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Running Head: RE-EXPERIENCE OF DISCRETE EMOTIONS IN AMNESIA

Preserved re-experience of discrete emotions: amnesia and executive function

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Abstract

Amnesic patients can re-experience emotions elicited by forgotten events, suggesting that brain systems for episodic and emotional memory are independent. However, the range of such emotional memories remains under-investigated (most studies employing just positive-negative emotion dyads), and executive function may also play a role in the re-experience of emotions. This is the first investigation of the intensity of the emotional re-experience of a range of discrete emotions (*anger*, *fear*, *sadness*, and *happiness*) for a group of amnesic patients. Twenty Korsakoff syndrome (KS) patients and 20 neurologically normal controls listened to four novel emotional vignettes selectively eliciting the four basic emotions. Emotional experience was measured using pen-and-paper Visual Analogue Mood Scales and episodic memory using verbal recollections. After 30 minutes, the recollection of stories was severely impaired for the patient group, but the emotional re-experience was no different from that of controls. Notably, there was no relationship between episodic recall and the intensity of the four emotions, such that even profoundly amnesic patients reported moderate levels of the target emotion. Exploratory analyses revealed negative correlations between the intensity of basic emotions and executive functions (e.g., cognitive flexibility and response inhibition) for controls but not patients. The results suggest that discrete emotions can be re-experienced independently of episodic memory, and that the re-experience of certain discrete emotions appears to be dampened by executive control. KS patients with absent or mild cognitive symptoms should benefit from emotion-regulation interventions aimed at reducing the recognised affective burden associated with their episodic memory deficit.

Keywords: emotional memory; episodic memory; amnesia; Korsakoff syndrome; executive function; discrete emotions

Past emotions have long been shown to be encoded and accurately retrieved in the absence of an episodic memory trace of the eliciting event. The famous early report of Swiss neurologist Édouard Claparède describes an amnesic Korsakoff's syndrome patient avoiding his handshake after being pricked with a hidden pin (Claparède, 1911/1951). More recent studies have found that even densely amnesic patients show an improved recognition of emotional stimuli, of roughly the same magnitude as controls (Hamann, Cahill, McGaugh, & Squire, 1997), and possess the same ability to access past emotional experiences and to employ them in guiding present decisions (Turnbull & Evans, 2006). The dissociation between the roles of the amygdala and hippocampus (Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995; see also Phelps, 2004), have offered insight into the neural mechanisms behind the preserved ability of amnesic patients to accurately re-experience past emotions. We use the term "emotional re-experience" as a generic reference to instances of emotional conditioning (e.g., Bechara et al., 1995). This can happen when an emotion is first experienced following an emotional event and then re-experienced when the event is merely cued or prompted, but in the absence of any actual emotional stimuli or their explicit recollection. Notably, this emotional conditioning (re-experience) can take place following both direct affective experiences, such as, after a loud noise, or an emotional image/clip (Bechara et al., 1995) or as a result of an instructed episodic representation of an event of emotional significance (Phelps, 2004).

A large body of psychological evidence has proposed that cognition can influence and be influenced by emotions (Bower, 1992). 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).

Executive functions play a role in moderating emotional responses and behavioural actions (Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012). Executive control is often reported to influence the processing and experience of emotions in both the absence of emotion disorders (Cohen, Henik, & Moyal, 2012), as well as in a range of psychiatric patients (Etkin, Prater, Hoeft, Menon, & Schatzberg, 2010). Furthermore, neuroimaging evidence showed that emotion regulation and re-experience are strictly linked with brain regions involved in executive function (Cohen, Henik, & Mor, 2011; Kim & Hamman, 2007). 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). Thus, executive function and episodic recall are closely linked with emotional re-experience, but the influences they exert on specific forms of affect remain unclear. This is unsurprising given that the definition and classification of emotions is the subject of a long-lasting and ongoing debate in the literature (Russell & Feldman Barrett, 1999).

Not all emotional experiences are the same, and negative emotions have been suggested to possess a special property of being more stable than happiness, in the absence of episodic memory. For example, *sadness* was reported to be more enduring for amnesic patients than controls, while *happiness* might not be any different (Feinstein, Duff, & Tranel, 2010). Such a dissociation would not be surprising, since positive and negative emotions appear to be affected by different classes of bias (Levine, Lench, & Safer, 2009) and by different emotion regulation processes (Kim & Hamann, 2007). However, a growing body of evidence argues that not only *generic* positive and negative emotions, but *discrete* basic emotions (e.g., *anger*,

fear, *sadness*, *happiness*) may differ in the way they are re-experienced. Discrete emotions have 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 (Stephens, Christie, & Friedman, 2010), and to elicit specific changes in cognition, judgment, and behaviour (Lench, Flores, & Bench, 2011). A definitive conclusion on the differences between the re-experience of discrete emotions is far from close (Lench et al., 2011), but the relationship between emotional re-experience and closely related cognitive function (e.g., episodic memory and executive functions) provides new opportunities to identify the differences in the re-experience of discrete emotions.

However, the explicit influence of cognitive processes on the re-experience of discrete emotions has not been directly investigated for a comprehensive *range* of emotions. Thus, two questions of interest were addressed presently: (1) can all classes of discrete emotions be re-experienced equally in the absence of episodic recall, over a sustained period of time (30 minutes); and (2) what cognitive functions can predict the intensity of the re-experience of discrete basic emotions (with the most likely options being episodic recall and executive functions)? This is the first investigation of 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. Firstly, the relationship between the episodic recall and the experience of each discrete emotion after 30 minutes was assessed. Secondly, the relationship between the intensity of the emotional re-experience of *anger*, *fear*, *sadness*, and *happiness after 30 minutes*, and executive function abilities was also investigated.

Method

Participants

Twenty Korsakoff's syndrome (KS) patients were recruited from the local health board in Wales (*N*=6), and from a residential care home in England (*N*=14). North Wales patients had been diagnosed with Korsakoff's syndrome by the collaborating Consultant Neurologist and were living at home or in residential care units. England patients had been diagnosed at an outside clinic and were living in the residential care home from where they were recruited. The inclusion criteria (i.e., the clinical diagnosis and general eligibility) were assessed by the referring clinician from the patients' medical notes (i.e., the collaborating Consultant Neurologist for the Wales patients, and the clinical staff at the residential care home for the England patients). These included a documented history of acute Wernicke's encephalopathy, a lasting anterograde amnesia not related to progressive dementia, and no evidence of other neurological disease (e.g., history of hypoxia, traumatic brain injury, and any relevant examination or neuroimaging findings) that could account for amnesia. In four of the six patients from Wales, the diagnosis was also confirmed with high-resolution magnetic resonance imaging (MRI) scans showing atrophy of the mammillary bodies or lesions in the medial thalamus on T1-weighted images. Patients were excluded if they lacked capacity to give consent, had major psychiatric disorders (e.g., delirium, schizophrenia, schizoaffective disorder, unipolar depressive disorder, bipolar affective disorder, etc.), severe language impairments (expressive/receptive/conduction or transcortical sensory/motor aphasias or anomia, affecting comprehension, production or repetition), or English fluency below native speaker level. Episodic memory and general cognitive functioning (including separate verbal and procedural components) were also assessed and are reported in this study.

Twenty neurologically normal control (NC) participants were selected from the local community participant panel. All patients provided written informed consent at the beginning of each of the four experimental sessions and continued verbal consent throughout each session. All participants completed all four sessions of the study in return for the usual participant payment (£10/hour).

Basic demographics and neuropsychological assessment data for both groups (see Table 1) showed that Korsakoff patients were younger, but had fewer years of education than controls. Their episodic memory tested via the auditory modality was significantly impaired (Cohen's d >3.50), but not their working memory. The scores on the Mini-mental Scale Examination were also in the non-clinical range for both groups. And although the raw performance of the Korsakoff patients on the Trail Making Test was deficient compared to controls, the contrast scores were non-significant, revealing that their deficit may be explained by the visual and perhaps motor symptoms associated with their deficit, rather than a substantial cognitive decline (i.e., dementia). The patients' scores on the adult intelligence test reinforced this argument, showing no difference in verbal IQ, and verbal comprehension, but inferior scores on performance IQ and processing speed.

------------------------------------Insert Table 1--

Stimuli and Measures

Four emotional vignettes were used to elicit discretely *anger*, *fear*, *sadness*, and *happiness* respectively (i.e., at higher intensity levels than all other non-target emotions). A propositional analysis (Kintsch, 1994; Kintsch & van Dijk, 1978) was performed on all vignettes and each propositional unit was treated as a discrete recall unit. A detailed description

of the protocol was reported by Turner and Greene (1977). Each story had 60 recall units, whose complete recollection was used to calculate the recall accuracy. 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 from the Visual Analogue Mood Scales (VAMS; Stern, 1997), presented in random order. The questionnaire displays a single vertical analogue scale per page, corresponding to one discrete emotion, and anchored at both ends by schematic faces and label words (i.e., Neutral, Angry, Afraid, Happy, or Sad). The neutral expression is always at the top of the scale, and the target emotion at the bottom. VAMS have been devised specifically for neurologically and cognitively impaired patients, and have been validated successfully (Arruda, Stern, Somerville, 1999; Nyenhuis, Yamamoto, Stern, Luchetta, & Arruda, 1997). VAMS produced a high test-retest reliability for each of the four scale used: anger (r=0.73), fear (r=0.69), sadness (r=0.49) and happiness (r=0.73); and similarly high content validity respectively (0.70, 0.50, 0.81, and 0.90) in validation studies by Stern, Arruda, Hooper, Wolfner, and Morey (1997).

Design and procedure

The experiment employed a mixed-factorial design with two groups (Korsakoff's syndrome 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. Participants completed the study over four separate sessions, scheduled exactly one week apart. Starting times for each session were aimed to be the same for each

participant and varied non-significantly. Each session targeted a specific basic emotion, using a different emotional vignette, and following a similar procedure between sessions.

The emotion elicitation paradigm was modelled after the Rey Auditory Verbal Learning Test (RAVLT) – a long-established instrument for measuring episodic memory specifically designed for amnesic patients (see Schmidt, 1996) and used emotional narratives instead of word-lists presented in three (instead of five in RAVLT) successive repetitions to allow participants to fixate the episodic details of the emotional stories. This was aimed to allow 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. Similarly with the RAVLT, the stories were read out to each participant by the same researcher, in a neutral tone of voice, practiced and validated in extensive initial piloting. Both Korsakoff's patients and controls listened to the target vignette in three successive repetitions, and after each presentation recalled the story, and provided momentary ratings of the four basic emotions. Standardised instructions were used for the orienting task (i.e., "Please listen to the following story and imagine that you are personally experiencing what is happening in the text."), and the same for the recall task ("Please try to reproduce out loud the previous story, including as many details as you can remember.") and emotion measurement task ("Please indicate on the following questionnaire how angry (afraid, sad, happy) you feel right now. You should place a mark anywhere along the length of this vertical the line from right at the top – if you are *not at all* angry (afraid, sad, happy), to right at the bottom, if you are *very* angry (afraid, sad, happy)."

The three presentations were followed by an Interference phase, when participants listened to a novel, distracting story, followed by similar recall and emotion rating tasks. Orienting instructions were adjusted slightly as follows: "Please listen to the following *new*

story and imagine that you are personally experiencing what is happening in the text." Similarly, the instructions for the recall task were "Please try to reproduce out loud the *previous* story, including as many details as you can remember." Instructions for the emotion rating task remained unchanged for this and all subsequent phases.

Next, participants were asked to directly recall the initial target story once again, but notably unlike before, without a prior presentation (Immediate Recall phase) and provide momentary ratings of emotions. The recall instructions used were: "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." Similarly with the RAVLT paradigm, the story was never identified by name or topic, and no further information or prompts about the target story were provided to participants (even if they requested them), other than that the story had been read three times, not immediately before, but at the start of the session.

After a 30 minute delay interval, occupied with various pen-and-paper filler tasks, participants were asked again to recall the target story without prior presentation (Delayed Recall phase) and to provide emotion ratings for each of the four basic emotions. All instructions were the same as in the Immediate Recall phase.

Data analysis

All participants completed all four sessions of the study. 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. Independent-samples one-way ANOVAs confirmed that there were *no order effects* for the recall accuracy scores (*anger*, $F(3,36)$=.04, p=.988., η_p^2=.004.; *fear*, $F(3,36)$=.04, p=.991, η_p^2=.003; *sadness*, $F(3,36)$=.15, p=.927, η_p^2=.013; *happiness*, $F(3,36)$=.07, p=.975, η_p^2=.006), the overall intensity of emotion ratings (*anger*, $F(3,36)$=1.32, p=.284, η_p^2=.099; *fear*, $F(3,36)$=2.02, p=.129, η_p^2=.144; *sadness*, $F(3,36)$=.84, p=.480, η_p^2=.066; *happiness*, $F(3,36)$=2.06, p=.123, η_p^2=.146), or the intensity of target emotions (*anger*, $F(3,36)$=.97, p=.417, η_p^2=.075; *fear*, $F(3,36)$=2.0, p=.132, η_p^2=.142; *sadness*, $F(3,36)$=1.02, p=.394, η_p^2=.078; *happiness*, $F(3,36)$=1.88, p=.151, η_p^2=.135).

Recall accuracy scores and emotion intensity ratings were analysed using mixed-factorial ANOVAs. Moreover, emotion intensity ratings were also analysed using a MANOVA (where individual ratings of discrete emotions at each time point were viewed as four dependent variables), and the results of the mixed-factorial ANOVA were confirmed. Only the ANOVA results are presented below.

Two further exploratory correlation analyses were performed for the Korsakoff patients group only, between the affective re-experience of the four discrete emotions after 30 minutes, and executive function and higher cognitive abilities. Partial correlations (controlling for recall accuracy) were performed separately for Korsakoff patients and control participants between the intensity ratings of the four basic emotions after recalling the stories after the 30 minutes delay and (i) five composite scores of the DKEFS Trail Making Test (see Table 1), and (ii) seven indices and composite scores of the WAIS. Bonferroni corrections for multiple comparisons were applied to all exploratory analyses, and the results are reported separately.

Results

The present study investigated the discrete emotional experience of four basic emotions (anger, fear, sadness, and happiness) for a group of 20 Korsakoff patients and 20 control participants, following the recollection of four emotional vignettes. Firstly, we sought to establish the difference in the recall accuracy between the two groups, compare the emotional experience for each discrete emotion after the story recall, and investigate the relationship between recall accuracy and emotional re-experience. Secondly, a further set of correlational analyses was carried out between the intensity of the target emotion and the performance on executive function and complex cognitive function (IQ) tests.

The recall accuracy of the emotional stories

The Korsakoff patients were expected to show a substantial level of memory impairment compared to controls, across all four emotions. As shown in Figure 1, the patients' recall accuracy was several times lower than that of controls, at all time points.

--Insert Figure 1 --

An initial 2x4x6 factorial ANOVA (Group x Story x Time) of recall accuracy scores confirmed the substantial differences between the recall scores of Korsakoff patients and control participants for all four stories: anger ($F(1,38)=201.49$, $p<.001$, $\eta_p^2=.841$), fear ($F(1,38)=145.41$, $p<.001$, $\eta_p^2=.793$), sadness ($F(1,38)=573.92$, $p<.001$, $\eta_p^2=.938$), and happiness ($F(1,38)=323.28$, $p<.001$, $\eta_p^2=.895$), as well as two significant interactions between the participant groups across the five time points ($F(4,152)=30.27$, $p<.001$, $\eta_p^2=.443$), and

between the participant groups and the four emotions ($F(3,114)=13.41$, $p<.001$, $\eta_p^2=.261$). Thus, the difference between the recall of the two groups was substantial for all stories ($.793 \leq \eta_p^2 \leq .938$). Follow-up analyses further explored the two interactions (Group x Time and Group x Emotion). The two interactions can be explained together. On the one hand, as expected, the repetition helped improve control participants' recall accuracy, after the second and third presentations (Table 2; Presentation 2 vs 1 and Presentation 3 vs 1), for all four emotions. Moreover, their recall accuracy remained unchanged after the interference story (Table 2; Immediate Recall vs Presentation 3) or after 30 minutes (Table 2; Delayed Recall vs Presentation 3), overall showing substantial learning of the story details (Table 2; Delayed Recall vs Presentation 1).

--------------------------------------- Insert Table 2 ---------------------------------------

On the other hand, the Korsakoff patients' recall accuracy scores showed a different pattern over time (explaining the Group x Time interaction) and varied between stories (Group x Emotion interaction). Thus, patients' recall accuracy either did not change over time (anger stories), or showed minimal improvements by the third presentation only (fear, sadness, and happiness stories). Subsequently, the patients showed significant forgetting after the interference phase for the sadness and happiness stories (Table 2; Immediate Recall vs Presentation 3) and after 30 minutes for the fear, sadness and happiness stories (Table 2; Delayed Recall vs Presentation 3). Overall, the patients' recall accuracy scores at the beginning and at the end of each session were unchanged, showing that over time, their episodic memory performance did not benefit from the repeated presentations of the stories (Table 2; Delayed Recall vs Presentation 1). Thus, the Korsakoff patients presented a substantial episodic memory impairment, and any minimal learning of some episodic details was lost for most

stories after the interference phase and for all after the 30 minute delay (which was the time point of interest in this study). These results encourage the investigation of the differences in the re-experience of discrete emotions, in the presence and absence of episodic information about the original events − especially after the 30 minute delay.

The re-experience of discrete emotions

The intensity of discrete emotions after each of the four stories showed a specific elicitation of the target emotion (see Figure 2). Despite the large difference in episodic recall between the two groups (reported above), emotional experience was surprisingly similar for Korsakoff patients and controls.

--- Insert Figure 2 ---

An initial 2x4x4x6 factorial ANOVA (Group x Story x Emotion x Time)[1] of emotion intensity ratings found that the largest effect was a significant Story by Emotion by Time interaction ($F(45,1575)=28.40$, $p<.001$, $\eta_p^2=.448$), which we explored further. There was no effect of Group ($F(1,35)=2.39$, $p=.131$, $\eta_p^2=.064$). The effect of Story was significant ($F(3,35)=14.92$, $p<.001$, $\eta_p^2=.299$), but this is unremarkable because each story targeted a different emotion, thus we expected a different pattern of emotion ratings, by design. The largest effect (Story x Emotion x Time interaction) was followed up with two separate factorial ANOVAs for each story, one including and one excluding the Interference time point (alpha level corrected for multiple comparisons, $\alpha=.006$; see Table 3). This allowed us to isolate the effect of the Interference phase, which included a story of an opposite valence to the other time points, and thus, was expected to elicit a different emotional experience. Firstly, a 2x4x6

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[1] Results were also confirmed by a 2x4x6 MANOVA (Group x Story x Time).

factorial ANOVA (Group x Emotion x Time) included the Interference phase confirmed that the previous overall interaction between Emotion and Time remained significant for each story in part. This showed that emotions intensity ratings changed over time – as was expected due to the Interference story. However, when the second 2x4x5 factorial ANOVA (Group x Emotion x Time) analysed the emotion ratings excluding the Interference phase, the interaction between Emotion and Time was no longer significant for any story, with only a main effect of Emotion remaining each time. Thus, the experience of emotions remained unchanged over time, from the first presentation until the last recall after 30 minutes, for both Korsakoff patients and controls (see Table 3).

----------------------------------- Insert Table 3 --

Finally, the main effect of Emotion was explained using planned simple contrasts between the target emotion and each of the non-target emotions for all stories (see Table 4). The intensity of the target emotion was highest for each story, for both participant groups – suggesting a discrete elicitation of the target emotion both when the episodic memory was severely impaired (Korsakoff patients) and when memory performance was intact (Control participants).

--- Insert Table 4 --

The relationship between recall accuracy and emotion intensity

As shown above, despite the sizable difference in episodic recall, both groups of participants experienced the target emotion of each story at significantly higher levels than any of the non-target emotions. This would predict a null relationship between the intensity of the

target emotion and the information remembered from each story after the 30 minutes delay (see Figure 3).

-- Insert Figure 3 --

Pearson correlations failed to reach significance for the stories eliciting negative emotions (anger, fear, and sadness). The Korsakoff patients' data showed an initially positive relationship between the intensity ratings and recall accuracy scores of the happiness story. Three outliers were identified in the dataset, and when removed, the correlation failed to reach significance ($r(16)=0.55$, $p=.029$, $\alpha=.025$). It should be noted that the Pearson correlation test is underpowered at this relatively low sample size. However, even when Korsakoff patients' and control participants' data are combined (on account of the similar emotion experience ratings between the two groups), the correlations remain distinctly non-significant. Composite scores of emotion intensity ratings and recall accuracy across all stories are similarly uncorrelated for either group of participants. Interestingly, patients whose recall accuracy was almost nil (4-5%) reported a wide range of intensity ratings (0-90%) for all target emotions. The null correlations between emotional intensity and recall accuracy seemed to be explained by equal spread in emotion intensity scores for participants with considerably different recall scores. Specifically, some of amnesic patients with low 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 seems not to be related to the intensity of basic emotions re-experience, regardless of whether episodic memory is impaired or not.

The relationship between emotion re-experience and executive function

Korsakoff patients' performance on the Delis-Kaplan Executive Function System (DKEFS) Trail Making Test was normal – and similar to controls' – when their ocular movement impairment (nystagmus – a common sign of their condition; Victor, Adams, & Collins, 1989) was taken into account (see contrast scores 1-4). The Trail Making Test was the only measure with a sufficient sample size in this study to allow the investigation of the relationship between the intensity of the re-experience of the four basic emotions after the 30 minutes delay and executive function, in the two groups of participants.

Control participants showed a strong negative relationship between the re-experience of *anger* after delayed recall and the Contrast Score 1 of the DKEFS Trail Making Test (Number Letter Switching accounting for Visual Scanning performance). This relationship was moderately negative for the re-experience of fear (see Table 5), and nonsignificant (but continuing to show a negative trend) for sadness and happiness[2].

-- Insert Table 5 --

The results show that when controlling for episodic memory differences, greater cognitive flexibility and inhibition ability are associated with a *dampened* re-experience of emotions after 30 minutes (e.g., the high arousal emotions of anger and fear). Korsakoff patients failed to show a similar relationship between the executive function measure and the re-experience of discrete emotions. This is remarkable in the context of earlier findings that Korsakoff patients re-experienced all basic emotions at similar levels with control participants after 30 minutes, and scored similarly on the contrast measures of executive function. The only

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[2] When Bonferroni corrections for multiple comparisons are applied to the significance level only the anger correlations reached significance. Correlation analyses are notably underpowered at these sample sizes.

notable difference between the two groups is their episodic memory performance. Thus, when episodic memory is impaired, executive function, even when preserved at normal levels, seems to play a negligible role in reducing the emotion re-experience over time.

The re-experience of discrete emotions and general intellectual abilities

Finally, the relationship between the Wechsler Adult Intelligence Scale (WAIS) and the intensity of the re-experience of the four basic emotions after 30 minutes delay was analysed, controlling for recall accuracy. The sample of available data was too low to perform two separate partial correlation analyses (for Korsakoff patients and controls), and a second covariate (Group) was added to account for the differences between participants[3].

-- Insert Table 6 --

Only Processing Speed Index showed a strong positive correlation with the intensity of *fear* and *happiness*, and a moderately positive correlation with the intensity of *sadness*[4]. This measure of cognitive performance assesses focusing attention, and requires persistence and planning abilities. Thus, it would seem surprising that processing speed should show a positive correlation with emotional re-experience, opposite to the previous findings about the negative correlation between emotion re-experience and the executive function of cognitive flexibility, inhibition, and task switching. Although Korsakoff patients contributed most of the data for

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[3] The order of covariates in each analysis was: Group and then Recall Accuracy.
[4] Fear and happiness correlations remain significant when correcting the α level for multiple comparisons, but all correlations are substantially underpowered at this sample size.

these analyses (*N*=13), the limited dataset and the lack of a group emphasize the need for further inquiry.

Discussion

This study focused on the relationship between re-experience and episodic recall, and also executive function, in a group of Korsakoff syndrome patients and neurologically normal controls. As expected, the Korsakoff patients recalled significantly less (between 70% and 80% less) episodic material from each of the four stories than did controls. In addition, despite the substantial difference in recall, the experience of each discrete emotion was not significantly different between the two groups of participants. Korsakoff patients, especially those who recalled almost nothing (0-5%) from the original story, reported wide-ranging levels of emotional experience (0-90%), similarly with control participants, whose episodic memory was unimpaired. This represents expanded evidence for the independence of emotional memory from episodic memory systems (see Haman, 2001; LaBar & Cabeza, 2006; Phelps, 2006). Finally, certain executive functions (e.g., cognitive flexibility and response inhibition) were significantly and negatively related to the intensity of discrete emotions (e.g., anger and fear). This represents novel evidence for the relationship between the magnitude of emotional re-experience and specific executive functions of cognitive flexibility and response inhibition.

The independence of emotional from episodic memory has been supported by reports of amnesic patients able to reliably re-experience past emotions, without the ability to episodically recall the triggering events, but only for simple emotional dyads (Chapelle, Philippot, & van der Linden, 2007; Feinstein, et al., 2010; Guzman-Velez, Feinstein, & Tranel, 2014). The present study reported this phenomenon for *fine-grained* individual basic emotions (*anger*,

fear, *sadness*, and *happiness*), and not just for *generic* positive or negative affect. This finding has important theoretical implications. The encoding and retrieval of emotional stimuli has long been associated with an extended network of brain regions, strongly interconnected with the amygdala, including the thalamus (LaBar & Cabeza, 2006), and certain cortical areas: the insular, anterior cingulate and orbitofrontal cortices (LeDoux, 1993; Maratos, & Rugg, 2001; Smith, Henson, Dolan, & Rugg, 2004). However, neurological studies investigating the dissociation between emotional and other memory mechanisms have been limited to showing either (1) a preserved generic ability of amnesic patients to re-experience arousing emotional stimuli – neuroanatomically associated with the amygdala (Adolphs, Cahill, Schul, & Babinsky, 1997; Hamman, 2001; Zald, 2003), or (2) their ability to re-experience separate positive and negative emotions – argued to originate in phylogenetically older structures of the brain, in particular, the periaqueductal grey (Panksepp, 2009). The present study found that this effect was maintained independently for discrete emotions, usually involving more complex brain systems (Vytal & Hamman, 2010). The specificity of emotional memory shown presently invites further enquiry into the neural pathways that support such complex affective processes independently of episodic memory systems.

Furthermore, we reported that amnesic patients have 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 an increased re-experience in the case of amnesic patients than controls. This is particularly notable since the present investigation benefits from two superior experimental characteristics (resolution and power), because (1) separate classes of negative affect were investigated (i.e., *anger*, *fear* and *sadness*) in (2) a larger sample of patients and controls. Importantly, while the previous two studies investigated different amnesic pathologies

(hippocampal amnesia; Feinstein et al.) and probable Alzheimer's Dementia (Guzman-Vellez et al.), their patients presented a similar range of episodic memory performance to the Korsakoff syndrome patients in the present study. One possible explanation for the particularly stable re-experience in our study relates to the preserved executive function ability of the amnesic patients. We showed that high cognitive flexibility and inhibition are potentially related to a dampened re-experience, especially of negative emotions, and it is precisely these abilities that seem to be lost early in Alzheimer's disease (Amieva, Phillips, Della Sala, & Henry, 2004). Comparable executive function data is lacking from the previous reports. Thus, following from the present findings, it is recommended that future investigations (1) adopt a larger set of discrete emotions (especially on the negative side) to be investigated concomitantly for amnesic patients, and (2) evaluate executive function abilities at the same time as emotional re-experience, as the relationship between the two may explain differences in affective and cognitive performance.

The present data on multiple discrete emotions are also relevant when considering the relationship between emotional re-experience and executive function, reported for the first time in this study. The results showed negative correlations between measures of cognitive flexibility and response inhibition and the intensity of the re-experience of discrete emotions (e.g., *anger* and *fear*). This implies that independent emotional memory systems may be closely linked with abilities traditionally ascribed to the prefrontal cortices, in ways that are not been specifically explained in the literature so far. Our findings are broadly consistent with previous reports that performance on the Trail Making Test, and the Stroop Test correlated with the ability to down-regulate negative emotions, and up-regulate positive emotions (Gyurak et al., 2012). Revealing the mechanisms that support this relationship between

executive control and specific affective re-experience, in particular in the absence of episodic memory, remains a presently unexplored and potentially fecund area of study.

A first key question regarding the current findings refers to the *quality,* as opposed to the *quantity,* of amnesic patients' episodic recall, particularly in relation to *gist memory*. The number of episodic details reproduced by the Korsakoff patients was substantially reduced by comparison with controls, but the question remains whether the amnesic patients managed to remember the *key* emotional events of the stories, which may have had some contributions to the *gist*, without the details surrounding these events. Several authors have suggested that the gist of a memory seems to be encoded in a distinct schema from other episodic details (Rubin, Stoltzfus, & Wall, 1991), and neurological studies have reported that gist-based conceptual processing can be preserved in amnesic patients (Deason, Hussey, Budson, & Ally, 2012). For example, 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). Amnesic patients' gist memory performance was also shown to be similar to that of healthy controls (Baddeley & Wilson, 2002; Nissan, Abrahams, & Della Sala, 2013). We propose that the mechanism that enables gist information to be retained might be based, at least in part, on emotional memory processes (Adolphs, Tranel, & Buchanan, 2005; Wessel & Merckelbach, 1998). Therefore, in the context of the present findings, despite the substantially impaired episodic recall of the Korsakoff patients, it could be argued that the emotional *gist* of stories has been retained by patients. As the encoding of the *gist* of memories may rely at least in part on neural structures central to affective experience, such as the amygdalae (Adolphs, Denburg, & Tranel, 2001; Adolphs, Tranel, Buchanan, 2005; LaBar & Cabeza, 2006), *gist* information may be in part derived from emotional memory. Consistent with this idea we found that even

patients who failed to recall anything at all from the stories (i.e., whose recall accuracy was indeed nil), reported moderate-to-high levels of the *target* discrete emotions. Conversely, the remaining patients who recalled little of the stories and re-experienced little of the target emotion did so throughout the study from the first presentation to the delayed recall phase, and it could be argued that they either failed to encode even the gist of the stories, or failed to respond to the emotion elicitation paradigm. However, any influence of gist memory on the specific experience of discrete emotions of amnesic patients remains an empirical question beyond the scope of the current study. The present data did not allow the examination of this hypothesis, but minor design and stimuli alterations could potentially allow it.

A second question can be asked about the possible role of procedural memory in the remarkable stability of all discrete emotions of Korsakoff patients, especially between the presentation and recall phases. Indeed, patients listened to the same story three times in succession, and provided ratings of their emotions each time, using similar pen-and-paper visual analogue scales. Therefore, when prompted to recall the story without another presentation (in the Immediate Recall and 30 minutes Delayed Recall phases), the Korsakoff patients may not have accessed either their episodic memory (as expected), or emotional memory systems (as concluded previously), but instead may have remembered the procedural details of the emotion rating task, and may have simply filled in the questionnaire as they had practiced three times earlier. One key methodological aspect of the emotion measurement task, and one piece of empirical evidence from the patients' own data make procedural memory and unlikely confound. Firstly, the during the emotion rating task patients provided measurements of each emotion on a separate page of the questionnaire, and the four pages were presented in *random* order. Thus, in producing similar emotion ratings over time, patients actively and correctly selected the target emotion, each time, while disregarding all 3 non-target emotions (a

distinctly cognitive task). Secondly, the amnesic patients showed a dramatic and accurate response to the interference story (which had an opposite valence to the target story). Their emotion ratings changed consistently and unequivocally away from the target story, in favour of the opposite emotional valence of the interference story. Subsequently, during the Immediate and Delayed recall phases amnesic patients switched back to the exact original target emotion, ignoring all three other emotions. This level of flexibility cannot be explained by procedural processes, because it was not rehearsed. Thus, the target emotion must have held a special value for patients when they attempted to recall the related story, and this value was markedly different from all other emotions – effect which was observed similarly for control participants.

The association between emotional memory and executive functions identified in this study is particularly relevant for patient care and psychotherapy. Episodically amnesic patients (including many Korsakoff syndrome and Alzheimers' patients) often show a selective memory deficit, but adequate levels of executive function (Hannula, Tranel, & Cohen, 2006; Press, Amaral, & Squire, 1989). In light of the present study, these patients are likely to retain the capacity to re-experience a full range of discrete basic emotions, including on the negative side (anger, fear, sadness), leading to two important implications for their care and management. Firstly, despite their episodic memory impairment, amnesic patients' sustained emotional acuity, means their social environment can have a lasting impact on their emotional wellbeing. Thus, professional support is required particularly in stressful periods of their care pathway. Families and friends, often the first to discover the patients' deficit, can also play a role in limiting the usually negative emotional experience associated with the patients' realisation of their neurological deficit, and their need for long term care. Secondly, therapeutic interventions should address not only the obvious episodic memory deficit, but also the often

substantial emotional burden associated with amnesia (Tarrier, Barrowclough, Ward, Donaldson, Burns, Gregg, 2002). We showed that amnesic patients who have sufficient levels of executive functions (especially cognitive inhibition and flexibility) remain particularly vulnerable to the effect of negative emotions, and previous work has already shown that emotion regulation strategies are effective for this patient group (Beer, Lombardo, & Gross, 2007). Important emotion regulation strategies, such as reappraisal (i.e., changing the way that one thinks about a situation, to perceive an event in less negative or more positive terms), are known to be reliant on cognitive inhibition (McRae, Jacobs, Ray, John, & Gross, 2012; Salas, Gross, & Turnbull, 2014). Moreover, even neurological patients with impaired flexibility and inhibition can reappraise when prompted (Salas, Gross, Rafal, Viñas-Guasch & Turnbull, 2013). Thus, amnesic patients who show intact emotional memory and executive function are good candidates for emotion-regulation interventions, and are likely to show the highest therapeutic gain. Those patients with unimpaired emotional memory, but poor executive function can potentially experience powerful but poorly regulated emotions, and are likely to require more intensive emotional support. Notably, the present study did not investigate whether these patients were capable of generating re-appraisal strategies, and this remains an interesting direction for future research.

Patients who have profound episodic memory impairment tend to learn on the basis of emotional experience, and this is unrelated to the magnitude of the episodic memory ability. It is not completely clear what other factors are driving this process, but we have some hints that executive function and processing speed might be important. However, opportunities to understand the detail and extent of emotional memory have not been pursued and explored fully. There are obvious implications for extensions of the present study, for example in the management of dementia, or in understanding how emotional memory underpins the

therapeutic alliance in psychotherapy. We look forward to seeing the growth in this important

research area.

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Table 1. *Basic demographics and neuropsychological assessment data of Korsakoff syndrome patients and control participants.*

	Korsakoff syndrome patients (*N*=20)		Neurologically normal control participants (*N*=20)		χ^2	t-test
	N	*M (SD)*	*N*	*M (SD)*	*p*	*p (d)*
Basic demographics						
Age (years)	20	53.5 (7.8)		64.0 (7.8)		<.001 (1.34)
Education (years)	20	11.0 (0.3)		13.1 (0.7)		.008 (0.88)
Gender (men/women)	20	14 / 6		10 / 10	.197	-
Wechsler Memory Scale III-R (Index Scores, *M*=100, *SD*=15)						
Auditory Immediate	20	69.2 (10.8)	16	118.8 (15.2)		<.001 (3.76)
Auditory Delayed	20	66.6 (10.8)	16	121.5 (12.5)		<.001 (4.70)
Auditory Recognition Delayed	19	71.1 (11.9)	5	107.0 (20.8)		.015 (2.12)
Working Memory	14	90.3 (14.7)	5	99.4 (14.3)		.247
Mini Mental State Examination	20	24.6 (3.8)	20	29.9 (0.5)		<.001 (1.97)
Delis-Kaplan Executive Function System (Scaled Scores, *M*=10, *SD*=3)						
Trail Making Test (TMT)						
TMT Condition 1 – Visual Scanning	19	5.9 (3.0)	19	9.7 (3.9)		.002 (1.06)
TMT Condition 2 – Number Sequencing	19	6.6 (4.2)	19	10.4 (2.7)		.002 (1.07)

TMT Condition 3 – Letter Sequencing	19	6.9 (4.3)	19	11.6 (1.9)	<.001 (1.43)
TMT Condition 4 – Number-Letter Sequencing	19	6.4 (3.9)	19	11.3 (1.8)	<.001 (1.62)
TMT Condition 5 – Motor Speed	19	7.9 (3.8)	19	9.8 (2.2)	.078
TMT Contrast 1 – Number-Letter Switching vs. Visual Scanning	19	10.5 (3.7)	19	11.4 (3.2)	.406
TMT Contrast 2 – Number-Letter Switching vs. Number Sequencing	19	9.9 (4.4)	19	10.9 (2.4)	.419
TMT Contrast 3 – Number-Letter Switching vs. Letter Sequencing	19	9.5 (3.7)	19	9.6 (2.2)	.916
TMT Contrast 4 – Number-Letter Switching vs. Number and Letter Sequencing	19	9.7 (4.1)	19	9.8 (2.0)	.961
TMT Contrast 5 – Number-Letter Switching vs. Motor Speed	19	8.5 (4.6)	19	13.8 (4.3)	.001 (1.18)
Design Fluency Test (DFT)					
DFT Condition 1 – Filled Dots Only – Total Correct	14	7.4 (1.9)	5	9.4 (3.4)	.111
DFT Condition 2 – Empty Dots Only – Total Correct	14	7.1 (2.5)	5	9.0 (3.7)	.210
DFT Condition 3 – Filled-to-Empty Dots Switching – Total Correct	14	7.8 (2.9)	5	11.8 (2.9)	.018 (1.36)
DFT – Design Fluency Total Correct	14	5.4 (2.6)	5	8.6 (4.2)	.059
DFT – Combined Filled Dots and Empty Dots Total Correct	14	7.4 (1.8)	5	9.6 (3.0)	.066
DFT Contrast – Switching vs Combined Filled Dots and Empty Dots	14	4.5 (1.6)	5	4.2 (3.0)	.777

Wechsler Adult Intelligence Scale (Index Scores, *M*=100, *SD*=15)					
Verbal IQ	13	84.0 (19.1)	4	97.0 (5.6)	.209
Performance IQ	13	74.5 (16.3)	4	107.3 (18.0)	.004 (1.90)
Full Scale IQ	13	80.8 (11.9)	4	101.5 (10.8)	.007 (1.82)
Verbal Comprehension Index	13	85.3 (24.7)	4	98.0 (7.9)	.336
Perceptual Organisation Index	13	77.2 (22.4)	4	105.0 (13.6)	.035 (1.50)
Working Memory Index	13	80.7 (20.7)	4	102.8 (4.6)	.056
Processing Speed Index	13	72.8 (19.9)	4	121.5 (17.7)	.001 (2.58)

Table 2. *Follow-up analyses of recall accuracy scores show Korsakoff patients were unable to learn the stories over time, and reproduced as few details of the stories after 30 minutes as they did after the first presentation. Control participants learned the stories over the three presentations and could reproduce them with peak accuracy after 30 minutes. (Alpha level corrected for multiple comparisons.)*

Story	Analysis	Contrast	Korsakoff patients			Control participants		
			F	p	η_p^2	F	p	η_p^2
Anger	Learning	Presentation 2 vs 1	5.41	.031	.222	91.87	<.001*	.829
		Presentation 3 vs 1	3.84	.065	.168	76.59	<.001*	.801
	Forgetting	Immediate Recall vs Presentation 3	.09	.774	.004	.07	.798	.004
		Delayed Recall vs Presentation 3	2.74	.115	.123	<.01	.970	<.001
	Overall	Delayed Recall vs Presentation 1	<.01	.981	<.001	76.59	<.001*	.787
Fear	Learning	Presentation 2 vs 1	4.80	.041	.201	51.61	<.001*	.731
		Presentation 3 vs 1	14.92	.001*	.440	75.21	<.001*	.798
	Forgetting	Immediate Recall vs Presentation 3	4.44	.049	.189	1.17	.292	.058
		Delayed Recall vs Presentation 3	14.86	.001*	.439	2.85	.108	.130
	Overall	Delayed Recall vs Presentation 1	.44	.514	.023	46.87	<.001*	.712
Sadness	Learning	Presentation 2 vs 1	3.00	.100	.136	65.00	<.001*	.774
		Presentation 3 vs 1	6.87	.017*	.266	80.91	<.001*	.810
	Forgetting	Immediate Recall vs Presentation 3	6.85	.017*	.265	1.18	.292	.058
		Delayed Recall vs Presentation 3	9.83	.005*	.341	3.34	.083	.150
	Overall	Delayed Recall vs Presentation 1	.38	.545	.020	46.21	<.001*	.709
Happiness	Learning	Presentation 2 vs 1	.94	.344	.047	55.14	<.001*	.744
		Presentation 3 vs 1	8.02	.011*	.297	74.93	<.001*	.798
	Forgetting	Immediate Recall vs Presentation 3	8.13	.010*	.300	1.31	.267	.064
		Delayed Recall vs Presentation 3	11.95	.003*	.386	0.28	.604	.014
	Overall	Delayed Recall vs Presentation 1	2.36	.141	.110	94.37	<.001*	.832

$\alpha = .017$

Table 3. *The intensity of emotions varied over time, only due to the Interference phase, when an oppositely valenced story was presented. Conversely, when only the target stories were presented or recalled, emotion experience remained unchanged for both groups (P1-P3=Presentation 1-3; Int=Interference, IR=Immediate Recall; DR=Recall after 30 minutes).*

Story	Stories	Time points	Emotion*Time interaction		
			F	p	η_p^2
Anger	Target & Interference	P1 P2 P3 Int IR DR	24.06	<.001*	.388
	Target story only	P1 P2 P3 IR DR	1.33	.256	.034
Fear	Target & Interference	P1 P2 P3 Int IR DR	38.54	<.001*	.517
	Target story only	P1 P2 P3 IR DR	1.50	.120	.040
Sadness	Target & Interference	P1 P2 P3 Int IR DR	22.25	<.001*	.369
	Target story only	P1 P2 P3 IR DR	2.40	.130	.059
Happiness	Target & Interference	P1 P2 P3 Int IR DR	29.27	<.001*	.448
	Target story only	P1 P2 P3 IR DR	4.38	.044	.108

α =.006

Table 4. *The main effect of Emotion for each story shows the discrete elicitation of the target emotion over time, after both the presentation and recall of stories, for both groups (P1-P3=Presentation 1-3; IR=Immediate Recall; DR=Recall after 30 minutes).*

Story	Time points		Contrast	Emotion		
				F	p	η_p^2
Anger	P1 P2 P3	IR DR	Anger v Fear	29.60	<.001*	.438
			Anger v Sadness	10.26	.003*	.213
			Anger v Sadness	25.97	<.001*	.406
Fear	P1 P2 P3	IR DR	Fear v Anger	25.90	<.001*	.418
			Fear v Sadness	4.52	.040*	.112
			Fear v Happiness	80.08	<.001*	.690
Sadness	P1 P2 P3	IR DR	Sadness v Anger	42.51	<.001*	.528
			Sadness v Fear	34.63	<.001*	.477
			Sadness v Happiness	15.44	<.001*	.289
Happiness	P1 P2 P3	IR DR	Happiness v Anger	149.03	<.001*	.805
			Happiness v Fear	132.76	<.001*	.787
			Happiness v Sadness	121.29	<.001*	.771

α =.050

Table 5. *The relationship between the intensity of discrete emotions after 30 minutes and measures of executive function are reported as partial correlations controlling for recall accuracy. Negative emotions are presented in alphabetical order, followed by happiness.*

Story	DKEFS Trail Making Test	Korsakoff patients			Control participants		
		r	*p*	*df*	*r*	*p*	*df*
Anger	TMT Contrast score 1	0.22	.388	16	-0.80	<.001*	16
	TMT Contrast score 2	0.11	.666	16	-0.08	.756	16
	TMT Contrast score 3	0.25	.310	16	-0.59	.009*	16
	TMT Contrast score 4	0.21	.411	16	-0.41	.090	16
Fear	TMT Contrast score 1	-0.24	.329	16	-0.52	.028*	16
	TMT Contrast score 2	-0.22	.392	16	0.05	.838	16
	TMT Contrast score 3	-0.36	.143	16	-0.35	.156	16
	TMT Contrast score 4	-0.29	.241	16	-0.16	.520	16
Sadness	TMT Contrast score 1	0.17	.506	16	-0.36	.146	16
	TMT Contrast score 2	0.07	.784	16	0.05	.837	16
	TMT Contrast score 3	0.35	.150	16	-0.31	.209	16
	TMT Contrast score 4	0.20	.417	16	-0.19	.442	16
Happiness	TMT Contrast score 1	0.11	.661	15	-0.36	.137	16
	TMT Contrast score 2	0.21	.415	15	-0.12	.640	16
	TMT Contrast score 3	0.19	.472	15	-0.04	.864	16
	TMT Contrast score 4	0.23	.364	15	-0.15	.542	16

α = .013

Table 6. The relationship between the intensity of discrete emotions after 30 minutes and the index scores of the Wechsler Adult Intelligence Scale are reported as partial correlations controlling for recall accuracy. Negative emotions are presented in alphabetical order, followed by happiness.

| Story	WAIS Index Score	r	p	df
Anger	Verbal IQ	0.00	.998	13
	Performance IQ	0.27	.324	13
	Full Scale IQ	-0.01	.986	13
	Verbal Comprehension	-0.03	.904	13
	Perceptual Organisation	0.25	.377	13
	Working Memory	0.28	.308	13
	Processing Speed	0.41	.125	13
Fear	Verbal IQ	0.26	.353	13
	Performance IQ	0.29	.294	13
	Full Scale IQ	0.07	.794	13
	Verbal Comprehension	0.22	.439	13
	Perceptual Organisation	0.20	.479	13
	Working Memory	0.50	.057	13
	Processing Speed	0.84	<.001*	13
Sadness	Verbal IQ	0.17	.535	13
	Performance IQ	0.46	.082	13
	Full Scale IQ	0.24	.398	13
	Verbal Comprehension	0.16	.574	13
	Perceptual Organisation	0.43	.108	13
	Working Memory	0.32	.248	13
	Processing Speed	0.59	.022*	13
Happiness	Verbal IQ	0.14	.629	12
	Performance IQ	0.34	.237	12
	Full Scale IQ	0.20	.485	12
	Verbal Comprehension	0.10	.731	12
	Perceptual Organisation	0.16	.593	12
	Working Memory	0.18	.539	12
	Processing Speed	0.75	.002*	12

$\alpha = .007$
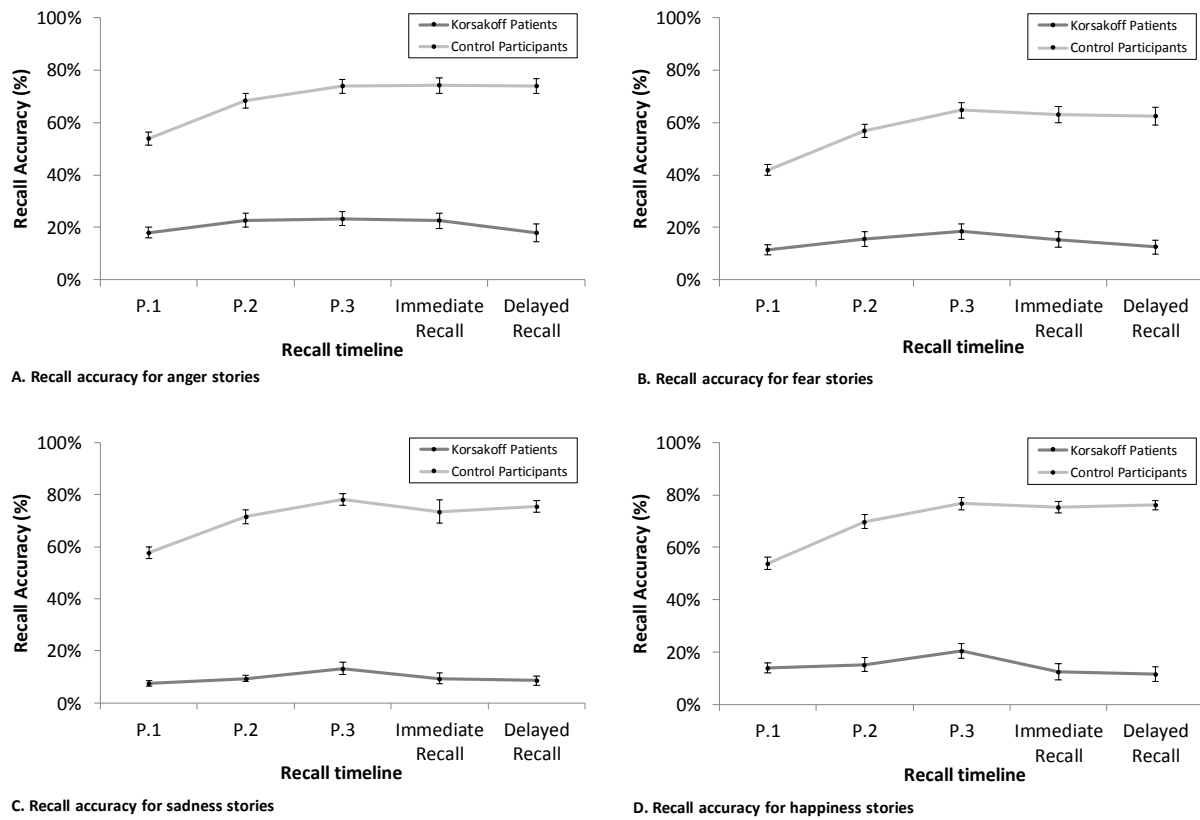
Figure 1. Episodic recall of emotion stories for Korsakoff patients and controls. Korsakoff

patients recalled substantially fewer story details compared to healthy controls. Error bars show

+/− 1 SE. (P.1=Presentation 1; P.2=Presentation 2; P.3=Presentation 3; Delayed Recall = recall

after 30 minutes).
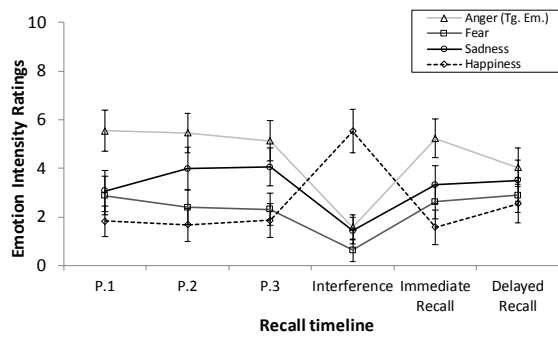
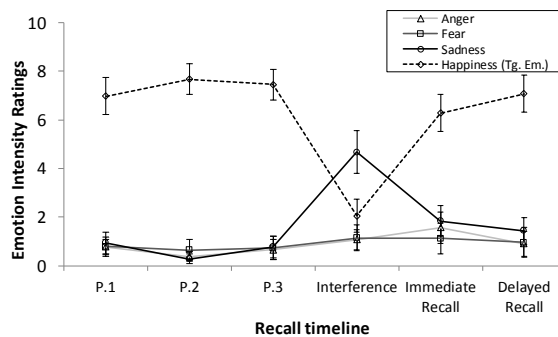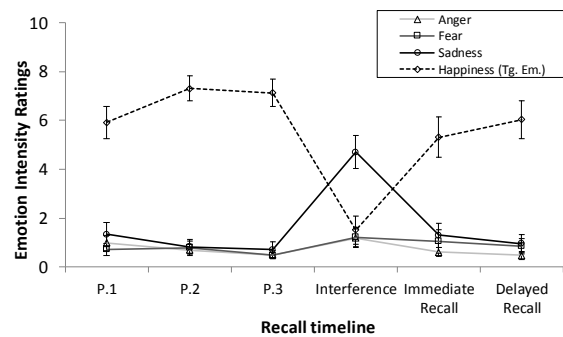A1. Emotion ratings of *Korsakoff patients* for the *anger* story
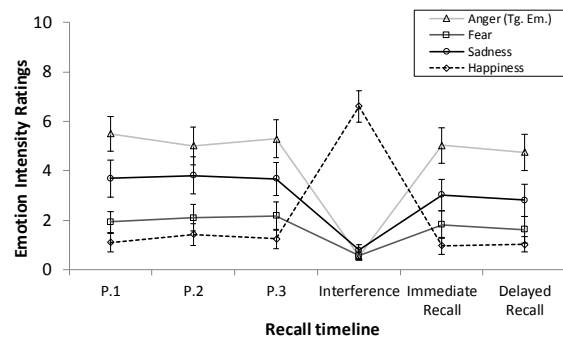
A2. Emotion ratings of *control participants* for the *anger* story
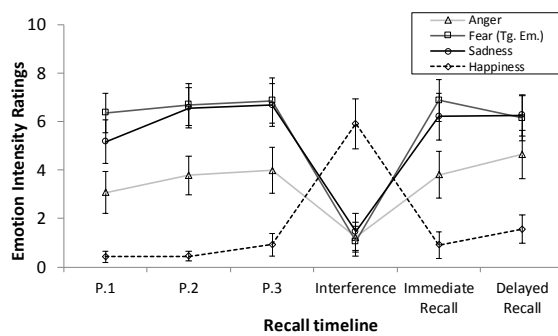
B1. Emotion ratings of *Korsakoff patients* for the *fear* story
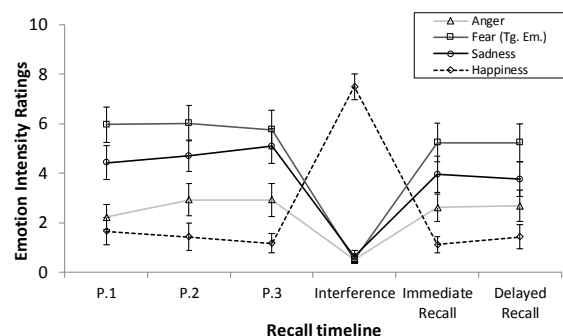
B2. Emotion ratings of *control participants* for the *fear* story
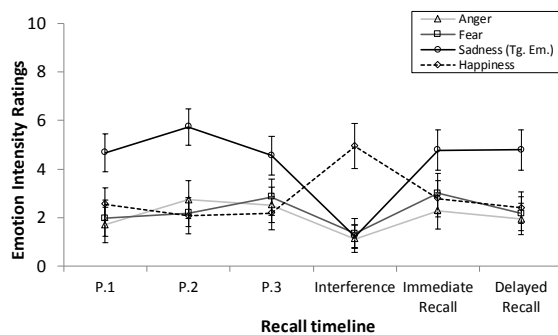
C1. Emotion ratings of *Korsakoff patients* for the *sadness* story
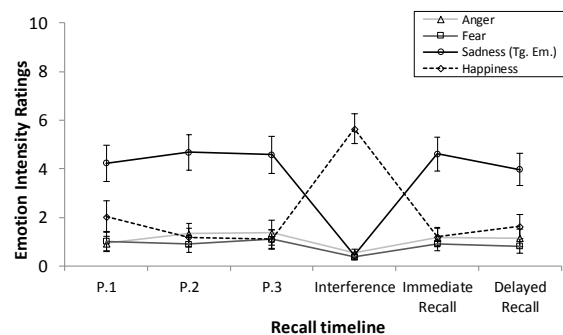
C2. Emotion ratings of *control participants* for the *sadness* story

D1. Emotion ratings of *Korsakoff patients* for the *happiness* story

D2. Emotion ratings of *control participants* for the *happiness* story

Figure 2. Ratings of discrete emotions for Korsakoff patients and control participants, for the

four stories. Each story showed a specific elicitation of the target emotion, and Korsakoff

patients showed a similar emotional experience to healthy controls. Both participant groups

demonstrated a significant interaction during the Interference phase, when an oppositely

valenced story was read and recalled. Error bars show +/− 1 SE. (Figure legend: Tg. Em. =

Target Emotion; *x*-axis: P.1=Presentation 1; P.2=Presentation 2; P.3=Presentation 3; Delayed
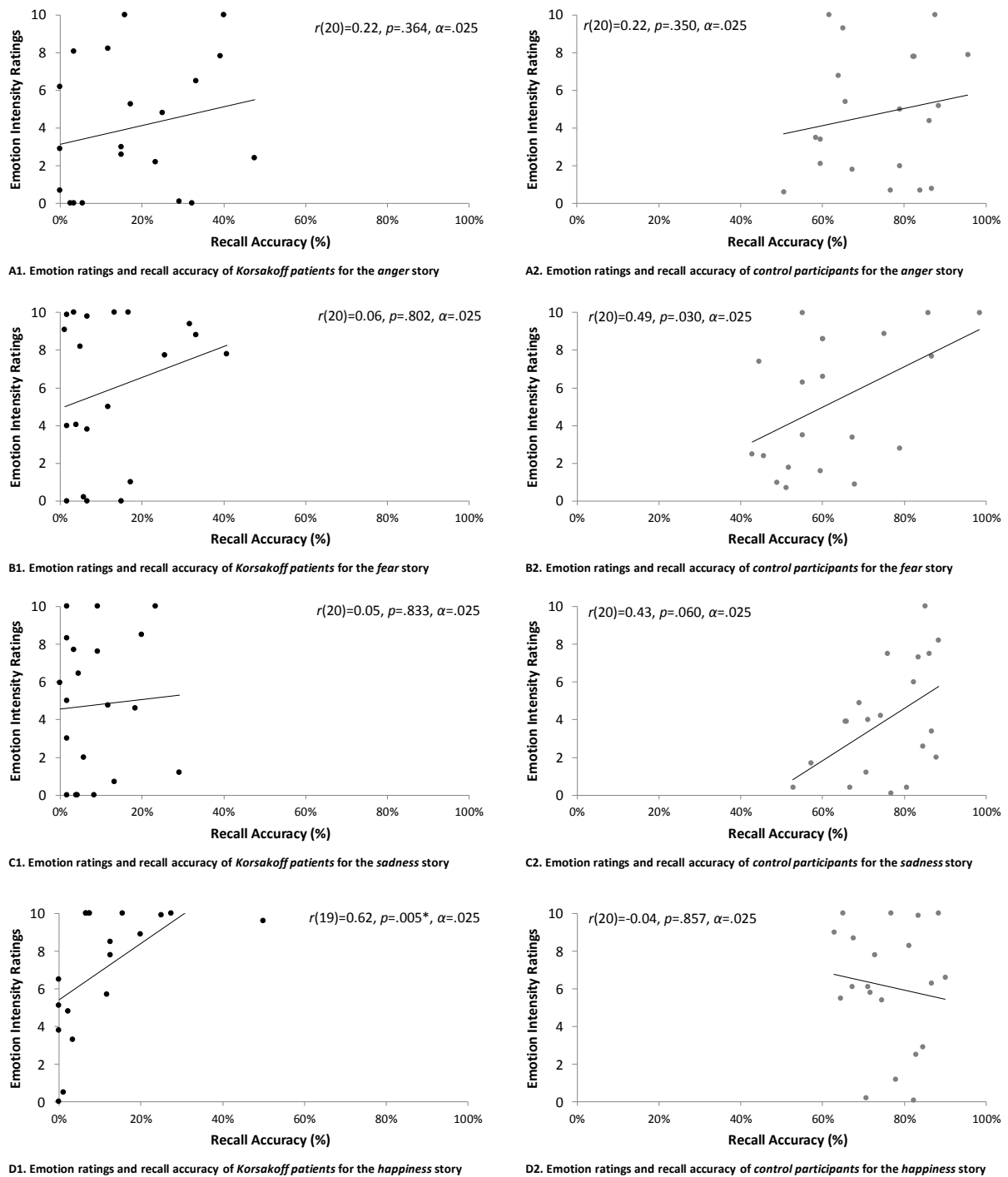
Recall = recall after 30 minutes)

Figure 3. The correlations between the recall accuracy and the ratings of each of the four

discrete emotions were not significant for either Korsakoff patients (A1-D1) or control

participants (A2-D2). The correlation between emotion ratings and recall accuracy of the

happiness story for Korsakoff patients was no longer significant when the 3 outlier data are

removed from analysis.