	E	25
His brother had died 4 years ago.	Quality of: brother, teenager's	E	26
	Die: the brother	E	27
	Number of: years, 4	N	28
	Time: 4 years ago	N	29
The brother was a year older than him.	Quality older, than boy	N	30
	Be brother, older than boy	N	31
	Number of: years, 1	N	32
	Quality: older brother, 1 year	N	33

Target Story Name: DS **Target emotion: Sadness**

Continued from previous page

Sentence	Proposition	Valence	
His sister lives in a hospice, 360 miles away	Quality of: sister, teenager's	E	34
	Location: sister, hospital	E	35
	Number of: miles, 360	N	36
	Location: hospice, 360 miles	N	37
	Live: sister, hospice	E	38
suffering from a terminal illness	Quality: illness, terminal	E	39
	Suffer, sister, terminal illness	E	40
She was admitted into hospital after his brother died.	Be admitted: sister	E	41
	Die, brother	E	42
	Time: after died brother, admitted sister	E	43
His sister was two years younger than the teenager.	Quality younger, than boy	N	44
	Be sister, younger than boy	N	45
	Number of: years, 2	N	46
	Quality: younger sister, 2 years	N	47
The boy was not able to see his sister since she fell ill.	Fall ill, sister	E	48
	See, boy sister	E	49
	Time: since, fall ill sister, see boy sister	E	50
	Negate: see boy sister	E	51
The boy shows you a picture with his dog and with his brother	Quality of: picture, brother	N	52
	Quality of: picture, dog	N	53
	Show, boy, you, picture	N	54
from when they were on a trip in the mountains.	Be on a trip, boys	N	55
	Location: in the mountains, trip	N	56
	Quality of: picture, trip	N	57
His brother fell off a cliff and could not be saved.	Fall, brother, cliff	E	58
	be saved, brother	E	59
	negate	E	60

Target Story Name: SH **Target emotion: Happiness**

Sentence	Proposition	Valence	
You are walking back home on a Friday afternoon.	Quality of, Friday, afternoon	N	1
	walk back you, home,	N	2
	Time: Walk, afternoon/Friday	N	3
The streets are busy as many people are walking home from work.	Qualify streets, busy	N	4
	number of people, many	N	5
	walk home people	N	6
	location: walk people from work	N	7
	Causality: because, people walk home, streets busy	N	8
A man/woman is crossing the street in a hurry	Cross, woman, street	N	9
	qualify, cross, hurry	N	10
	qualify, name, your	N	11
and calls your name.	call, woman your name	N	12
The man/woman is one of your closest childhood friends	qualify friend, childhood	E	13
	qualify friend, close	E	14
	qualify friend, your	E	15
	Is man/woman, friend	E	16
You used to live next door to him/her,	qualify next door, man/woman	N	17
	Live, you, next door	N	18
but after you turned 14, his/her family moved to a far away town.	qualify, family his/her	N	19
	qualify town, far away	N	20
	move, family, town	N	21
	turn you 14	N	22
	Time: after, turn 14, move family,	N	23
You haven't seen him/her since he/she left.	leave he/she	N	24
	see you, him/her	N	25
	Negate: See you friend	N	26
	Time: since, she left, not see you her	N	27
He/she is very excited to see you	qualify excited, very	E	28
	He/she is excited	E	29
	See, she you	E	30
	Causality: He/She is excited, see you	E	31
and says he/she has been hoping for this moment for a long time.	hope she for this moment	E	32
	Time: for a long time, hope she,	E	33
	Say she, hope she	E	34

Target Story Name: SH **Target emotion: Happiness**

Continued from previous page

Sentence	Proposition	Valence	
He/she has moved recently into town. He/she lives near you,	Move into town friends	N	35
	qualify, recently	N	36
	live she	N	37
	location: near you, live he/she	N	38
and invites you to visit him/her one weekend.	visit you him/her	N	39
	invite he/she to visit	N	40
	time: at the weekend, visit	N	41
Your friend's younger brother and his lovely partner join you.	qualify brother, younger	E	42
	qualify, brother, friend's	E	43
	qualify partner, lovely	E	44
	qualify partner, brother's	E	45
	brother, and partner	E	46
	join you, brother and partner	E	47
They are getting married, and are excited about the wedding.	Marry, they (brother and partner)	E	48
	are excited, they	E	49
	Causality: because, excited, wedding	E	50
The wedding will be on a cruise ship, in four weeks	Location: wedding, cruise ship	E	51
	number of weeks, 4	E	52
	time: wedding, four weeks	E	53
and they are paying for all their guests' tickets and expenses.	quality of, ticket, guests	E	54
	quality of, expenses, guests	E	55
	pay they for tickets	E	56
	pay they for expenses	E	57
They invite you to the wedding and you gladly accept the invitation.	invite you, they	E	58
	accept you invitation	E	59
	qualify, accept, gladly	E	60

Appendix H. Summary of neuropsychological assessments

Group	PID	MMSE	HADS	WMS-III	HDS	BDI	ERQ	BADS	WAIS	WASI
Control	C-01	x	x	x						
Control	C-02	x	x	x						
Control	C-03	x	x	x						
Control	C-04	x	x	x						
Control	C-05	x	x	x						
Control	C-06	x	x	x						
Control	C-07	x	x							
Control	C-08	x	x	x						
Control	C-09	x	x	x						
Group	**PID**	**MMSE**	**HADS**	**WMS-III**	**HDS**	**BDI**	**ERQ**	**BADS**	**WAIS**	**WASI**
Control	C-10	x	x							
Control	C-11	x	x							

Control	C-12	x	x	x						
Control	C-13	x	x	x						
Control	C-14	x	x	x						
Control	C-15	x	x							
Control	C-16	x	x	x	x	x	x	x	x	x
Control	C-17	x	x	x	x	x	x	x	x	x
Control	C-18	x	x	x	x	x	x	x		x
Control	C-19	x	x	x	x	x	x	x	x	x
Control	C-20	x	x	x	x	x	x	x	x	x
Group	**PID**	**MMSE**	**HADS**	**WMS-III**	**HDS**	**BDI**	**ERQ**	**BADS**	**WAIS**	**WASI**
Korsakoff	P-01	x	x	x						
Korsakoff	P-02	x	x	x						
Korsakoff	P-03	x	x	x						
Korsakoff	P-04	x	x	x						
Korsakoff	P-05	x	x	x						

Korsakoff	P-06	x	x	x						
Korsakoff	P-07	x	x	x	x	x	x	x	x	x
Korsakoff	P-08	x	x	x	x	x	x	x		x
Korsakoff	P-09	x	x	x	x	x	x	x	x	x
Korsakoff	P-10	x	x	x	x	x	x	x	x	x
Korsakoff	P-11	x	x	x	x	x	x	x	x	x
Group	**PID**	**MMSE**	**HADS**	**WMS-III**	**HDS**	**BDI**	**ERQ**	**BADS**	**WAIS**	**WASI**
Korsakoff	P-12	x	x	x	x	x	x	x	x	x
Korsakoff	P-13	x	x	x	x	x	x	x	x	x
Korsakoff	P-14	x	x	x	x	x	x	x	x	x
Korsakoff	P-15	x	x	x	x	x	x	x	x	x
Korsakoff	P-16	x	x	x	x	x	x	x	x	x
Korsakoff	P-17	x	x	x	x	x	x	x	x	x
Korsakoff	P-18	x	x	x	x	x	x	x	x	x
Korsakoff	P-19	x	x	x	x	x	x	x	x	x

Korsakoff	P-20	x	x	x	x	x	x	x	x	x

Legend:

MMSE	Mini Mental State Examination
HADS	Hospital Anxiety and Depression Scale
WMS-III	Wechsler Memory Scale III
HDS	Hamilton Depression Scale
BDI	Becks Depression Inventory
ERQ	Emotion Regulation Questionnaire
BADS	Behavioural Assessment of Dysexecutive Syndrome
WAIS	Wechsler Adult Intelligence Scale
WASI	Wechsler Abbreviated Scale of Intelligence

Appendix – Summary of Neuropsychological Assessments (continued)

Group	PID	DKEF STM	DK…VF	DK…DF	DK…CWI	DK…ST	DK…TQT	DK…WCT	DK…TT	DK…PT
Control	C-01	x	x							
Control	C-02	x	x							
Control	C-03	x	x							
Control	C-04		x							
Control	C-05	x	x							
Control	C-06	x	x							
Control	C-07	x								
Control	C-08	x	x							
Control	C-09	x								
Control	C-10	x								

Control	C-11	x	x							
Control	C-12	x	x							
Control	C-13	x	x							
Control	C-14	x	x							
Control	C-15	x								
Control	C-16	x	x	x	x	x	x	x	x	x
Control	C-17	x	x	x	x	x	x	x	x	x
Control	C-18	x	x	x	x	x	x	x	x	x
Control	C-19	x	x	x	x	x				
Control	C-20	x	x	x	x	x	x	x	x	x
Group	**PID**	**DKEFSTM**	**DK…VF**	**DK…DF**	**DK…CWI**	**DK…ST**	**DK…TQT**	**DK…WCT**	**DK…TT**	**DK…PT**
Korsakoff	P-01	x	x							
Korsakoff	P-02	x	x							
Korsakoff	P-03	x	x							
Korsakoff	P-04									

Korsakoff	P-05	x	x							
Korsakoff	P-06	x	x							
Korsakoff	P-07	x	x	x	x	x	x	x	x	x
Korsakoff	P-08	x	x	x	x	x	x	x	x	x
Korsakoff	P-09	x	x	x	x	x	x	x	x	x
Korsakoff	P-10	x	x	x	x	x	x	x	x	x
Korsakoff	P-11	x	x	x	x	x	x	x	x	x
Group	**PID**	**DKEFSTM**	**DK…VF**	**DK…DF**	**DK…CWI**	**DK…ST**	**DK…TQT**	**DK…WCT**	**DK…TT**	**DK…PT**
Korsakoff	P-12	x	x	x	x	x	x	x	x	x
Korsakoff	P-13	x	x	x	x	x	x	x	x	x
Korsakoff	P-14	x	x	x	x	x	x	x	x	x
Korsakoff	P-15	x	x	x	x	x	x	x	x	x
Korsakoff	P-16	x	x	x	x	x	x	x	x	x
Korsakoff	P-17	x	x	x	x	x	x	x	x	x
Korsakoff	P-18	x	x	x	x	x	x	x	x	x

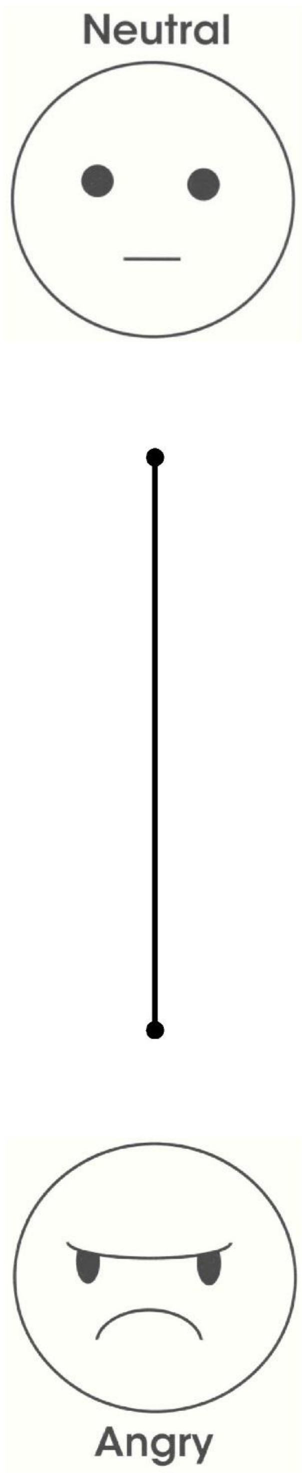
Korsakoff	P-19	x	x	x	x	x	x	x	x	x
Korsakoff	P-20	x	x	x	x	x	x	x	x	x

Legend:

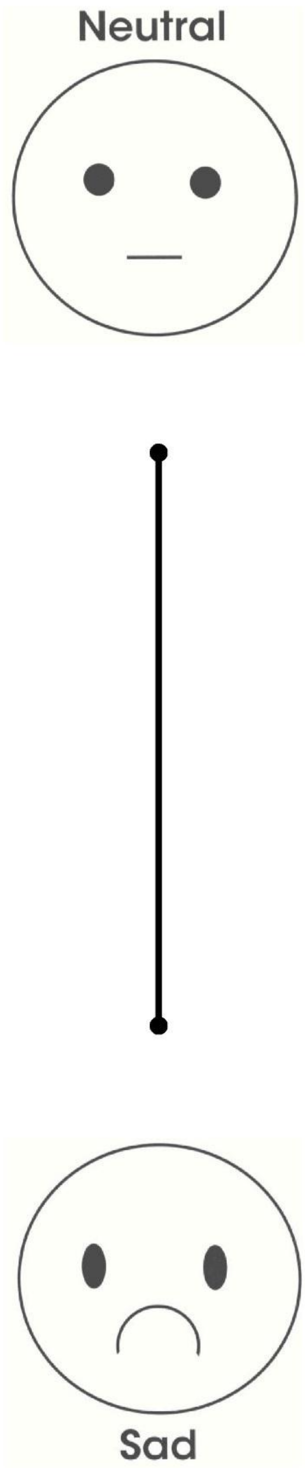
DKEFSTM	Delis–Kaplan Executive Function System - Trail Making
DKEFSVF	Delis–Kaplan Executive Function System - Verbal Fluency
DKEFSDF	Delis–Kaplan Executive Function System - Design Fluency
DKEFSCWI	Delis–Kaplan Executive Function System - Colour-Word Interference
DKEFSST	Delis–Kaplan Executive Function System - Sorting Test
DKEFSTQT	Delis–Kaplan Executive Function System - Twenty Questions Test
DKEFSWCT	Delis–Kaplan Executive Function System - Word Context Test
DKEFSTT	Delis–Kaplan Executive Function System - Tower Test
DKEFSPT	Delis–Kaplan Executive Function System - Proverb Test

Appendix I. Self-report measures of emotions – Visual Analogue Mood Scales (VAMS)

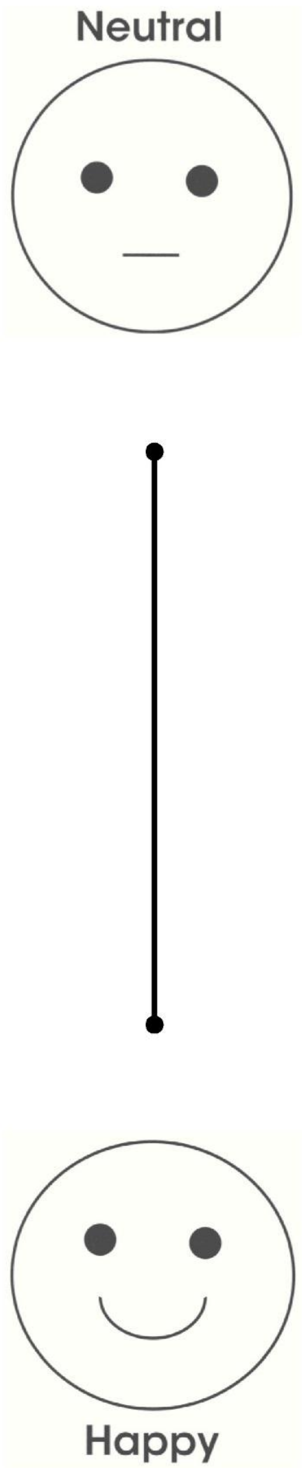
Participant Code: __________________ Session: _________________ Task: 01



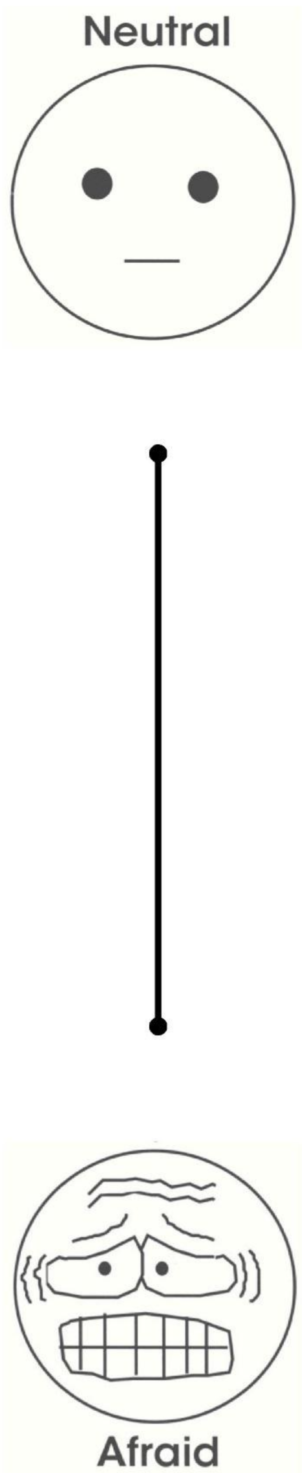
Participant Code: __________________ Session: _________________ Task: 01



Participant Code: _________________ Session: ________________ Task: 01



Participant Code: __________________ Session: _________________ Task: 01



Appendix J. Sample of free recall transcripts – neurologically normal participant

Control #01, Session: DS

Iteration 1: 00:03:03

I'm in a park, and there's a white dog running around, and it falls down at my feet. A teenagers comes up. He's got a green top and gray slacks. He picks up the dog and tells me that his parents are dead for 9 years. His brother died a year earlier, His sister is in a hospice with a terminal illness. His brother, a year before, had fallen off a cliff and could not be saved. He shows me a picture with him, his brother, and the dog, from before his brother died.

Iteration 2: 00:08:22

I'm in a park. There's a white dog running around. It looks sick and it falls dead at my feet. The teenager is running after the dog. He picks it up and strokes it. He tells me that he's got no friends. His parents are dead. He's been looking after the dog since his parents died, 9 years previously. His brother died and his sister is 360 miles away, in a hospice with a terminal illness, that she was diagnosed the year after his brother died. He is unable to see her. He shows me a photo of his brother, himself and the dog, on a trip in the mountains, where his brother fell off a cliff and could not be saved.

Iteration 3: 00:11:53

I'm in a park. There's a white dog running around. It looks sick and falls dead at my feet. The teenager was chasing the dog, wearing a green top and gray trousers. The dog belonged to him. He picks up the dog, and strokes the dog, and tells me that he's looked after the dog ever since his parents died, 9 years previous. He tells me that his brother's died. His brother's 4 years younger than him. His sister is in a hospice 360 miles away, and was diagnosed with a terminal illness a year after his brother died. He shows me a picture of his brother, himself and the dog when they were on a trip up in the mountains, when his brother fell off a mountain and could not be saved.

Interference: 00:14:55

I'm walking down the street and I catch the eye of an attractive man. He smiles. He's tall, slim with a beautiful face, and he reminds me of someone I used to know when I went to school. And I wonder if he can be the same person. When he passes he calls my name, and I turn around. We go to a restaurant.

Recall 1: 00:16:28

I'm having a walk in the park, and there is a white dog running around. He looks sick and it falls dead at my feet. A teenager was chasing the dog, He was wearing a green top and gray slacks. He picks the dog up and strokes it. He tells me he's been looking after the dog ever since his parents died, 9 years previous. His brother died, and his sister's got a terminal illness and is in a hospice 360 miles away, and he's not been able to see her ever since his brother died, two years previous. He shows me a photo of him, his brother and the dog from a trip in the mountains, when his brother fell off a cliff and could not be saved.

Recall 2: 00:39:40

I was walking in the park. There was a white dog running around. It looked sick, it fell dead at my feet. The teenager who had been chasing the dog was wearing a green top and gray slacks. He picked the dog up and stroked the dog, and tells me he had been looking after the dog ever since his parents died, 9 years previous. His brother had died a year before. His sister had a terminal illness and was in a hospice 360 miles away, and he hadn't been able to visit her ever since she'd gotten ill, a year before his brother died. He showed me a photo of himself, his brother and his dog, where his brother fell off a mountain and could not be saved.

Control #01, Session: LF

Iteration 1: 00:00:00

My friend is giving me a lift in a small car. It makes a terrible noise and it swerves, and there is a silver car in front with a pink baby sign in the back where two girls are playing. We hit the car. There is a blue lorry coming towards us. It puts on its brakes and it swerves and it hits our car into the side, and I am trapped inside. There is screaming coming from the car in front.

Iteration 2: 00:03:12

My friend is giving me a lift to a nearby town in a small car. We turn into a busy road. There is a noise, an explosion from underneath the car, and it swerves to the side. I bang my head, and it shatters the glass which gets in my eyes. There is a silver car in front that stops. It’s got a pink baby on board sticker, And there are two young girls playing on the back seat, who turn to look. The brakes don’t work on our car. It swerves to the side and hits the silver car, pushing it into a ditch. There is a blue lorry coming towards us, that brakes. It turns on its side, and turns towards us, hitting us in the side, and jams the door. And we are unable to get out.

Iteration 3: 00:06:30

My friend is giving me a lift into a nearby town in a small car. We turn into the main road, which is busy, there is a loud explosion from underneath the engine. It swerves violently, and my head hits the window to the side, breaking it. The glass gets into my eyes, and it hurts terribly. There is a small silver car in front. It’s got a pink baby on board sticker on the back, where there are two young girls playing, who turn to look. My driver loses control of the car. The brakes don’t work. It swerves and hits the car in front, pushing it off the road. The blue lorry coming from the opposite direction, and slams on its brakes violently. It skids and hits us and the door is jammed and I can't get out.

Interference: 00:09:28

I'm on an exotic holiday, on a terrace, looking out at the horizon. I'm eating my favourite flavour of ice-cream. There are three yachts, and the sailors are waving at somebody on the beach. The waves are lapping against the pristine white sand.

Recall 1: 00:10:56

My friend is giving me a lift in his small car. We turn onto the main road, which is very busy, there is a loud explosion from underneath the engine, and the car swerves. There is a silver car in front and it's got a pink baby-on-board sign. There are two young girls playing on the back seat and they turn to look. My friend loses control of the car. He slams on the brake. They don't work. He hits the car in front, knocking it off the road. There is loud screaming coming from the car. A blue lorry, in the opposite direction, coming towards us slams on its brakes violently. The lorry turns over and skids, and hits us, and we're trapped inside.

Recall 2: 00:53:30

My friend is giving me a lift in a small car to a nearby town. We go onto the main road, which is very busy. There is a loud explosion underneath the engine. The car swerves and I hit my head in the window. It shatters and the glass goes in my eyes, which hurts terribly. There is a silver car in front with a pink baby-on-board sign, and two girls are playing on the back seat. They turn to look at us. My friend loses control of the car. He puts his foot down on the brakes, but they don't work. We hit the car in front, and knock it to the side of the road. There's loud screaming coming from the car. There is a blue lorry coming from the opposite direction. It slams on its brakes violently, and veers to the side. It hits us and we are trapped in the car, and we can't open the door.

Control #01, Session: NH

Iteration 1: 00:01:25

It’s a Friday afternoon, and I am walking back home. The streets are busy with people. Someone calls my name and I look. She crossed the street to me. It’s a dear friend of mine from when I was younger. She’s moved away when I was 14. She now lives close to me and she invites me around to her house, where her son and fiancé are there. They’re getting married on a cruise ship, and they are paying for all their guests. They invite me to join them for the wedding and I accept.

Iteration 2: 00:04:00

I’m walking back home on a Friday afternoon. It’s busy and there are many people going home. A lady’s crossing the road and calls to me. It’s an old childhood friend who moved away when I was 14. I hadn’t seen her since then. She is excited to see me and says she has been waiting for this moment for a long time. She invites me to her house at the weekend, where her younger brother and his fiancé are there. They are getting married in 4 weeks’ time on a cruise ship and they are paying for all their guests. They invite me to the wedding and I gladly accept.

Iteration 3: 00:06:31

I am walking back home on a Friday afternoon, and it’s very busy. There are many people walking home too. A lady is crossing the street and calls my name. It’s a life’s childhood’s friend, who moved out of the area after I turned 14 with her parents, and I hadn’t seen her since then. She is very excited to see me and tells me has been waiting for this moment for a long time. She’s recently moved back into town and lives quite close to me, and invites me to her home on the weekend. Her younger brother is there with his lovely partner and are very excited as they are getting married in 4 weeks time on a cruise ship. They are paying for all their guests expenses and invite me along, which I gladly accept.

Interference: 00:09:13

It’s a Tuesday afternoon and I’m not busy, so I decided to go for a walk. I see my neighbour’s son who is crying. I ask him what’s the matter and he tells me that his nana’s died the day before. He’s clutching something to his chest and he tells me that his nana gave it to him yesterday. A roller-skater is coming up behind me and falls and sprains her ankle. She’s quite distressed, because she tells me she was in a competition that afternoon, and she wouldn’t be able to compete.

Recall 1: 00:10:48

I’m coming back home on a Friday afternoon. It’s very busy and there many people walking back home. A lady is crossing the street and calls my name. It’s a close childhood friend whom I haven’t seen for a long time, since I was 14, when she moved out of the area with her mum. She is very excited and tells me she has been waiting for this moment for a long time. She has just moved back into town, close to me and invites me around for the weekend. Her younger brother is there with his beautiful partner, and they’re very excited as are getting married in 4 weeks’ time. They are paying for all their guests to come, their expenses, and they invite me to the wedding, which I gladly accept.

Recall 2: 00:43:25

It’s a Friday afternoon, and I am coming back from work. It’s very busy and there are many people walking back home. A lady is crossing the street and calls my name. It’s a very close childhood friend, whom I haven’t; seen for many years, since I was 14, when she moved far away with her parents. She’s just moved back into the area and lives close by me, and invites me around to her house at the weekend. Her younger brother is there, with his beautiful partner, who is very excited and tells me they are getting married on a cruise ship in 4 weeks' time. They are paying for all the expenses for their guests and they invite me to come to the wedding.

Control #01, Session: WA

Iteration 1: 00:01:30

I'm going out with my friend on a Saturday afternoon to the pub. I sit down at my table while my friend buys the drinks. He comes to the table, and before he can put them on the table, he spills them and the drinks go down my legs. A lady standing by, in a blue dress has the drinks spilt down her dress, and accuses me of doing it, I explained that it wasn't me. My friend was shouting at me that it was my fault, and I said I hadn't touched the glasses. There's a lady standing by in a blue dress, and she accuses me of knocking the drink down her dress. I explained to her that it wasn't me, and I hadn't touched the drinks. A couple standing by a jukebox … A crowd of people are watching what is going on. A couple standing by a jukebox come and speak to my friend, and take my friend's side, and accuse me of knocking the drinks over.

Iteration 2: 00:05:28

I meet my friend on a Saturday afternoon at my local pub. I go and seat at a small table in the corner while he goes to the bar to fetch the drinks. When he fetches the drinks back, he drops them on the table, smashing the glass and the drinks go down my legs. He shouts at me that it's my fault, and I tell him that I didn't even touch the drinks. There's a young lady standing beside me in a new blue dress, and the dress is now stained. She shouts at me that it's my fault, and I try to explain to her that I hadn't even touched the glasses. She throws her cocktail in my face and leaves the pub. The pub is busy and many people comment about the lady's dress. A couple standing by the fruit-machines come over and speak to my friend, and they take his side and they shout insults at me. The bar staff ask me to leave and bar me from the pub.

Iteration 3: 00:08:25

I meet my friend at the local pub on a Saturday afternoon. The pub is quite busy. I sit down at a small table in the corner, while he goes for the drinks. He fetches the drinks back and he drops them on the table, smashing the drink's glass. The drinks pour down my legs, He shouts at me that it's my fault. And a young lady standing besides me, her dress had gotten stained and she accuses me of staining her dress. And I explained to her that I never even touched the glasses. She throws her cocktail….

I meet my friend on a Saturday afternoon at the local pub. It's quite busy. I sit at a small table in the corner of the room, while he goes to get the drinks. He brings the drinks back. He drops them before placing them on the table and they smash. The drinks pour down my legs. He shouts at me that it was my fault, even though I didn't touch the drinks. There's a young lady standing beside me in a new blue dress, which is now stained. She accuses me of staining the dress. I tried to explain to her that I didn't even touch the glasses. She threw her cocktail in my face and quickly leaves the pub. Several people turn and comment about the stain on the lady's dress. A couple standing by the fruit machine come over and speak to my friend, taking his side and hurling insults at me. The bar staff ask me to leave and bar me from the pub.

Interference: 00:13:25

I'm going shopping on a Saturday afternoon and I meet my friend. We stand chatting in the shop. She goes first to buy her shopping. And she asks me what lottery ticket to buy, and I tell her. While buying my shopping, she laughs loudly and tells me she's won £250,000 and that must go for a meal to celebrate. When we get to the restaurant, she decides to book a holiday and invites me along, free. We then go to the restaurant to celebrate.

Recall 1: 00:14:49

On a Saturday afternoon, I meet my friend in the local pub. He goes to the bar to buy the drinks, while I sit at a small table in the corner. He brings the drinks over and drops the drinks, smashing the glass, and the drink splashes, and goes down my leg. He shouts at me, accusing me of spilling the drinks, even though I hadn't touched the glasses. A young lady is standing beside me, wearing a new blue dress. The drinks spill and stain her dress. She accuses me of staining her dress, even though I didn't touch the glasses. I tell her, and she throws her cocktail in my face, and quickly leaves the pub. Several people standing around comment on the stain of the lady's dress. A couple standing at the fruit machine come over and speak to my friend, and start hurling insults at me. The bar staff come over and ask me to leave and bar me from the pub.

Recall 2: 00:52:10

On a Saturday afternoon I meet my friend at the local pub. It's very busy in the pub, and I sit at a small table in the corner, while he goes to the bar to get the drinks. He brings them back to the table and drops them smashing the glass. The drinks go down my legs. There's a young lady standing beside me in a new blue dress and it stains her dress. She shouts at me even though it's not my fault and I didn't touch the glass, she throws her cocktail in my face and leaves the pub. Several people around comment on the state of the lady's dress. A couple standing by the fruit machine come over and speak to my friend, and insult me. They take his side. The staff come over and ask me to leave and bar me from the pub.

Appendix K. Sample of free recall transcripts – Korsakoff's syndrome patients

Patient #04, Session 1: LF – WH

Iteration 1: LF

There's a contact with the other car, like a little crash, like a little bump. They were arguing a little bit. Eventually they settled it out, in the end. (That was it, really.)

Iteration 2: LF

There was a bit of a crash. Then we panicked a bit. So we had to stop. And…

Iteration 3: LF

Panic, basically. And we were talking a lot about the opponent's car. (That's basically it.)

Interference: WH

We were very anxious, and that was it, really.

Recall 1: LF

We were just driving. And, then, we got into contact with the other car. We had a little bit of a crash. We were shocked and a little bit angry with the other car.

Recall 2: LF

We had a bit of a crash, a car accident. We just got into the car, and this car came into us, and we had a bit of a crash, but we weren't injured. We had our seat belts on.

Patient #04, Session 2: NS – DH

Iteration 1: NS

He (the neighbour's little boy) was a bit frightened. And there was a little bit of an argument.

Iteration 2: NS

He was a little bit angry. There was a bit of an argument, because his parents were angry with him.

Iteration 3: NS

The boy was angry. He was creating a little bit of a scene.

Interference: DH

The girl was a bit in despair. She had the dog to comfort her. She just took it for a walk. The dog was a bit frightened, but she comforted it. But she was frightened as well. And she just took it for a walk and she tried to reassure it. (And that's basically it.)

Recall 1: NS

He (the neighbour's little boy) was alright, but a little frightened for the dog's sake, because the dog was in a bit of distress in the beginning, and he was trying to reassure the dog, really.

Recall 2: NS

He was a bit frightened, because there was a bit of a racket, so he clung to his mother, and his mother calmed him down. (And that's all I can remember from this story.)

Patient #04, Session 3: WA – LH

Iteration 1: WA

She (the friend) had a bit of an argument. There was a bit of a showdown. She was sad as well.

Iteration 2: WA

There was a bit of an argument, but it did get resolved eventually.

Iteration 3: WA

She had a bit of an argument. And it did get resolved eventually… that I was with her. We were friends afterwards, but we've just had a bit of an argument. Too much drink.

Interference: LH

There was a bit of an argument, but it did get resolved eventually.

Recall 1: WA

I met a friend in a pub.

Recall 2: WA

I used to work with a friend and then we went to the pub.

Patient #04, Session 4: DH – NS

Iteration 1: DH

I went for a walk and I met up with this girl and she had this dog. She was very fond of this dog. And I stroked it and we just went for a walk in the park with the dog. (And that's basically it, really.)

Iteration 2: DH

She was in the park and the dog was excited. But it was a little angry at first, because it wanted something to eat. And she gave it something to eat, and it was a little bit better after that. And I was with her and I stroked the dog, and… that was basically it, we just went for a walk with the dog.

Iteration 3: DH

She was angry in the beginning, but the dog played about a bit. And we were happy afterwards, that the dog was alright.

Interference: NS

We were walking the park and the dog got a bit excited. The owner was a bit panicky in the beginning.

Recall 1: DH

It was afraid in the beginning, but it was alright afterwards with his owner, and we assured the dog.

Recall 2: DH

A girl was walking a dog in the park and I was with her.

Appendix L. Sample of neuropsychological assessments – neurologically normal control participant

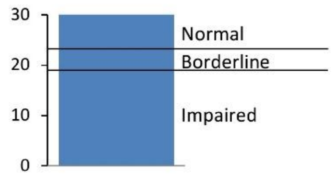
General Assessment

Participant Name:		DoB:	62 years old
Participant ID:	C-01	Date Tested:	2012
Sex:	Female	Years of Education:	17

Mini Mental State Examination

The Mini Mental State Examination (MMSE) is the most commonly used test to screen for cognitive impairment. It can be used by clinicians to help diagnose dementia and to help assess its progression and severity.

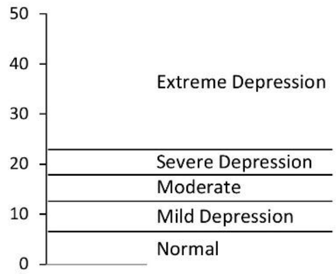
Task	Participant Score	Max Score
Orientation:	10	10
Immediate recall:	3	3
Attention and Calculation:	5	5
Recall:	3	3
Language:	9	9
Total:	**30**	**30**



Hamilton Depression Rating Scale

The Hamilton Depression Scale (abbreviated as HDS, HAMD or HAD) is a depression test measuring the severity of clinical depression symptoms. It is a standard measure of depression used in research and for the evaluation of effectiveness of depression therapies and treatments. However, the result is NOT an official diagnosis, it is for orientation only.

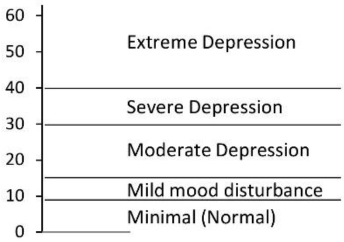
Participant Score	Max Score
	50



Beck Depression Inventory

The Beck Depression Inventory (BDI) is a questionnaire developed to measure the intensity, severity, and depth of depression in patients with psychiatric diagnoses. It is also used to detect depressive symptoms in a primary care setting as part of a psychological or medical examination.

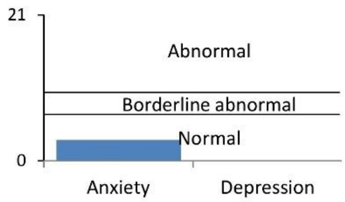
Participant Score	Max Score
	63



Hospital Anxiety and Depression Scale

The Hospital Anxiety and Depression Scale (HADS) is a valid and reliable self-rating scale that measures anxiety and depression in both hospital and community settings.

Measure	Participant Score	Max Score
Anxiety	3	**21**
Depression	0	**21**



C-01 Neuropsychological Assessments.xlsx

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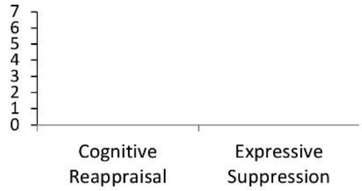
General Assessment

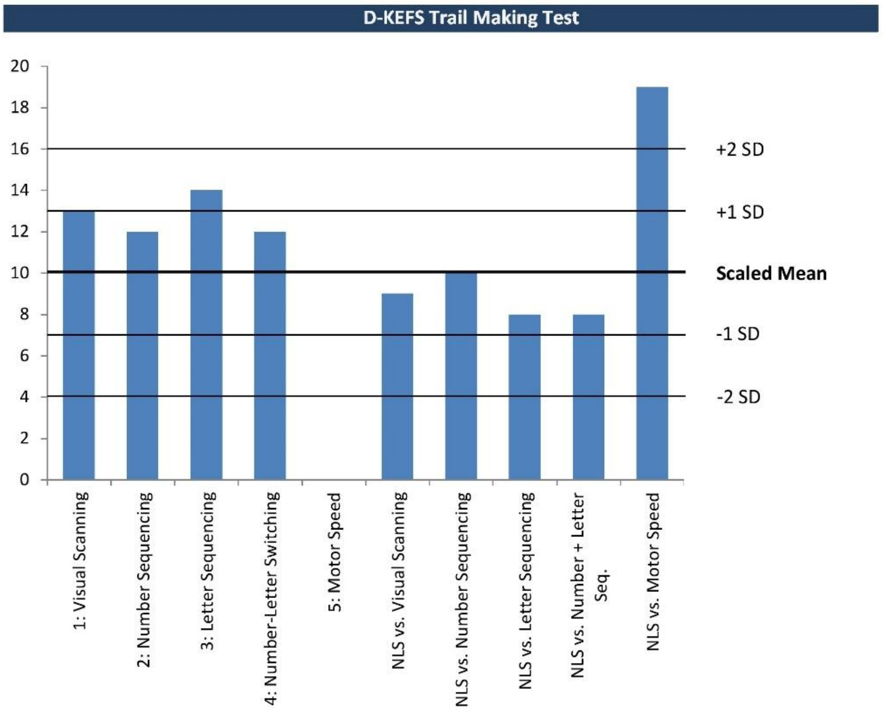
Emotion Regulation Questionnaire

The Emotion Regulation Questionnaire (ERQ) is designed to measure respondents' tendency to regulate their emotions in two ways: (1) Cognitive Reappraisal and (2) Expressive Suppression. Cognitive reappraisal is a form of cognitive change that involves construing a potentially emotion-eliciting situation in a way that changes its emotional impact. For example, during an admissions interview, one might view the give and take as an opportunity to find out how much one likes the school, rather than as a test of one's worth. Expressive suppression is a form of response modulation that involves inhibiting ongoing emotion-expressive behaviour (Gross, 1998). For example, one might keep a poker face while holding a great hand during a card game. Reappraisal is an antecedent-focused strategy: it occurs early, and intervenes before the emotion response tendencies have been fully generated. This means that reappraisal can thus efficiently alter the entire subsequent emotion trajectory. More specifically, when used to down-regulate negative emotion, reappraisal should successfully reduce the experiential and behavioural components of negative emotion. By contrast, suppression is a response-focused strategy: it comes relatively late in the emotion-generative process, and primarily modifies the behavioural aspect of the emotion response tendencies. Suppression should thus be effective in decreasing the behavioural expression of negative emotion, but might have the unintended side effect of also clamping down on the expression of positive emotion. At the same time, suppression will not be helpful in reducing the experience of negative emotion, which is not directly targeted by suppression and may thus continue to linger and accumulate unresolved. In addition, because suppression comes late in the emotion-generative process, it requires the individual to effortfully manage emotion response tendencies as they continually arise. These repeated efforts may consume cognitive resources that could otherwise be used for optimal performance in the social contexts in which the emotions arise. Moreover, suppression creates in the individual a sense of incongruence, or discrepancy, between inner experience and outer expression. This sense of not being true to oneself, of being inauthentic rather than honest with others, may well lead to negative feelings about the self and alienate the individual not only from the self but also from others.

Measure	Participant Score	Max Score
Cognitive Reappraisal		**7**
Expressive Suppression		**7**



Executive Function



D-KEFS Trail Making Test

The primary executive function task is Condition 4: Number-Letter Switching, which assesses cognitive flexibility on a visual-motor sequencing task. The other four conditions allow the examiner to determine if a deficient score on the switching condition is related to a deficit in cognitive flexibility and/or to an impairment in one or more underlying skills.

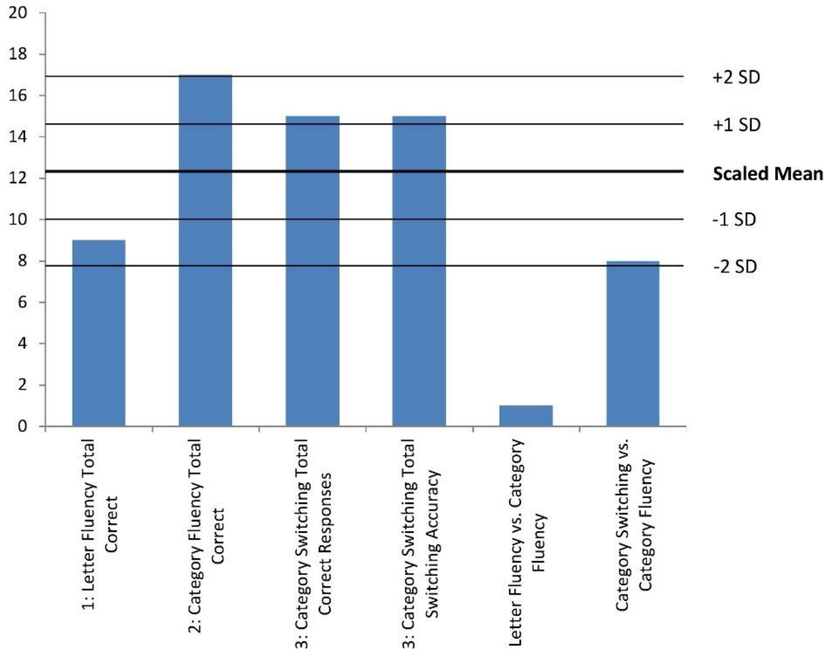
D-KEFS Trail Making Test	Score	Scaled Score
Primary Measures: Completion Times		(*M* =10, *SD* =3)
Condition 1: Visual Scanning	**20**	13
Condition 2: Number Sequencing	**37**	12
Condition 3: Letter Sequencing	**20**	14
Condition 4: Number-Letter Switching	**78**	12
Condition 5: Motor Speed		
Primary Combined Measures: Completion Times		
Combined Number Sequencing + Letter Sequencing	**26**	14
Primary Contrast Measures: Completion Times		
Number-Letter Switching vs. Visual Scanning	**-1**	9
Number-Letter Switching vs. Number Sequencing	**0**	10
Number-Letter Switching vs. Letter Sequencing	**-2**	8
Number-Letter Switching vs. Combined Number + Letter Sequencing	**-2**	8
Number-Letter Switching vs. Motor Speed	**12**	19

Executive Function

Optional Measures: Error Analysis		
Condition 1 - Visual Scanning: Omission Errors	**0**	100
Condition 1 - Visual Scanning: Commission Errors	**0**	100
Condition 2 - Number Sequencing: Sequencing Errors	**0**	100
Condition 2 - Number Sequencing: Set-Loss Errors	**0**	100
Condition 2 - Number Sequencing: Time-Discontinue Errors	**0**	100
Condition 3 - Letter Sequencing: Sequencing Errors	**0**	100
Condition 3 - Letter Sequencing: Set-Loss Errors	**0**	100
Condition 3 - Letter Sequencing: Time Discontinue Errors	**0**	100
Condition 4 - Number-Letter Switching: Sequencing Errors	**1**	31
Condition 4 - Number-Letter Switching: Set-Loss Errors	**0**	100
Condition 4 - Number-Letter Switching: Time-Discontinue Errors	**0**	100
Condition 4 - Number-Letter Switching: All Error Types	**1**	10
Condition 5 - Motor Speed: Time Discontinue Errors	**0**	100

Executive Function

D-KEFS Verbal Fluency



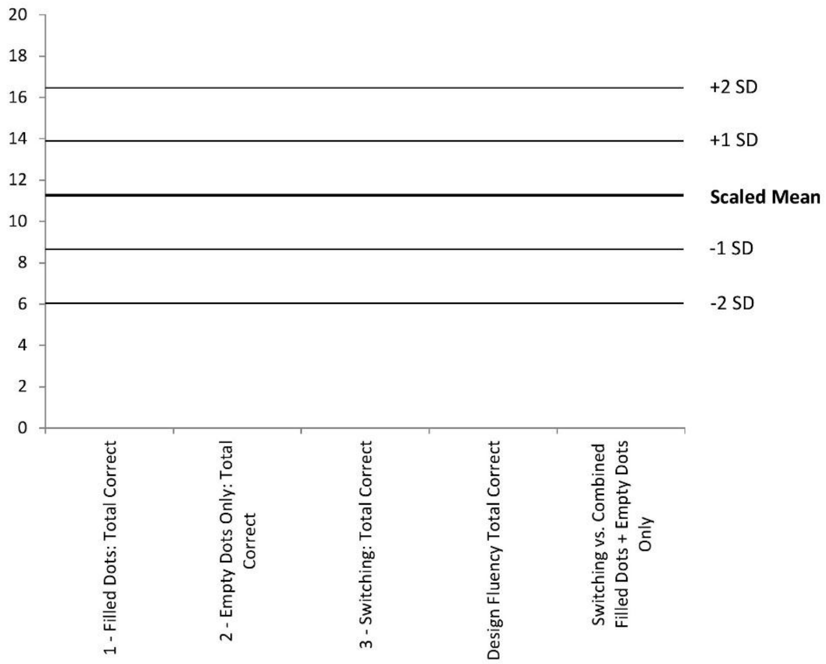
D-KEFS Verbal Fluency

This test measures the examinee's ability to generate words fluently in an effortful, phonemic format (Letter Fluency), from overlearned concepts (Category Fluency), and while simultaneously shifting between overlearned concepts (Category Switching).

D-KEFS Verbal Fluency	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measures		
Condition 1: Letter Fluency Total Correct	**31**	9
Condition 2: Category Fluency Total Correct	**52**	17
Condition 3: Category Switching Total Correct Responses	**17**	15
Condition 3: Category Switching Total Switching Accuracy	**16**	15
Primary Contrast Measures		
Contrast Measures: Letter Fluency vs. Category Fluency	**-8**	1
Contrast Measures: Category Switching vs. Category Fluency	**-2**	8
Optional Measures		
First Interval (0-15): Total Correct - Conditions 1-3	**41**	13
Second Interval (16-30): Total Correct - Conditions 1-3	**8**	3
Third Interval (31-45): Total Correct - Conditions 1-3	**6**	4
Fourth Interval (46-60): Total Correct - Conditions 1-3	**4**	4
Set-Loss Errors - Conditions 1-3	**2**	10
Repetition Errors - Conditions 1-3	**1**	12
Percent Set-Loss Errors - Conditions 1-3 (%)	**0.0**	13
Percent Repetition Errors - Conditions 1-3 (%)	**3.1**	10
Percent Swithcing Accuracy - Conditions 3 only (%)	**94.4**	11

Executive Function

D-KEFS Design Fluency



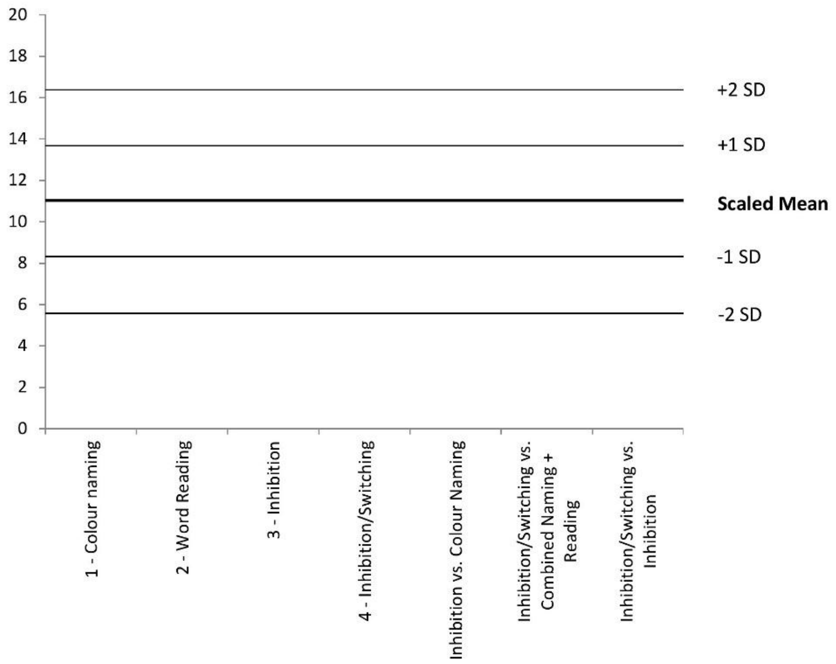
D-KEFS Design Fluency

This test assesses motor planning, cognitive flexibility, and fluency in generation of visual patterns, above and beyond contributions from motor speed. Condition 1 provides a basic test of design fluency, Condition 2 measures both design fluency and response inhibition, and Condition 3 measures both design fluency and cognitive flexibility.

D-KEFS Design Fluency	Score	Scaled Score (M =10, SD =3)
Primary Measures		
Condition 1 - Filled Dots: Total Correct		
Condition 2 - Empty Dots Only: Total Correct		
Condition 3 - Switching: Total Correct		
Design Fluency Total Correct	**0**	
Primary Combined Measures: Filled Dots + Empty Dots		
Condition 1 - Filled Dots: Scaled Score	**0**	
Condition 2 - Empty Dots Only: Scaled Score	**0**	
Sum of Scaled Scores	**0**	
Primary Contrast Measures		
Switching vs. Combined Filled Dots + Empty Dots Only	**0**	
Optional Measures		
Total Set Loss Design		
Total repeated Designs		
Total Attempted Designs		
Percent Design Accuracy		

Executive Function

D-KEFS Colour-Word Interference Test



D-KEFS Colour-Word Interference Test

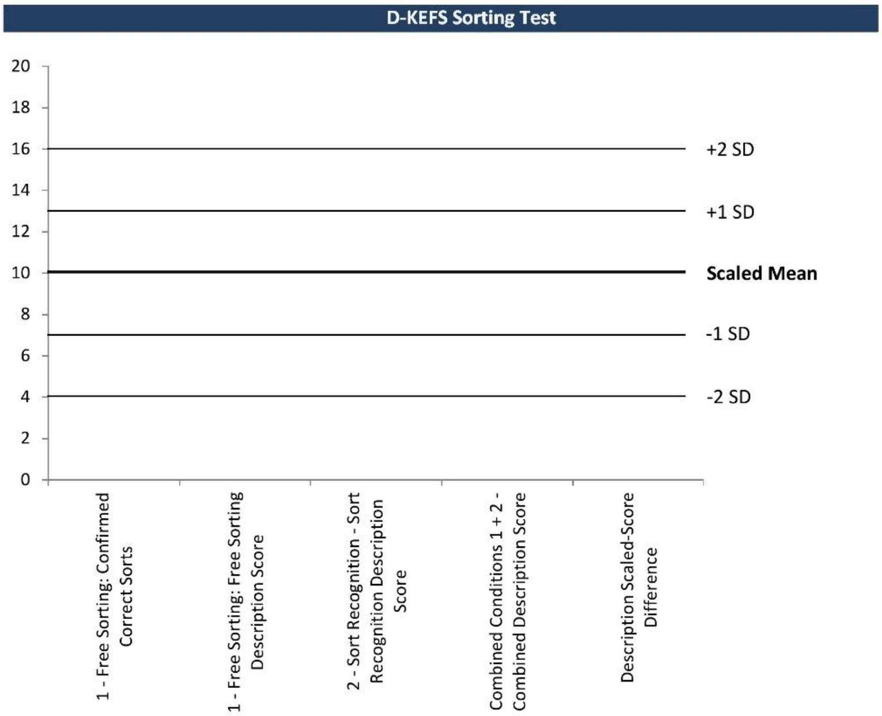
This test is based on the Stroop procedure. The primary executive functions measured are verbal inhibition, simultaneous processing, and cognitive flexibility. Condition 3: Inhibition is the traditional Stroop which measures verbal inhibition. Condition 4: Inhibition/Switching is a means of evaluating both inhibition and cognitive flexibility.

D-KEFS Colour-Word Interference Test	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measures: Completion Times		
Condition 1 - Colour naming		
Condition 2 - Word Reading		
Condition 3 - Inhibition		
Condition 4 - Inhibition/Switching		
Primary Combined Measures: Completion Times		
Combined Naming + Reading	**0**	
Primary Contrast Measures: Completion Times		
Inhibition vs. Colour Naming	**0**	
Inhibition/Switching vs. Combined Naming + Reading	**0**	
Inhibition/Switching vs. Inhibition	**0**	

Executive Function

Optional Contrast Measures: Completion Times		
Inhibition/Switching vs. Colour Naming	0	
Inhibition /Switching vs. Word Reading	0	
Optional Measures: Error Analysis		
Condition 1 - Colour naming: Total Errors		
Condition 2 - Word Reading: Total Errors		
Condition 3 - Inhibition: Corrected Errors		
Condition 3 - Inhibition: Uncorrected Errors		
Condition 3 - Inhibition: Total Errors	0	
Condition 4 - Inhibition/Switching: Corrected Errors		
Condition 4 - Inhibition/Switching: Uncorrected Errors		
Condition 4 - Inhibition/Switching: Total Errors	0	

Executive Function



D-KEFS Sorting Test

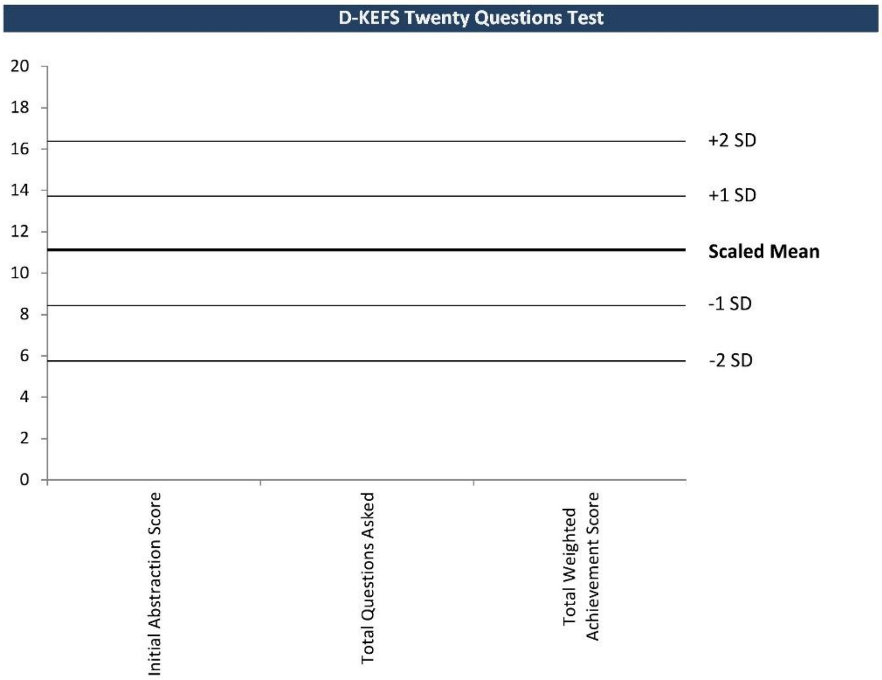
This test evaluates the examinee's abilities of problem solving and concept formation, while also tapping into the executive functions of initiation of problem-solving behaviourconcept formation skills, modality-specific probblem-solving skills (verbal versus nonverbal), creativity in forming responses, transfer of conceptual knowledge into goal-directed behavior, and the ability to inhibit previous responses in order to allow behavioural and cognitive flexibility.

D-KEFS Sorting Test	Score	Scaled Score
Primary Measures		(*M* =10, *SD* =3)
Condition 1 - Free Sorting: Confirmed Correct Sorts		
Condition 1 - Free Sorting: Free Sorting Description Score		
Condition 2 - Sort Recognition - Sort Recognition Description Score		
Combined Conditions 1 + 2 - Combined Description Score	**0**	
Contrast Measure: Sort recognition vs. Free Sorting		
Description Scaled-Score Difference	**0**	

Executive Function

Optional Measures: Condition 1 - Free Sorting: Sorting Measures		
Confirmed Correct Sorts: Card Set 1		
Confirmed Correct Sorts: Card Set 2		
Confirmed Correct Verbal Sorts		
Confirmed Correct Perceptual Sorts		
Confirmed/Unconfirmed Target Sorts		
Repeated Sorts		
Set-Loss Sorts		
Nontarget Even Sorts		
Attempted Sorts		
Percent Sorting Accuracy	**#DIV/0!**	
Time-Per-Sort Ratio		
Optional Measures: Condition 1 - Free Sorting: Description Measures		
Free Sorting Description Score: Card Set 1		
Free Sorting Description Score: Card Set 2		
Free Sorting Incorrect Descriptions		
Free Sorting Repeated Descriptions		
Percent Description Accuracy	**#DIV/0!**	
Optional Measures: Condition 2 - Sort Recognition: Description Measures		
Sort Recognition Description Score: Card Set 1		
Sort Recognition Description Score: Card Set 2		
Sort Recognition Incorrect Descriptions		
Sort Recognition Repeated Descriptions		
Optional Measures: Combined Conditions 1 + 2: Description Measures		
Combined Description Score: Verbal Rules		
Combined Description Score: Perceptual Rules		
Combined No/Don't Know Responses		
Combined Noncredit Descriptions		
Combined Overly Abstract Descriptions		
Combined Incorrect Descriptions	**0**	
Combined Repeated Descriptions		

Executive Function

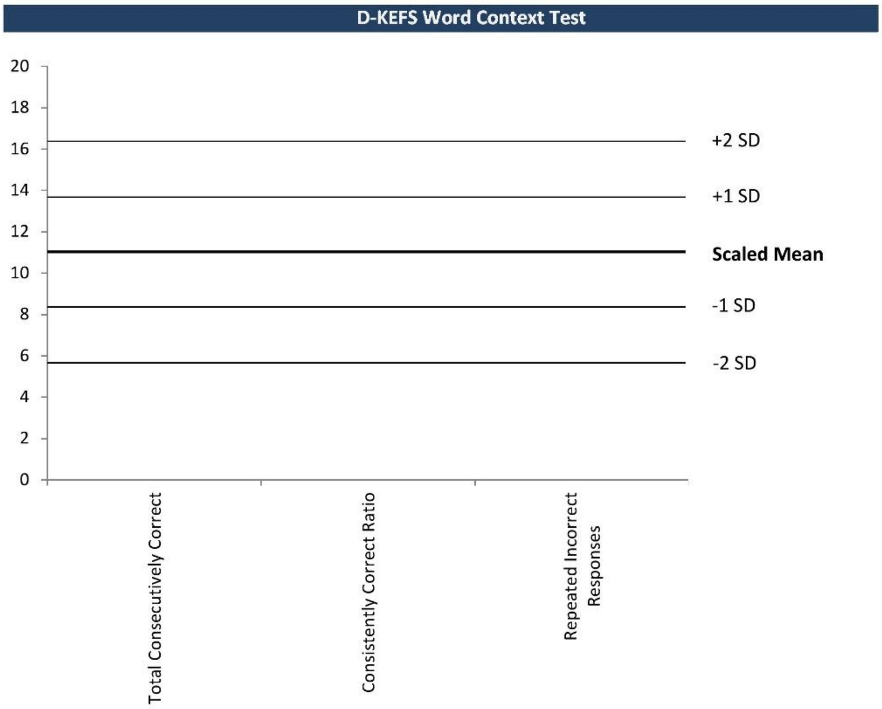


D-KEFS Twenty Questions Test

This test measures the examinee's logical thinking, hypothesis testing, and deduction, by assessing the ability to organise visual elements into categories and subcategories, formulate abstract questions, and incorporate the examiner's feedback.

D-KEFS Twenty Questions Test	Score	Scaled Score (M =10, SD =3)
Primary Measures		
Initial Abstraction Score		
Total Questions Asked		
Total Weighted Achievement Score		
Optional Measures		
Spatial Questions		
Repeated Questions		
Set-Loss Questions		

Executive Function

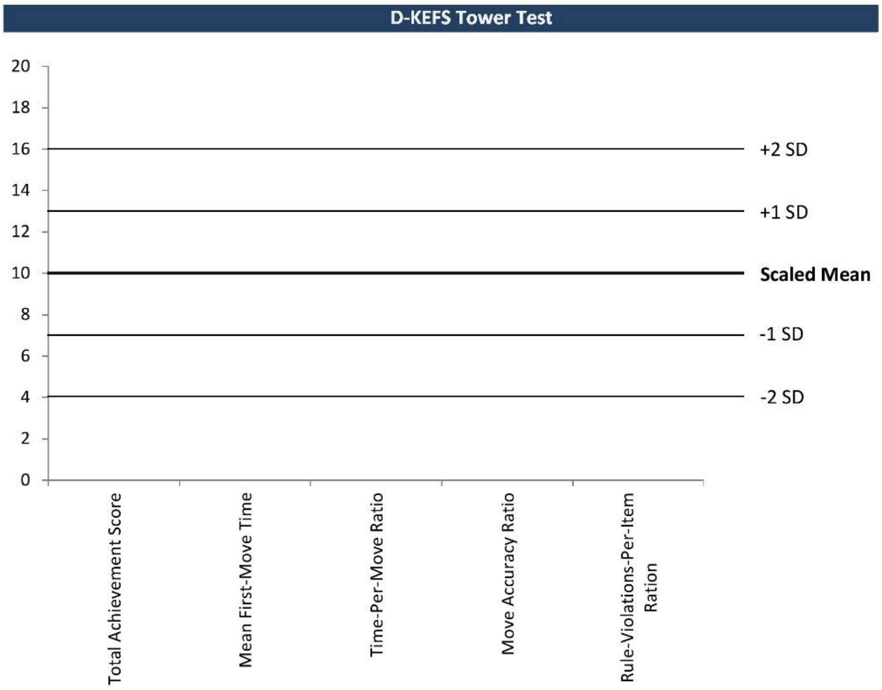


D-KEFS Word Context Test

This test is a means of evaluating executive functioning in the verbal modality and assessing such skills as deductive reasoning, integration of multiple bits of information, hypothesis testing, and flexibility of thinking.

D-KEFS Word Context Test	Score	Scaled Score
Primary Measure		(*M* =10, *SD* =3)
Total Consecutively Correct		
Optional Measures		
Consistently Correct Ratio		
Repeated Incorrect Responses		
No/Don't Know Responses		
Total Correct-To_Incorrect Errors		

Executive Function

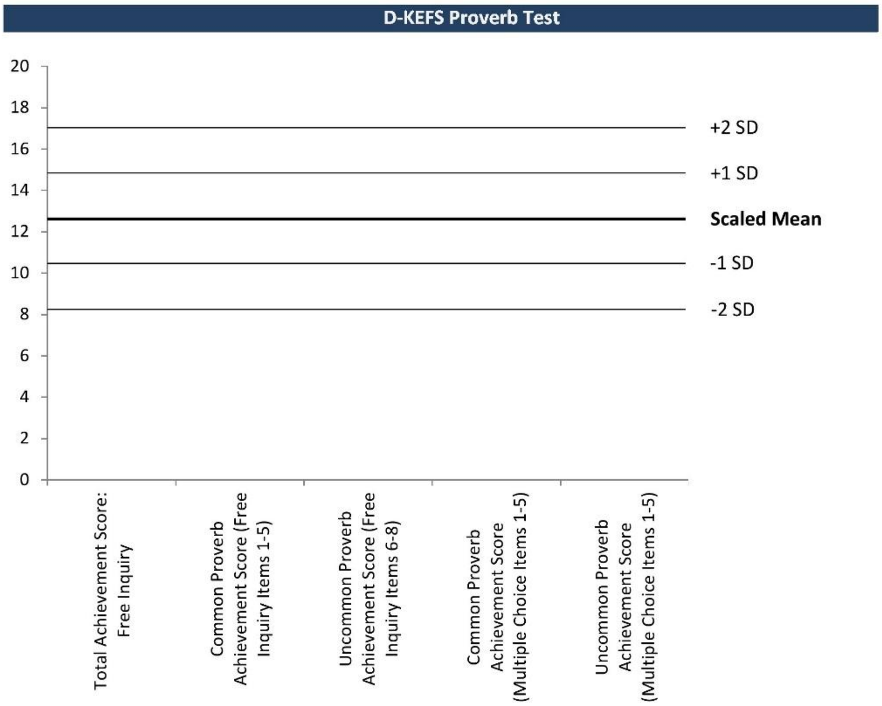


D-KEFS Tower Test

This test is a measure of visual attention, spatial planning, rule learning, inhibition of impulsive and perseverative responding, and the ability to establish and maintain a cognitive (instructional) set.

D-KEFS Tower Test	Score	Scaled Score
Primary Measure		(*M* =10, *SD* =3)
Total Achievement Score		
Optional Measures		
Mean First-Move Time		
Time-Per-Move Ratio		
Move Accuracy Ratio		
Total Rule Violation		
Rule-Violations-Per-Item Ration		

Executive Function



D-KEFS Proverb Test

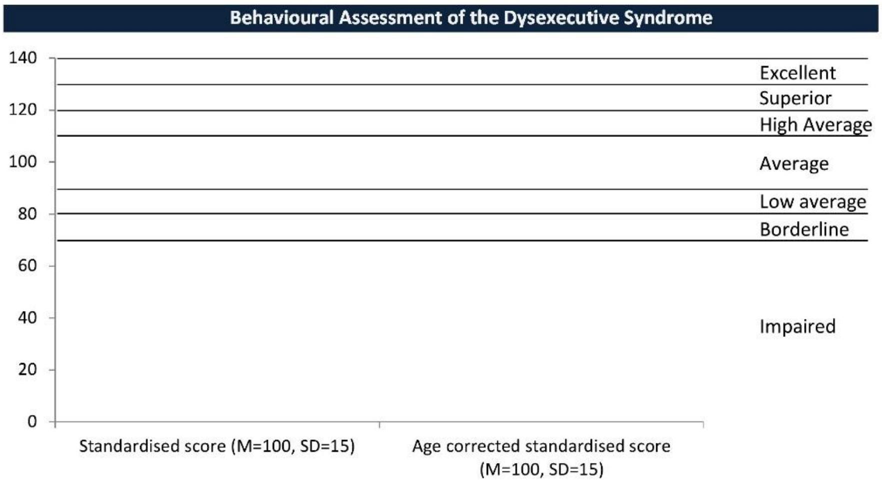
This test assesses the examinee's ability to interpret brief, concrete phrases that convey deeper, abstract meaning. The test requires higher level executive functions of verbal abstract thinking, semantic integration of the individual words into coherent, abstract principles or concepts, and generalisation to many situations beyond the concrete, literal interpretation.

D-KEFS Proverb Test	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measure		
Total Achievement Score: Free Inquiry		
Total Achievement Score: Multiple Choice		
Optional Measures: Free Inquiry		
Common Proverb Achievement Score (Free Inquiry Items 1-5)		
Uncommon Proverb Achievement Score (Free Inquiry Items 6-8)		
Accuracy Only Score		
Abstraction Only Score		
No/Don't Know Responses		
Repeated Responses		

Executive Function

Optional Measures: Multiple Choice	
Common Proverb Achievement Score (Multiple Choice Items 1-5)	
Uncommon Proverb Achievement Score (Multiple Choice Items 1-5)	
Total Correct Abstract Choices	
Total Correct Concrete Choices	
Total Incorrect Phonemic Choices	
Total Incorrect Unrelated Choices	
Total Incorrect Phonemic + Unrelated Choices	

Executive Function

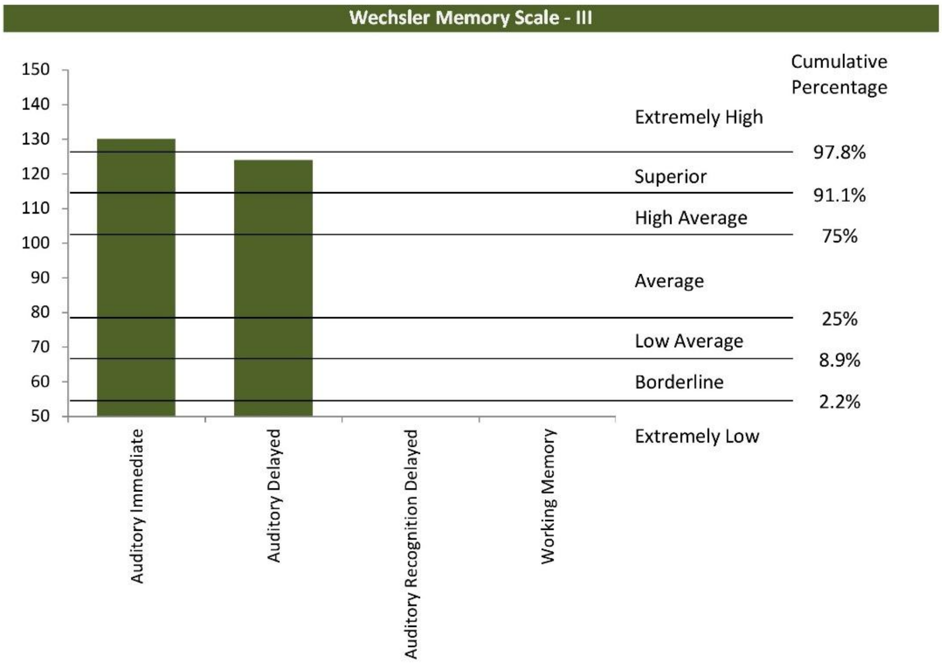


Behavioural Assessment of the Dysexecutive Syndrome

The BADS is a battery of six tests which require participants to plan, initiate, monitor and adjust behaviour in response to the explicit and implicit demands of a series of tasks. (1) Rule Shift Cards (RS) – This test purports to identify perseverative tendencies and its obverse, mental flexibility (perseveration refers to a difficulty in adjusting behaviour to meet the demands of a changing situation). (2) Action Programme (AP) – This test assesses the ability to devise and implement a solution to a practical problem (getting a cork out of a narrow plastic tube) while not contravening a set of rules. (3) Key Search (KS) – was influenced by one of the task in the Stanford-Binet Intelligence Scale, and it assesses ability to plan a strategy to solve a problem (finding a key lost in a field). (4) Temporal Judgement (TJ) – This test involves judgement and abstract thinking based on common knowledge, as the respondent is required to estimate times for everyday events. (5) Zoo Map (ZM) – This is a test to assess the ability to formulate and implement a plan while following a instructional set (spontaneous planning ability) and to follow a preformulated plan while observing the original set of instructions. (6) Modified Six Elements (6E) – This test assesses the ability to time-manage, while making demands on the examinee's ability to plan, organise and monitor behaviour, and also to remember to carry out an intention at a future time (prospective memory). It involves dividing the available time between a number of simple tasks (picture naming, arithmetic and dictation) while not contravening a set of rules.

Behavioural Assessment of the Dysexecutive Syndrome	Score	Max Score
Test 1: Rule shift cards		4
Test 2: Action program		4
Test 3: Key search		4
Test 4: Temporal judgement		4
Test 5: Zoo map		4
Test 6: Modified six elements		4
Total profile score	**0**	**24**
Standardised score (*M* =100, *SD* =15)		**140**
Age corrected standardised score (*M* =100, *SD* =15)		**140**

Memory



Wechsler Memory Scale - III				
Primary Indexes	Index Scores	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Auditory Immediate	130	98	121	135
Auditory Delayed	124	95	112	130
Auditory Recognition Delayed				
Working Memory				

Description of Indexes

Auditory Immediate: Indicates the examinee's ability to remember information immediately after it is orally presented. Scores from Logical Memory I and verbal Paired Associates I contribute to this index.

Auditory Delayed: Indicates the examinee's ability to remember orally presented information after a 25-30 minute delay. Scores from Logical Memory II and Verbal Paired Associates II contribute to this index.
Auditory Recognition Delayed: Indicates the examinee's ability to remember (via recognition) auditory information after 25-35 minute delay. Recognition scores from Logical Memory II and Verbal Paired Associates II contribute to this index.
Working Memory: Indicates the examinee's capacity to remember and manipulate both visually and orally presented information in short-term memory storage. Scores from Spatial Span and Letter-Number Seqeuncing contribute to this index.

Memory

Wechsler Memory Scale - III					
Primary Index Differences	Scor 1	Score 2	Difference	Stat. Sig. 0.05 Level	Freq. of Diff.
Auditory Immediate - Auditory Delayed	130	124	6	13.8	47.80%
Auditory Delayed - Auditory Recognition Delayed	124	0	124		

Memory

Wechsler Memory Scale - III		
Auditory Process Composite Scores	Sum of Scaled Scores	Percentiles
Single-Trial Learning	25	84
Learning Slope	24	80
Retention	21	55
Retrieval		

Description of Auditory Process Composite Scores

Single-Trial Learning: Indicates the examinee's capacity to immediately recall auditory information after a single exposure to the material to be remembered.

Learning Slope: Describes the examinee's ability to acquire new auditory information after repeated exposures. This index is a measure of the relative increase in recall performance from first trial to last trial.

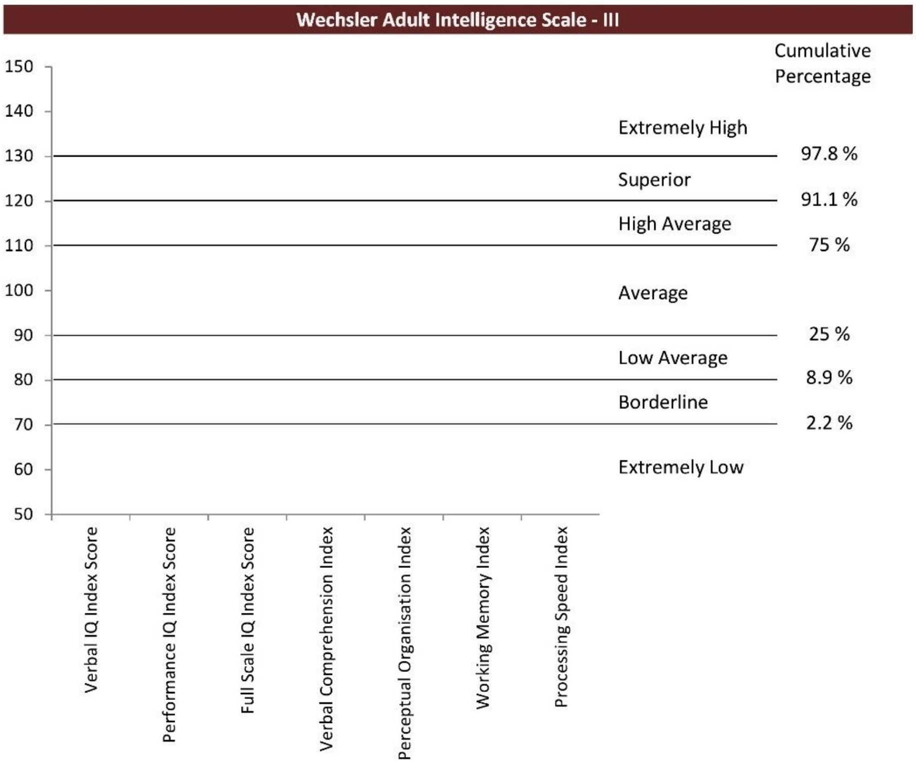
Retention: Indicates the examinee's delayed recall capacity as a function of immediate recall performance over a 25-35 minute delay. Scores are calculated as a percent retention score (i.e., delayed recall divided by immediate recall; the quotient is multiplied by 100).

Retrival: This index contrasts memory retrieval for recall versus recognition memory and is computed by subtracting delayed recall scores from recognition scores.

Memory

Wechsler Memory Scale - III							
Ability - Memory Indexes	WAIS-III FSIQ Score	Memory Index Predicted	Memory Index Actual	Diff. Score	Stat. Sig. 0.05 Level	Sig.	Freq. of Diff.
Auditory Immediate	0		130	-130		s	
Auditory Delayed	0		124	-124		s	
Auditory Recognition Delayed	0		0	0		s	
Working Memory	0		0	0		s	

Intelligence



Wechsler Adult Intelligence Scale - III				
	IQ / Index Score	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Verbal IQ Index Score				
Performance IQ Index Score				
Full Scale IQ Index Score				
Verbal Comprehension Index				
Perceptual Organisation Index				
Working Memory Index				
Processing Speed Index				

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Intelligence

Wechsler Adult Intelligence Scale - III							
Subtests	Scaled Score	Mean Score	Difference from Mean	Stat. Sig. 0.05 Level	Strength (+)	Weakness (-)	Freq. of Diff.
Vocabulary			0		s	w	
Similarities		0	0		s	w	
Arithmetic		0	0		s	w	
Digit Span		0	0		s	w	
Information		0	0		s	w	
Comprehension		0	0		s	w	
Letter-Number Sequencing		0	0		s	w	
Picture Completion		0	0		s	w	
Digit-Symbol (Coding)		0	0		s	w	
Block Design		0	0		s	w	
Matrix Reasoning		0	0		s	w	
Picture Arrangement		0	0		s	w	
Symbol Search		0	0		s	w	

Verbal IQ:

The verbal IQ is derived from scores on seven of the subtests: information, digit span, vocabulary, arithmetic, comprehension, similarities, and letter-number sequencing.

The information subtest is a test of general knowledge, including questions about geography and literature. The digit span subtest requires test takers to repeat strings of digits. The vocabulary and arithmetic subtests are general measures of a person's vocabulary and arithmetic skills. The comprehension subtest requires test takers to solve practical problems and explain the meaning of proverbs. The similarities subtest requires test takers to indicate the similarities between pairs of things. The letter-number sequencing subtest involves ordering numbers and letters presented in an unordered sequence. Scores on the verbal subtests are based primarily on correct answers.

Performance IQ:

The performance IQ is derived from scores on the picture completion, picture arrangement, block design, digit symbol, matrix reasoning, and symbol search.

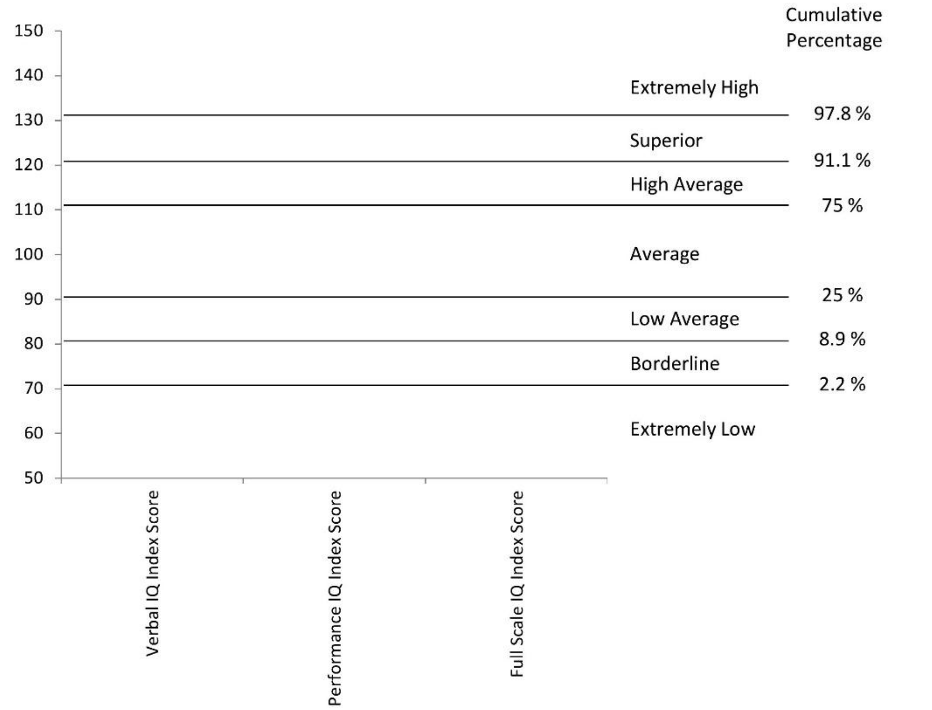
In the picture completion subtest, the test taker is required to complete pictures with missing elements. The picture arrangement subtest entails arranging pictures in order to tell a story. The block design subtest requires test takers to use blocks to make specific designs. In the digit symbol subtest, digits and symbols are presented as pairs and test takers then must pair additional digits and symbols. The matrix reasoning subtest requires test takers to identify geometric shapes. The symbol search subtest requires examinees to match symbols appearing in different groups. Scores on the performance subtests are based on both response speed and correct answers.

Intelligence

Wechsler Adult Intelligence Scale - III					
Discrepancy Comparisons	Score 1	Score 2	Difference	Stat. Sig. 0.05 Level	Freq. Of Diff.
Verbal IQ - Performance IQ	0	0	0		
Verbal Comprehens. - Perceptual Organisation	0	0	0		
Verbal Comprehension - Working Memory	0	0	0		
Perceptual Organisation - Processing Speed	0	0	0		
Verbal Comprehension - Processing Speed	0	0	0		
Perceptual Organisation - Working Memory	0	0	0		
Working memory - Processing Speed	0	0	0		

Intelligence

Wechsler Abbreviated Scale of Intelligence



Wechsler Abbreviated Scale of Intelligence				
	IQ / Index Score	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Verbal IQ Index Score				
Performance IQ Index Score				
Full Scale IQ Index Score				

Appendix M. Sample of neuropsychological assessments – Korsakoff's syndrome patient

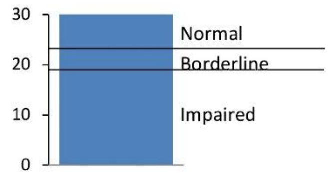
General Assessment

Participant Name:		DoB:	26/06/1950
Participant ID:	P-01	Date Tested:	Feb-Mar 2013
Sex:	F	Years of Education:	11

Mini Mental State Examination

The Mini Mental State Examination (MMSE) is the most commonly used test to screen for cognitive impairment. It can be used by clinicians to help diagnose dementia and to help assess its progression and severity.

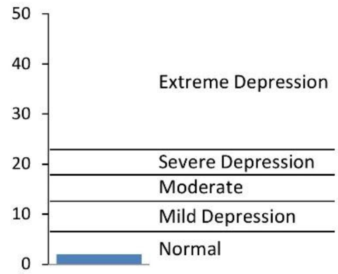
Task	Participant Score	Max Score
Orientation:	10	10
Immediate recall:	3	3
Attention and Calculation:	5	5
Recall:	3	3
Language:	9	9
Total:	**30**	**30**



Hamilton Depression Rating Scale

The Hamilton Depression Scale (abbreviated as HDS, HAMD or HAD) is a depression test measuring the severity of clinical depression symptoms. It is a standard measure of depression used in research and for the evaluation of effectiveness of depression therapies and treatments. However, the result is NOT an official diagnosis, it is for orientation only.

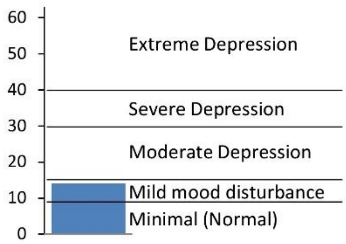
Participant Score	Max Score
2	**50**



Beck Depression Inventory

The Beck Depression Inventory (BDI) is a questionnaire developed to measure the intensity, severity, and depth of depression in patients with psychiatric diagnoses. It is also used to detect depressive symptoms in a primary care setting as part of a psychological or medical examination.

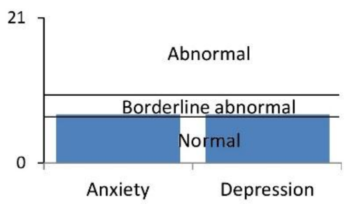
Participant Score	Max Score
14	**63**



Hospital Anxiety and Depression Scale

The Hospital Anxiety and Depression Scale (HADS) is a valid and reliable self-rating scale that measures anxiety and depression in both hospital and community settings.

Measure	Participant Score	Max Score
Anxiety	7	**21**
Depression	7	**21**



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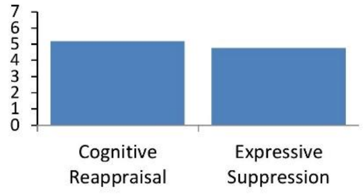
General Assessment

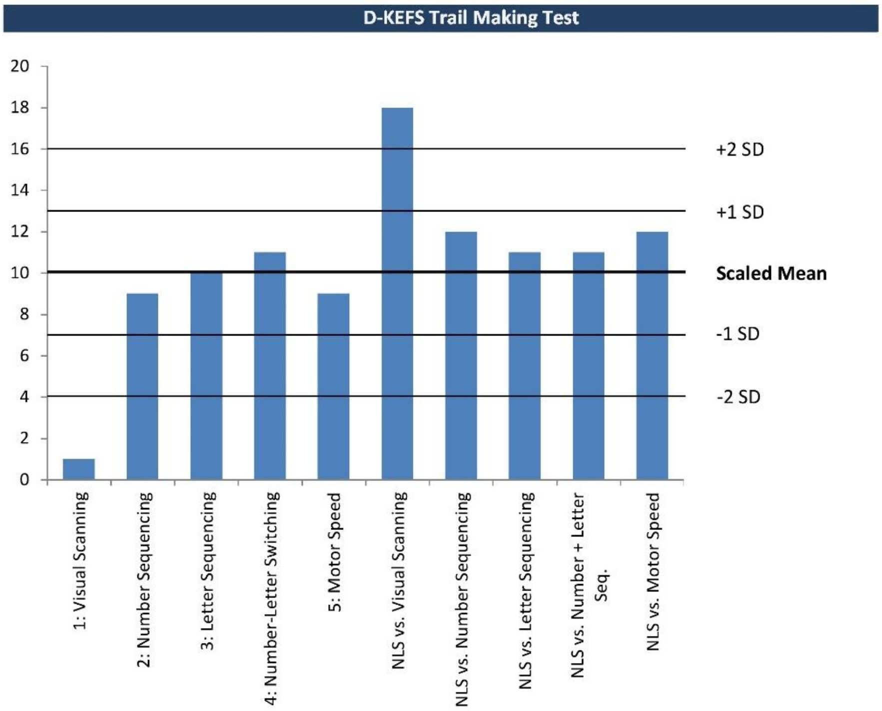
Emotion Regulation Questionnaire

The Emotion Regulation Questionnaire (ERQ) is designed to measure respondents' tendency to regulate their emotions in two ways: (1) Cognitive Reappraisal and (2) Expressive Suppression. Cognitive reappraisal is a form of cognitive change that involves construing a potentially emotion-eliciting situation in a way that changes its emotional impact. For example, during an admissions interview, one might view the give and take as an opportunity to find out how much one likes the school, rather than as a test of one's worth. Expressive suppression is a form of response modulation that involves inhibiting ongoing emotion-expressive behaviour (Gross, 1998). For example, one might keep a poker face while holding a great hand during a card game. Reappraisal is an antecedent-focused strategy: it occurs early, and intervenes before the emotion response tendencies have been fully generated. This means that reappraisal can thus efficiently alter the entire subsequent emotion trajectory. More specifically, when used to down-regulate negative emotion, reappraisal should successfully reduce the experiential and behavioural components of negative emotion. By contrast, suppression is a response-focused strategy: it comes relatively late in the emotion-generative process, and primarily modifies the behavioural aspect of the emotion response tendencies. Suppression should thus be effective in decreasing the behavioural expression of negative emotion, but might have the unintended side effect of also clamping down on the expression of positive emotion. At the same time, suppression will not be helpful in reducing the experience of negative emotion, which is not directly targeted by suppression and may thus continue to linger and accumulate unresolved. In addition, because suppression comes late in the emotion-generative process, it requires the individual to effortfully manage emotion response tendencies as they continually arise. These repeated efforts may consume cognitive resources that could otherwise be used for optimal performance in the social contexts in which the emotions arise. Moreover, suppression creates in the individual a sense of incongruence, or discrepancy, between inner experience and outer expression. This sense of not being true to oneself, of being inauthentic rather than honest with others, may well lead to negative feelings about the self and alienate the individual not only from the self but also from others.

Measure	Participant Score	Max Score
Cognitive Reappraisal	5.17	**7**
Expressive Suppression	4.75	**7**



Executive Function



D-KEFS Trail Making Test

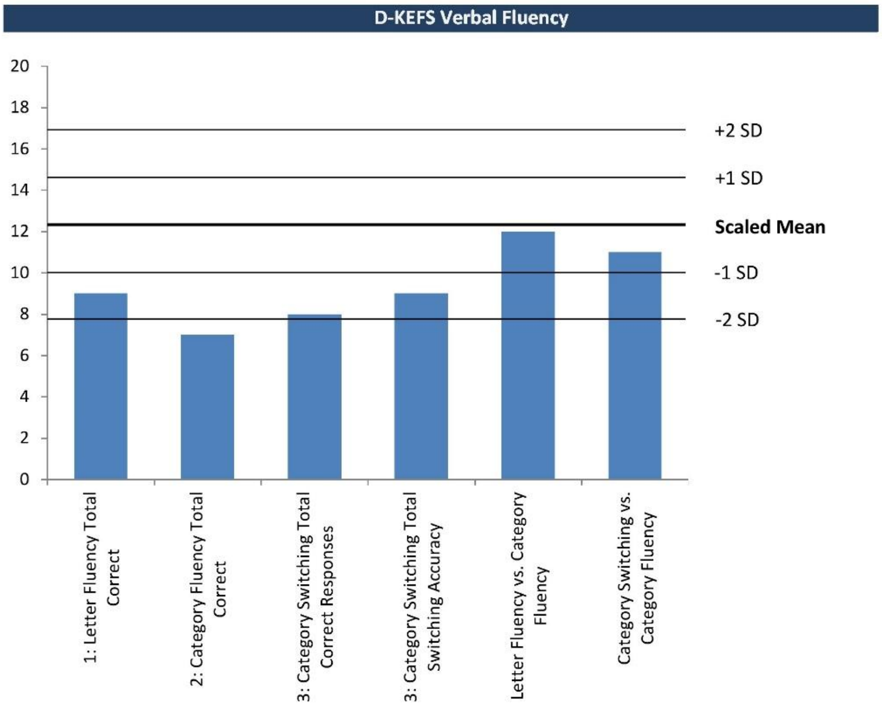
The primary executive function task is Condition 4: Number-Letter Switching, which assesses cognitive flexibility on a visual-motor sequencing task. The other four conditions allow the examiner to determine if a deficient score on the switching condition is related to a deficit in cognitive flexibility and/or to an impairment in one or more underlying skills.

D-KEFS Trail Making Test	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measures: Completion Times		
Condition 1: Visual Scanning	**57**	1
Condition 2: Number Sequencing	**51**	9
Condition 3: Letter Sequencing	**52**	10
Condition 4: Number-Letter Switching	**92**	11
Condition 5: Motor Speed	**48**	9
Primary Combined Measures: Completion Times		
Combined Number Sequencing + Letter Sequencing	**19**	10
Primary Contrast Measures: Completion Times		
Number-Letter Switching vs. Visual Scanning	**10**	18
Number-Letter Switching vs. Number Sequencing	**2**	12
Number-Letter Switching vs. Letter Sequencing	**1**	11
Number-Letter Switching vs. Combined Number + Letter Sequencing	**1**	11
Number-Letter Switching vs. Motor Speed	**2**	12

Executive Function

Optional Measures: Error Analysis		
Condition 1 - Visual Scanning: Omission Errors	**1**	17
Condition 1 - Visual Scanning: Commission Errors	**0**	100
Condition 2 - Number Sequencing: Sequencing Errors	**0**	100
Condition 2 - Number Sequencing: Set-Loss Errors	**0**	100
Condition 2 - Number Sequencing: Time-Discontinue Errors	**0**	100
Condition 3 - Letter Sequencing: Sequencing Errors	**0**	100
Condition 3 - Letter Sequencing: Set-Loss Errors	**0**	100
Condition 3 - Letter Sequencing: Time Discontinue Errors	**0**	100
Condition 4 - Number-Letter Switching: Sequencing Errors	**0**	100
Condition 4 - Number-Letter Switching: Set-Loss Errors	**0**	100
Condition 4 - Number-Letter Switching: Time-Discontinue Errors	**0**	100
Condition 4 - Number-Letter Switching: All Error Types	**0**	12
Condition 5 - Motor Speed: Time Discontinue Errors	**0**	100

Executive Function

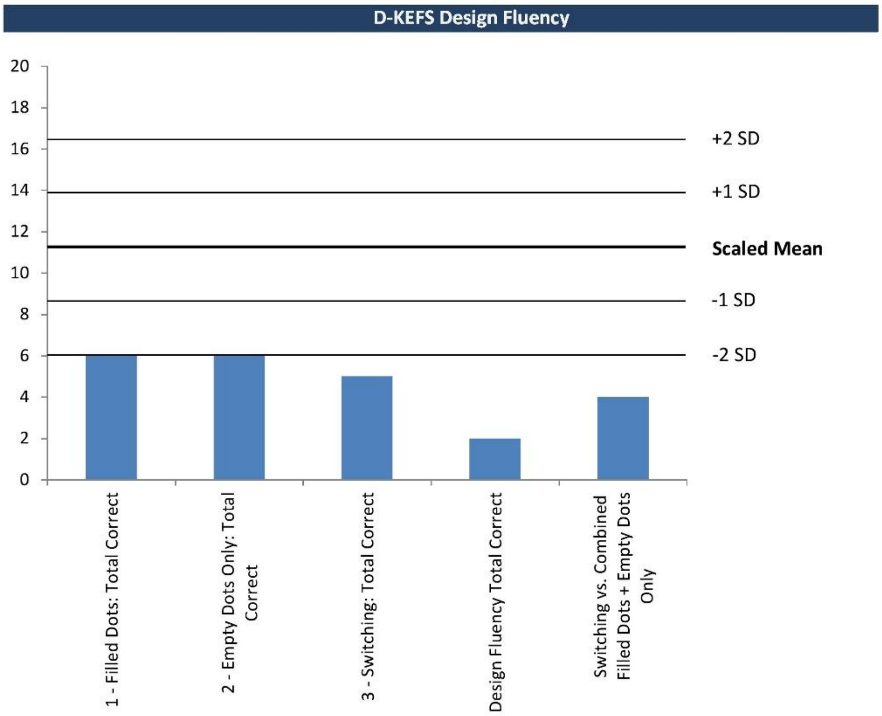


D-KEFS Verbal Fluency

This test measures the examinee's ability to generate words fluently in an effortful, phonemic format (Letter Fluency), from overlearned concepts (Category Fluency), and while simultaneously shifting between overlearned concepts (Category Switching).

D-KEFS Verbal Fluency	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measures		
Condition 1: Letter Fluency Total Correct	**31**	9
Condition 2: Category Fluency Total Correct	**27**	7
Condition 3: Category Switching Total Correct Responses	**11**	8
Condition 3: Category Switching Total Switching Accuracy	**10**	9
Primary Contrast Measures		
Contrast Measures: Letter Fluency vs. Category Fluency	**2**	12
Contrast Measures: Category Switching vs. Category Fluency	**1**	11
Optional Measures		
First Interval (0-15): Total Correct - Conditions 1-3	**35**	10
Second Interval (16-30): Total Correct - Conditions 1-3	**15**	7
Third Interval (31-45): Total Correct - Conditions 1-3	**13**	8
Fourth Interval (46-60): Total Correct - Conditions 1-3	**6**	6
Set-Loss Errors - Conditions 1-3	**0**	13
Repetition Errors - Conditions 1-3	**1**	12
Percent Set-Loss Errors - Conditions 1-3 (%)	**0.0**	13
Percent Repetition Errors - Conditions 1-3 (%)	**1.4**	12
Percent Swithcing Accuracy - Conditions 3 only (%)	**100**	12

Executive Function

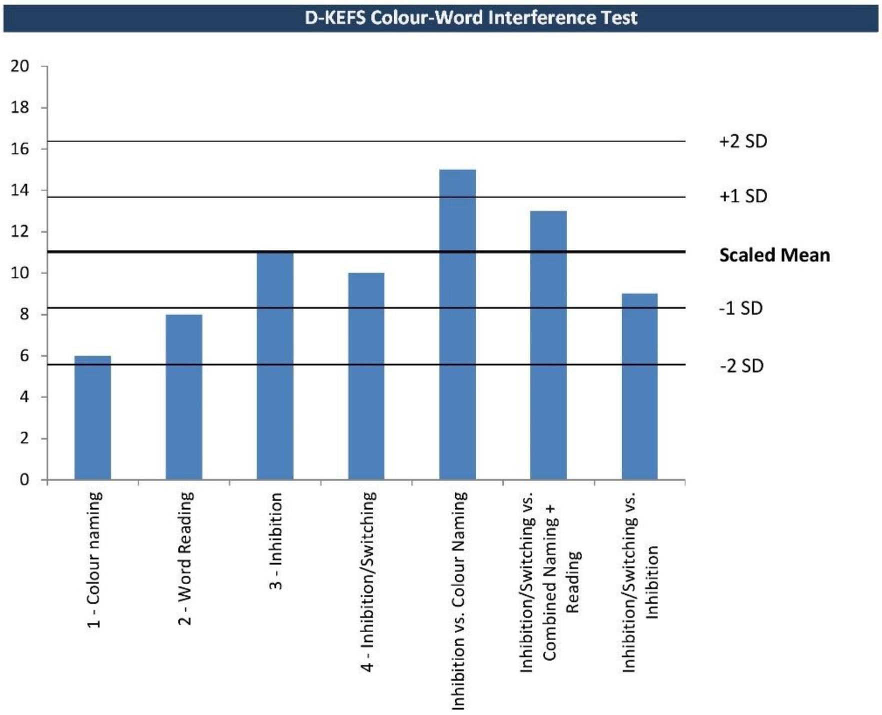


D-KEFS Design Fluency

This test assesses motor planning, cognitive flexibility, and fluency in generation of visual patterns, above and beyond contributions from motor speed. Condition 1 provides a basic test of design fluency, Condition 2 measures both design fluency and response inhibition, and Condition 3 measures both design fluency and cognitive flexibility.

D-KEFS Design Fluency	Score	Scaled Score
Primary Measures		(*M* =10, *SD* =3)
Condition 1 - Filled Dots: Total Correct	**4**	6
Condition 2 - Empty Dots Only: Total Correct	**4**	6
Condition 3 - Switching: Total Correct	**2**	5
Design Fluency Total Correct	**10**	2
Primary Combined Measures: Filled Dots + Empty Dots		
Condition 1 - Filled Dots: Scaled Score	**6**	
Condition 2 - Empty Dots Only: Scaled Score	**6**	
Sum of Scaled Scores	**12**	6
Primary Contrast Measures		
Switching vs. Combined Filled Dots + Empty Dots Only	**-7**	4
Optional Measures		
Total Set Loss Design	**1**	12
Total repeated Designs	**1**	13
Total Attempted Designs	**12**	4
Percent Design Accuracy	**83**	9

Executive Function



D-KEFS Colour-Word Interference Test

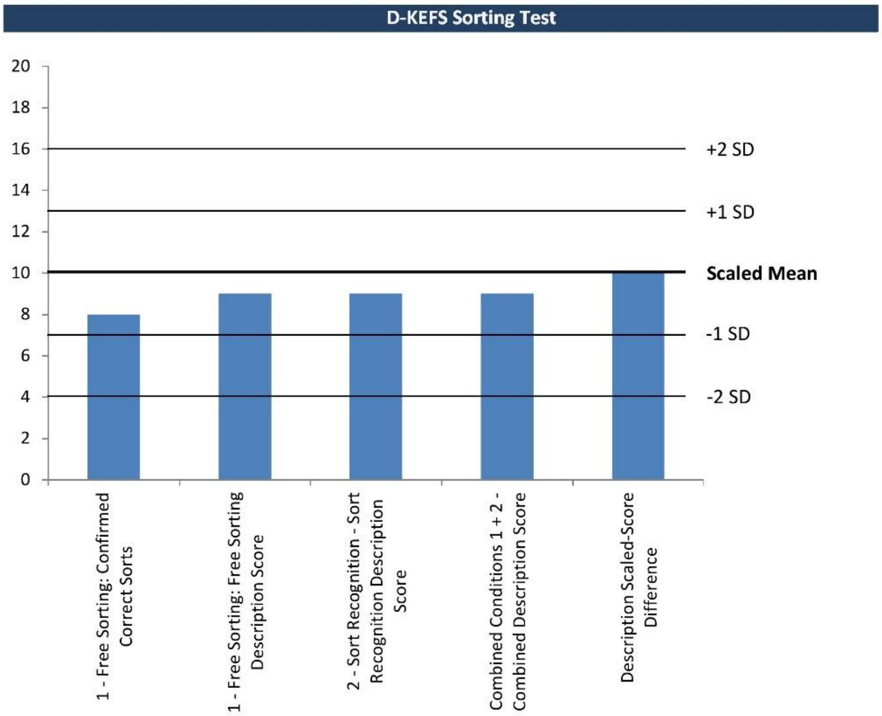
This test is based on the Stroop procedure. The primary executive functions measured are verbal inhibition, simultaneous processing, and cognitive flexibility. Condition 3: Inhibition is the traditional Stroop which measures verbal inhibition. Condition 4: Inhibition/Switching is a means of evaluating both inhibition and cognitive flexibility.

D-KEFS Colour-Word Interference Test	Score	Scaled Score (*M* =10, *SD* =3)
Primary Measures: Completion Times		
Condition 1 - Colour naming	**42**	6
Condition 2 - Word Reading	**29**	8
Condition 3 - Inhibition	**65**	11
Condition 4 - Inhibition/Switching	**75**	10
Primary Combined Measures: Completion Times		
Combined Naming + Reading	**14**	7
Primary Contrast Measures: Completion Times		
Inhibition vs. Colour Naming	**5**	15
Inhibition/Switching vs. Combined Naming + Reading	**3**	13
Inhibition/Switching vs. Inhibition	**-1**	9

Executive Function

Optional Contrast Measures: Completion Times		
Inhibition/Switching vs. Colour Naming	**4**	14
Inhibition /Switching vs. Word Reading	**2**	12
Optional Measures: Error Analysis		
Condition 1 - Colour naming: Total Errors	**0**	100
Condition 2 - Word Reading: Total Errors	**0**	100
Condition 3 - Inhibition: Corrected Errors	**0**	100
Condition 3 - Inhibition: Uncorrected Errors	**0**	100
Condition 3 - Inhibition: Total Errors	**0**	12
Condition 4 - Inhibition/Switching: Corrected Errors	**2**	10
Condition 4 - Inhibition/Switching: Uncorrected Errors	**0**	100
Condition 4 - Inhibition/Switching: Total Errors	**2**	10

Executive Function



D-KEFS Sorting Test

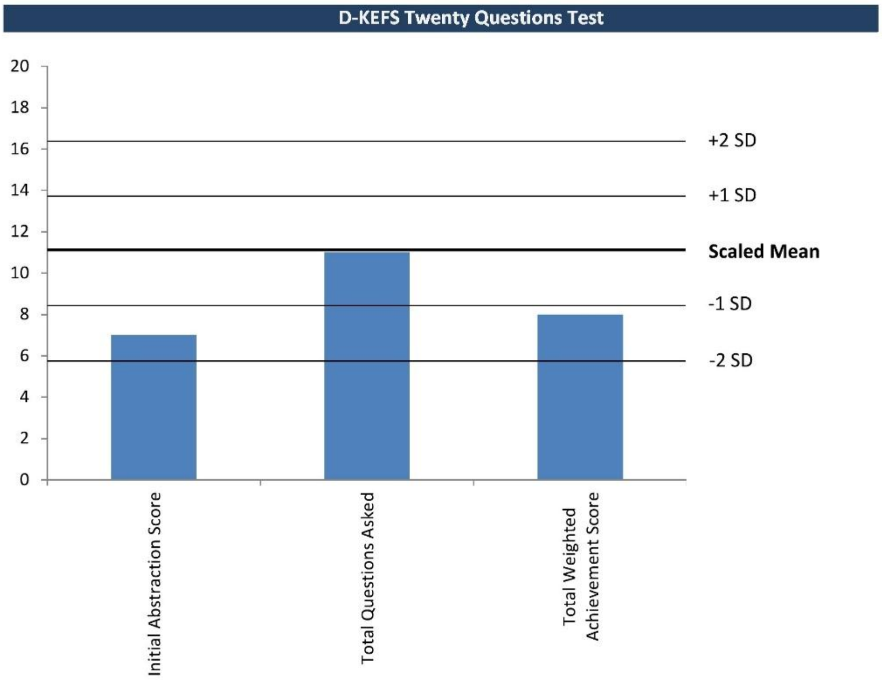
This test evaluates the examinee's abilities of problem solving and concept formation, while also tapping into the executive functions of initiation of problem-solving behaviourconcept formation skills, modality-specific probblem-solving skills (verbal versus nonverbal), creativity in forming responses, transfer of conceptual knowledge into goal-directed behavior, and the ability to inhibit previous responses in order to allow behavioural and cognitive flexibility.

D-KEFS Sorting Test Primary Measures	Score	Scaled Score (*M* =10, *SD* =3)
Condition 1 - Free Sorting: Confirmed Correct Sorts	**6**	8
Condition 1 - Free Sorting: Free Sorting Description Score	**24**	9
Condition 2 - Sort Recognition - Sort Recognition Description Score	**24**	9
Combined Conditions 1 + 2 - Combined Description Score	**18**	9
Contrast Measure: Sort recognition vs. Free Sorting		
Description Scaled-Score Difference	**0**	10

Executive Function

Optional Measures: Condition 1 - Free Sorting: Sorting Measures		
Confirmed Correct Sorts: Card Set 1	**3**	8
Confirmed Correct Sorts: Card Set 2	**3**	7
Confirmed Correct Verbal Sorts	**2**	7
Confirmed Correct Perceptual Sorts	**4**	9
Confirmed/Unconfirmed Target Sorts	**6**	7
Repeated Sorts	**0**	12
Set-Loss Sorts	**0**	100
Nontarget Even Sorts	**0**	100
Attempted Sorts	**6**	7
Percent Sorting Accuracy	**100**	13
Time-Per-Sort Ratio	**10.8**	12
Optional Measures: Condition 1 - Free Sorting: Description Measures		
Free Sorting Description Score: Card Set 1	**12**	9
Free Sorting Description Score: Card Set 2	**12**	9
Free Sorting Incorrect Descriptions	**0**	12
Free Sorting Repeated Descriptions	**0**	100
Percent Description Accuracy	**100**	14
Optional Measures: Condition 2 - Sort Recognition: Description Measures		
Sort Recognition Description Score: Card Set 1	**12**	9
Sort Recognition Description Score: Card Set 2	**12**	8
Sort Recognition Incorrect Descriptions	**0**	13
Sort Recognition Repeated Descriptions	**0**	100
Optional Measures: Combined Conditions 1 + 2: Description Measures		
Combined Description Score: Verbal Rules	**8**	3
Combined Description Score: Perceptual Rules	**16**	5
Combined No/Don't Know Responses	**40**	1
Combined Noncredit Descriptions	**0**	100
Combined Overly Abstract Descriptions	**0**	100
Combined Incorrect Descriptions	**25**	13
Combined Repeated Descriptions	**0**	100

Executive Function

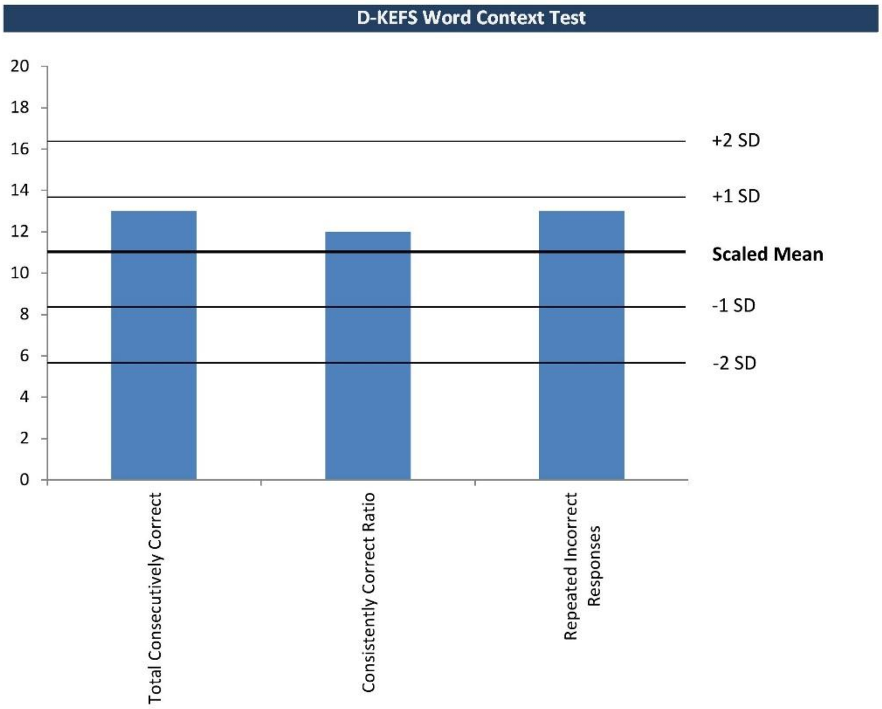


D-KEFS Twenty Questions Test

This test measures the examinee's logical thinking, hypothesis testing, and deduction, by assessing the ability to organise visual elements into categories and subcategories, formulate abstract questions, and incorporate the examiner's feedback.

D-KEFS Twenty Questions Test	Score	Scaled Score
Primary Measures		(*M* =10, *SD* =3)
Initial Abstraction Score	**12**	7
Total Questions Asked	**29**	11
Total Weighted Achievement Score	**11**	8
Optional Measures		
Spatial Questions	**0**	100
Repeated Questions	**0**	100
Set-Loss Questions	**0**	100

Executive Function

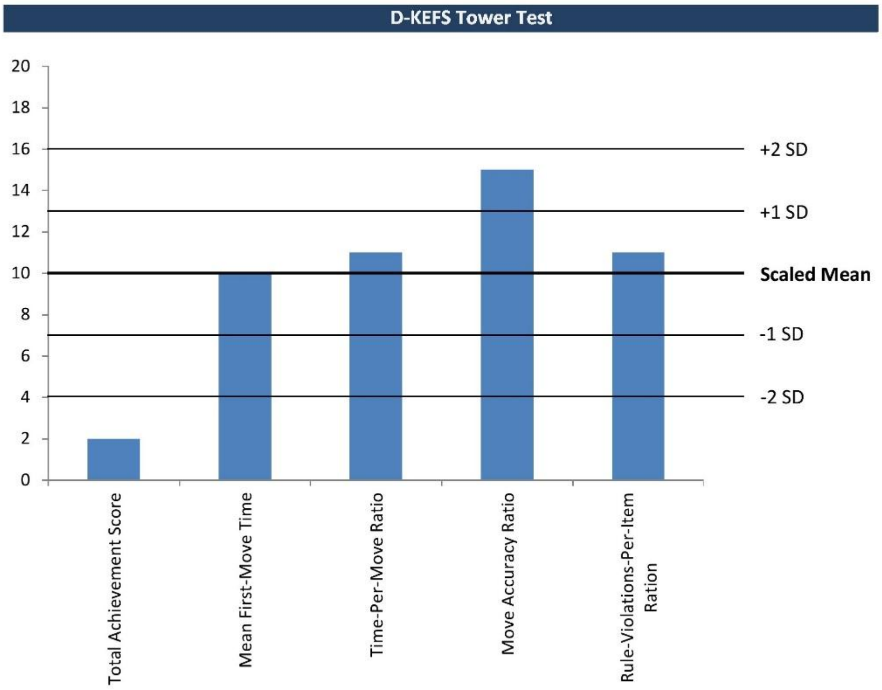


D-KEFS Word Context Test

This test is a means of evaluating executive functioning in the verbal modality and assessing such skills as deductive reasoning, integration of multiple bits of information, hypothesis testing, and flexibility of thinking.

D-KEFS Word Context Test	Score	Scaled Score
Primary Measure		(*M* =10, *SD* =3)
Total Consecutively Correct	**29**	13
Optional Measures		
Consistently Correct Ratio	**100**	12
Repeated Incorrect Responses	**3**	13
No/Don't Know Responses	**0**	100
Total Correct-To_Incorrect Errors	**0**	100

Executive Function

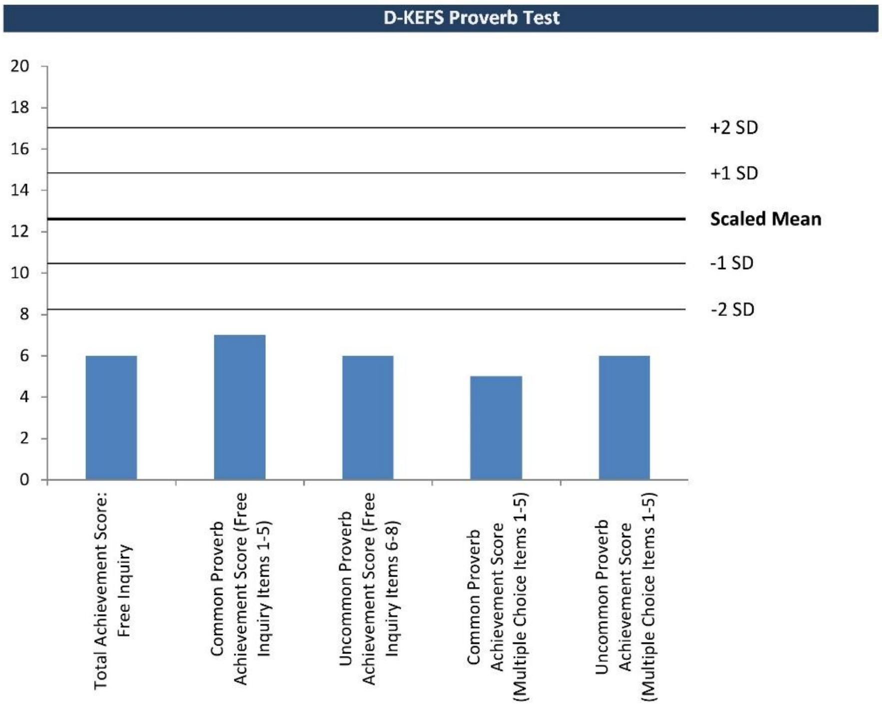


D-KEFS Tower Test

This test is a measure of visual attention, spatial planning, rule learning, inhibition of impulsive and perseverative responding, and the ability to establish and maintain a cognitive (instructional) set.

D-KEFS Tower Test	Score	Scaled Score
Primary Measure		(*M* =10, *SD* =3)
Total Achievement Score	**3**	2
Optional Measures		
Mean First-Move Time	**5.8**	10
Time-Per-Move Ratio	**3.4**	11
Move Accuracy Ratio	**0.5**	15
Total Rule Violation	**0**	100
Rule-Violations-Per-Item Ration	**0.0**	11

Executive Function



D-KEFS Proverb Test

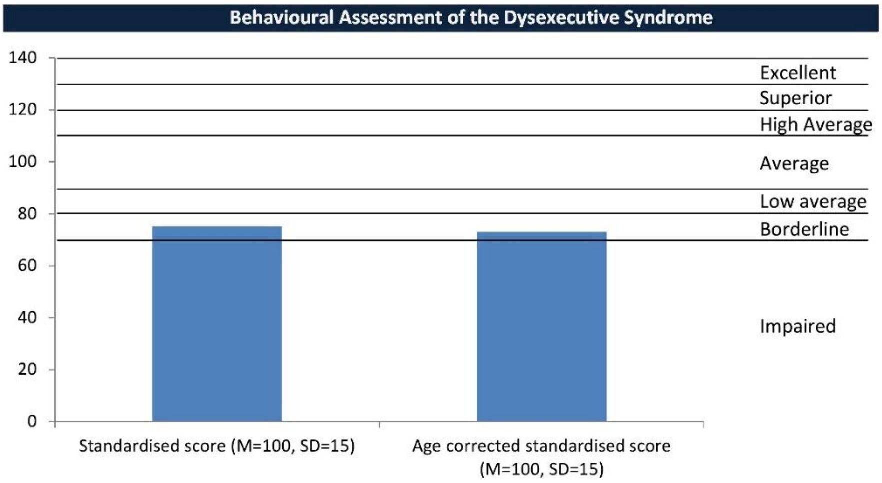
This test assesses the examinee's ability to interpret brief, concrete phrases that convey deeper, abstract meaning. The test requires higher level executive functions of verbal abstract thinking, semantic integration of the individual words into coherent, abstract principles or concepts, and generalisation to many situations beyond the concrete, literal interpretation.

D-KEFS Proverb Test	Score	Scaled Score
Primary Measure		(*M* =10, *SD* =3)
Total Achievement Score: Free Inquiry	**13**	6
Total Achievement Score: Multiple Choice	**28**	28
Optional Measures: Free Inquiry		
Common Proverb Achievement Score (Free Inquiry Items 1-5)	**12**	7
Uncommon Proverb Achievement Score (Free Inquiry Items 6-8)	**1**	6
Accuracy Only Score	**5**	5
Abstraction Only Score	**8**	6
No/Don't Know Responses	**1**	25
Repeated Responses	**0**	100

Executive Function

Optional Measures: Multiple Choice		
Common Proverb Achievement Score (Multiple Choice Items 1-5)	**20**	100
Uncommon Proverb Achievement Score (Multiple Choice Items 1-5)	**8**	30
Total Correct Abstract Choices	**7**	55
Total Correct Concrete Choices	**0**	1
Total Incorrect Phonemic Choices	**1**	25
Total Incorrect Unrelated Choices	**0**	100
Total Incorrect Phonemic + Unrelated Choices	**1**	28

Executive Function

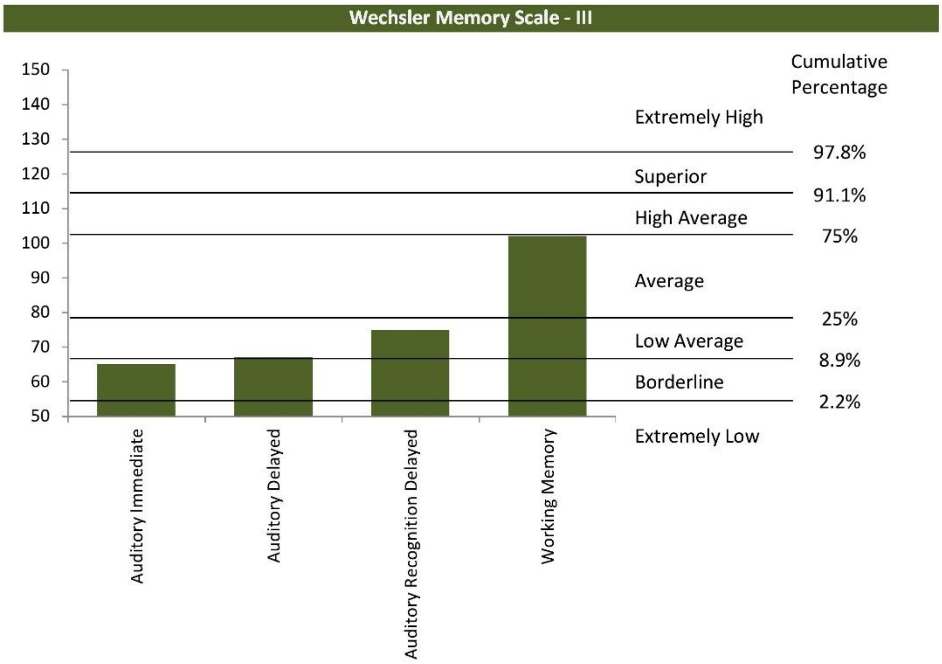


Behavioural Assessment of the Dysexecutive Syndrome

The BADS is a battery of six tests which require participants to plan, initiate, monitor and adjust behaviour in response to the explicit and implicit demands of a series of tasks. (1) Rule Shift Cards (RS) – This test purports to identify perseverative tendencies and its obverse, mental flexibility (perseveration refers to a difficulty in adjusting behaviour to meet the demands of a changing situation). (2) Action Programme (AP) – This test assesses the ability to devise and implement a solution to a practical problem (getting a cork out of a narrow plastic tube) while not contravening a set of rules. (3) Key Search (KS) – was influenced by one of the task in the Stanford-Binet Intelligence Scale, and it assesses ability to plan a strategy to solve a problem (finding a key lost in a field). (4) Temporal Judgement (TJ) – This test involves judgement and abstract thinking based on common knowledge, as the respondent is required to estimate times for everyday events. (5) Zoo Map (ZM) – This is a test to assess the ability to formulate and implement a plan while following a instructional set (spontaneous planning ability) and to follow a preformulated plan while observing the original set of instructions. (6) Modified Six Elements (6E) – This test assesses the ability to time-manage, while making demands on the examinee's ability to plan, organise and monitor behaviour, and also to remember to carry out an intention at a future time (prospective memory). It involves dividing the available time between a number of simple tasks (picture naming, arithmetic and dictation) while not contravening a set of rules.

Behavioural Assessment of the Dysexecutive Syndrome	Score	Max Score
Test 1: Rule shift cards	**4**	4
Test 2: Action program	**4**	4
Test 3: Key search	**1**	4
Test 4: Temporal judgement	**1**	4
Test 5: Zoo map	**2**	4
Test 6: Modified six elements	**1**	4
Total profile score	**13**	**24**
Standardised score (*M* =100, *SD* =15)	**75**	**140**
Age corrected standardised score (*M* =100, *SD* =15)	**73**	**140**

Memory



Wechsler Memory Scale - III				
Primary Indexes	Index Scores	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Auditory Immediate	65	1	60	74
Auditory Delayed	67	1	62	81
Auditory Recognition Delayed	75	5	70	93
Working Memory	102	55	92	111

Description of Indexes

Auditory Immediate: Indicates the examinee's ability to remember information immediately after it is orally presented. Scores from Logical Memory I and verbal Paired Associates I contribute to this index.

Auditory Delayed: Indicates the examinee's ability to remember orally presented information after a 25-30 minute delay. Scores from Logical Memory II and Verbal Paired Associates II contribute to this index.

Auditory Recognition Delayed: Indicates the examinee's ability to remember (via recognition) auditory information after 25-35 minute delay. Recognition scores from Logical Memory II and Verbal Paired Associates II contribute to this index.

Working Memory: Indicates the examinee's capacity to remember and manipulate both visually and orally presented information in short-term memory storage. Scores from Spatial Span and Letter-Number Seqeuncing contribute to this index.

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Memory

Wechsler Memory Scale - III					
Primary Index Differences	Scor 1	Score 2	Difference	Stat. Sig. 0.05 Level	Freq. of Diff.
Auditory Immediate - Auditory Delayed	65	67	-2	13.8	82.7
Auditory Delayed - Auditory Recognition Delayed	67	75	-8	19.7	51.7

Memory

Wechsler Memory Scale - III		
Auditory Process Composite Scores	Sum of Scaled Scores	Percentiles
Single-Trial Learning	13	5
Learning Slope	9	1
Retention	8	1
Retrieval	1	1

Description of Auditory Process Composite Scores

Single-Trial Learning: Indicates the examinee's capacity to immediately recall auditory information after a single exposure to the material to be remembered.

Learning Slope: Describes the examinee's ability to acquire new auditory information after repeated exposures. This index is a measure of the relative increase in recall performance from first trial to last trial.

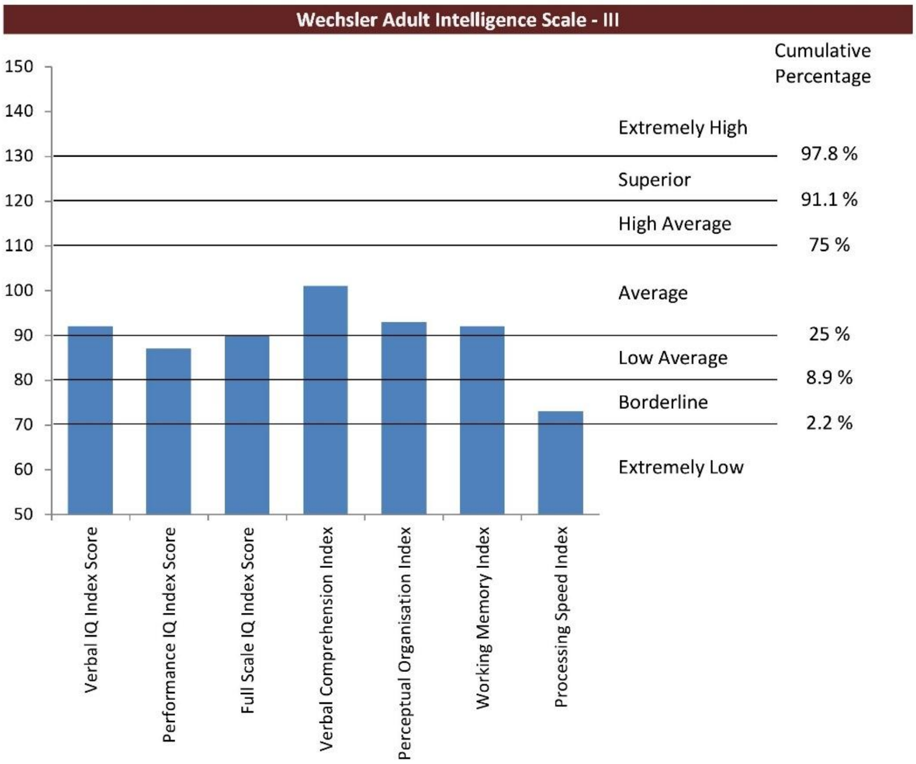
Retention: Indicates the examinee's delayed recall capacity as a function of immediate recall performance over a 25-35 minute delay. Scores are calculated as a percent retention score (i.e., delayed recall divided by immediate recall; the quotient is multiplied by 100).

Retrival: This index contrasts memory retrieval for recall versus recognition memory and is computed by subtracting delayed recall scores from recognition scores.

Memory

Wechsler Memory Scale - III							
Ability - Memory Indexes	WAIS-III FSIQ Score	Memory Index Predicted	Memory Index Actual	Diff. Score	Stat. Sig. 0.05 Level	Sig.	Freq. of Diff.
Auditory Immediate	90	94	65	29	16.9	s	< 1%
Auditory Delayed	90	94	67	27	13.8	s	2%
Auditory Recognition Delayed	90	95	75	20	10.7	s	5-10%
Working Memory	90	93	102	-9	13.5		20%

Intelligence



Wechsler Adult Intelligence Scale - III	IQ / Index Score	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Verbal IQ Index Score	92	30	87	97
Performance IQ Index Score	87	19	81	95
Full Scale IQ Index Score	90	25	86	94
Verbal Comprehension Index	101	53	95	107
Perceptual Organisation Index	93	32	86	101
Working Memory Index	92	30	86	99
Processing Speed Index	73	4	67	85

Intelligence

Wechsler Adult Intelligence Scale - III							
Subtests	Scaled Score	Mean Score	Difference from Mean	Stat. Sig. 0.05 Level	Strength (+)	Weakness (-)	Freq. of Diff.
Vocabulary	11	8.54	2.46	2.3	s		< 25%
Similarities	10	8.54	1.46	3.12			
Arithmetic	8	8.54	-0.54	2.95			
Digit Span	7	8.54	-1.54	2.67			
Information	10	8.54	1.46	2.59			
Comprehension	7	8.54	-1.54	3.35			
Letter-Number Sequencing	11	8.54	2.46	3.6			
Picture Completion	12	8.54	3.46	3.46	s		< 25%
Digit-Symbol (Coding)	4	8.54	-4.54	3.31		w	< 10%
Block Design	4	8.54	-4.54	3.19		w	< 10%
Matrix Reasoning	11	8.54	2.46	2.75			
Picture Arrangement	10	8.54	1.46	4.19			
Symbol Search	6	8.54	-2.54	3.93			

Verbal IQ:

The verbal IQ is derived from scores on seven of the subtests: information, digit span, vocabulary, arithmetic, comprehension, similarities, and letter-number sequencing.

The information subtest is a test of general knowledge, including questions about geography and literature. The digit span subtest requires test takers to repeat strings of digits. The vocabulary and arithmetic subtests are general measures of a person's vocabulary and arithmetic skills. The comprehension subtest requires test takers to solve practical problems and explain the meaning of proverbs. The similarities subtest requires test takers to indicate the similarities between pairs of things. The letter-number sequencing subtest involves ordering numbers and letters presented in an unordered sequence. Scores on the verbal subtests are based primarily on correct answers.

Performance IQ:

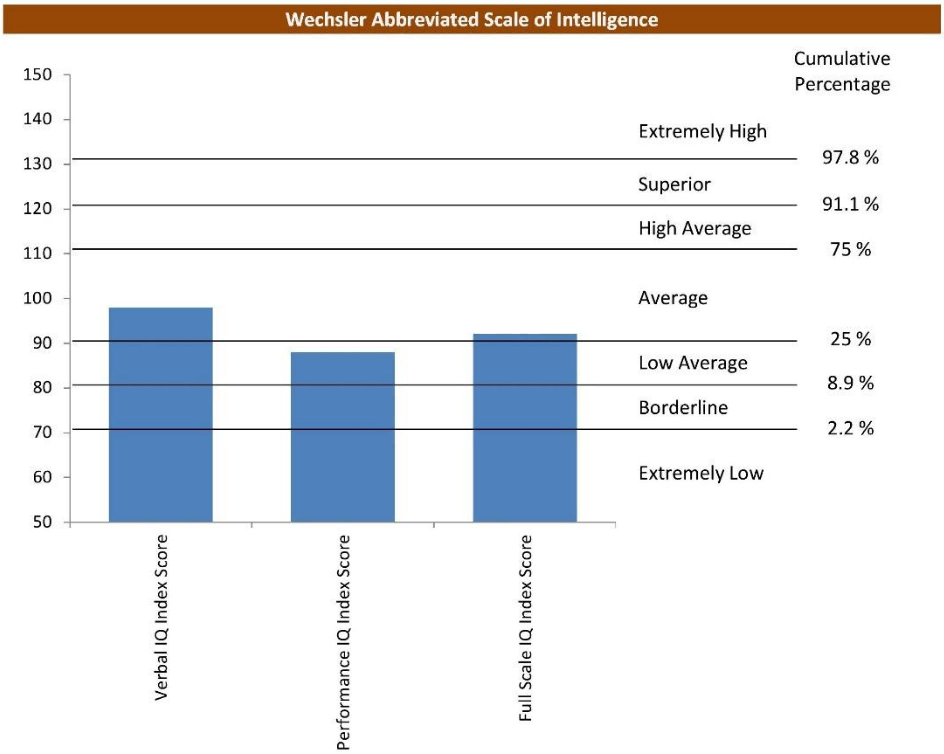
The performance IQ is derived from scores on the picture completion, picture arrangement, block design, digit symbol, matrix reasoning, and symbol search.

In the picture completion subtest, the test taker is required to complete pictures with missing elements. The picture arrangement subtest entails arranging pictures in order to tell a story. The block design subtest requires test takers to use blocks to make specific designs. In the digit symbol subtest, digits and symbols are presented as pairs and test takers then must pair additional digits and symbols. The matrix reasoning subtest requires test takers to identify geometric shapes. The symbol search subtest requires examinees to match symbols appearing in different groups. Scores on the performance subtests are based on both response speed and correct answers.

Intelligence

Wechsler Adult Intelligence Scale - III					
Discrepancy Comparisons	Score 1	Score 2	Difference	Stat. Sig. 0.05 Level	Freq. Of Diff.
Verbal IQ - Performance IQ	92	87	5	7.9	66.4
Verbal Comprehens. - Perceptual Organisation	101	93	8	8.4	52.8
Verbal Comprehension - Working Memory	101	92	9	9.08	47.7
Perceptual Organisation - Processing Speed	93	73	20	11.53	16.2
Verbal Comprehension - Processing Speed	101	73	28	10.91	6
Perceptual Organisation - Working Memory	93	92	1	9.81	87.1
Working memory - Processing Speed	92	73	19	11.93	18.9

Intelligence



Wechsler Abbreviated Scale of Intelligence				
	IQ / Index Score	Percentiles	Lower bound 95%CI	Upper bound 95%CI
Verbal IQ Index Score	98	45	92	104
Performance IQ Index Score	88	21	83	94
Full Scale IQ Index Score	92	30	88	96

Appendix N. Matlab code for the figures illustrating the simulation of the indices of affective specificity and accuracy

Specificity *Within* Discrete *Negative* Emotions

```
clear all;

n=0.1;
while n<10;
    x1=0:0.1:n;
    y1=n:0.1:10;

    [a1,b1]=meshgrid(x1,y1);
    z1=((a1+0.125).*(b1+0.125)).^(1/2)-0.125;

    mesh(x1,y1,z1,...
        'FaceColor','cyan',...
        'FaceAlpha',0.5,...
        'EdgeColor','black')

    set(gca,'XTick',0:2:10)
    set(gca,'YTick',0:2:10)
    set(gca,'ZTick',0:2:10)

    view([-35 15]); % view 1
% view([235 15]); % view 2
% view([-10 10]); % view 3
% view([275 10]); % view 4

    hold on
    n=n+0.1;
end
```

Accuracy *Within* Discrete *Negative* Emotions

```
clear all;

[x,y]=meshgrid(linspace(-10,10,101));
z=((((10+x)./2).*((10+y)./2)).^(1./2)-5).*2;
mesh(x,y,z,...
    'FaceColor','cyan',...
    'FaceAlpha',0.5,...
    'EdgeColor','black')

hold on

t=linspace(-10,10,101);
X1=0*t;
Y1=t;
Z1=((((10+t)./2).*((10)./2)).^(1./2)-5).*2;

X2=t;
Y2=0*t;
Z2=((((10+t)./2).*((10)./2)).^(1./2)-5).*2;

plot3(X1,Y1,Z1,'LineWidth',2)
plot3(X2,Y2,Z2,'LineWidth',2)

view([-35 15]); % view 1
% view([235 15]); % view 2
% view([-10 10]); % view 3
% view([275 10]); % view 4
```

Specificity *Between* Discrete *Positive and Negative* Emotions

```
clear all;

% 1: Delta(b2) = 0.1

x1=0:0.1:0.1;
y1=0.1:0.1:10;

[a1,b1]=meshgrid(x1,y1);
z1=(((0.1+0.0102907187508).*(a1+0.0102907187508).*(b1+0.0102907187508)
).^(1/3))-0.0102907187508;

mesh(x1,y1,z1,...
   'FaceColor','red',...
   'FaceAlpha',0.5,...
   'EdgeColor','black')

set(gca,'XTick',0:2:10)
set(gca,'YTick',0:2:10)
set(gca,'ZTick',0:2:10)

view([-35 15]); % view 1
% view([235 15]); % view 2
% view([-10 10]); % view 3
% view([275 10]); % view 4

hold on

% 2: Delta(b2) = 2.5

x2=0:0.1:2.5;
y2=2.5:0.1:10;

[a2,b2]=meshgrid(x2,y2);
z2=(((2.5+0.0102907187508).*(a2+0.0102907187508).*(b2+0.0102907187508)
).^(1/3))-0.0102907187508;

mesh(x2,y2,z2,...
   'FaceColor','green',...
   'FaceAlpha',0.5,...
   'EdgeColor','black')

hold on

% 3: Delta(b2) = 5

x3=0:0.1:5;
y3=5:0.1:10;
```

(continued on the next page)

```
[a3,b3]=meshgrid(x3,y3);
z3=(((5+0.0102907187508).*(a3+0.0102907187508).*(b3+0.0102907187508)).
^(1/3))-0.0102907187508;

mesh(x3,y3,z3,...
   'FaceColor','yellow',...
   'FaceAlpha',0.5,...
   'EdgeColor','black')

hold on

% 4: Delta(b2) = 7.5

x4=0:0.1:7.5;
y4=7.5:0.1:10;

[a4,b4]=meshgrid(x4,y4);
z4=(((7.5+0.0102907187508).*(a4+0.0102907187508).*(b4+0.0102907187508)
).^(1/3))-0.0102907187508;

mesh(x4,y4,z4,...
   'FaceColor','cyan',...
   'FaceAlpha',0.5,...
   'EdgeColor','black')

hold on

% 5: Delta(b2) = 9.9

x5=0:0.1:9.9;
y5=9.9:0.1:10;

[a5,b5]=meshgrid(x5,y5);
z5=(((9.9+0.0102907187508).*(a5+0.0102907187508).*(b5+0.0102907187508)
).^(1/3))-0.0102907187508;

mesh(x5,y5,z5,...
   'FaceColor','blue',...
   'FaceAlpha',0.5,...
   'EdgeColor','black')

hold on
```

Accuracy *Between* Discrete *Positive and Negative* Emotions

```
clear all;

% 1: Delta(b2) = -9.9

x1=-10:0.5:10;
y1=-10:0.5:10;

[a1,b1]=meshgrid(x1,y1);
z1=((((((10-9.9)/2)*((a1+10)/2).*((b1+10)/2)).^(1/3))-5)*2);

mesh(x1,y1,z1,...
   'FaceColor','red',...
   'FaceAlpha',1,...
   'EdgeColor','black')

set(gca,'XTick',-10:5:10)
set(gca,'YTick',-10:5:10)
set(gca,'ZTick',-10:5:10)

view([235 15]); % view 1
% view([145 15]); % view 2
% view([55 15]); % view 3
% view([-35 15]); % view 4

hold on

% 2: Delta(b2) = -5

x2=-10:0.5:10;
y2=-10:0.5:10;

[a2,b2]=meshgrid(x2,y2);
z2=((((((10-5)/2)*((a1+10)./2).*((b1+10)./2)).^(1/3))-5).*2);

mesh(x2,y2,z2,...
   'FaceColor','green',...
   'FaceAlpha',0.8,...
   'EdgeColor','black')

hold on

% 3: Delta(b2) = 0

x3=-10:0.5:10;
y3=-10:0.5:10;

[a3,b3]=meshgrid(x3,y3);
z3=((((5*((a1+10)./2).*((b1+10)./2)).^(1/3))-5).*2);
```

(continued on the next page)

```
mesh(x3,y3,z3,...
    'FaceColor','yellow',...
    'FaceAlpha',0.4,...
    'EdgeColor','black')

hold on

% 4: Delta(b2) = 5

x4=-10:0.5:10;
y4=-10:0.5:10;

[a4,b4]=meshgrid(x4,y4);
z4=((((((10+5)/2)*((a1+10)./2).*((b1+10)./2)).^(1/3))-5).*2);

mesh(x4,y4,z4,...
    'FaceColor','cyan',...
    'FaceAlpha',0.2,...
    'EdgeColor','black')

hold on

% 5: Delta(b2) = 9.9

x5=-10:0.5:10;
y5=-10:0.5:10;

[a5,b5]=meshgrid(x5,y5);
z5=((((((10+9.9)/2)*((a1+10)./2).*((b1+10)./2)).^(1/3))-5).*2);

mesh(x5,y5,z5,...
    'FaceColor','blue',...
    'FaceAlpha',0.1,...
    'EdgeColor','black')

hold on
```