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Emotion and prejudice in complex decision-making

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Emotion and Prejudice in Complex Decision-making

By

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Summary

Real-world social decision making often occurs in circumstances where objects come with some pre-existing tag of emotional valence, so that prejudicial attitudes appear to be based on emotionally-charged labels. However, investigations of race-bias typically do not model the complexity and ambiguity of real-world objects. The Iowa Gambling Task (IGT) provides a paradigm which aims to model real-world complexity, with targets that exhibit ambiguous, ambivalent, and shifting affective properties. The original IGT uses decision targets that hold no pre-existing affective nature at the outset, but targets in the real-world generally possess complex emotional histories, which form the basis of prejudice.

The present study examined the impact of labelling IGT decks with task-irrelevant stimuli that possess pre-existing emotional and/or social salience. Five experiments manipulated the class of deck label (e.g., race) using both congruent and incongruent association to the incentive values of the decks. A final study assessed the impact of lesions of the frontal lobe on performance on this IGT variant.

The experiments demonstrated that an incongruent association between pre-existing emotional valence and deck-rewarding properties can lead to persistent decision-making biases. A common theme was an inability to tolerate the inconsistency between task rewards and irrelevant pre-existing labels. The effects were especially powerful for emotionally salient labels (e.g., race), but were far less powerful for

other labels (e.g., facial attractiveness). Frontal lesions also produced a similar decision-making bias, and in one instance generated effects much larger than was observed in other patients or controls.

These findings highlight the importance of pre-existing emotional biases in complex decision-making. The data suggest that ineffective regulation of goal-irrelevant emotion can lead to large and persistent judgmental biases, even when the participant is faced with striking real-world losses.

Introduction

Overview

Human beings are inextricably linked to their social world. In fact, the inherent complexity of social interaction is suggested to underlie our expansive neocortex (Dunbar, 1998). However, the neural substrates of social cognition had been difficult to study until the availability of neuroimaging techniques. Recent scientific interest in the neural basis of social behaviour has led to the formation of a cross-disciplinary approach that has been named 'Social Neuroscience'. This new field involves examining the neural basis of social cognition using the techniques of neuroimaging, psychophysiological approaches, and focal brain lesion studies.

Of particular importance to an understanding of social behaviour is the psychology of intergroup processes. The formation of cooperative groups enhances survival of the individual compared with those leading an independent lifestyle (Leakey & Lewin, 1977). Group formation increases evolutionary fitness by protecting against threats from predators, providing a stable food supply, and by kin selection mechanisms (Hamilton, 1964a, 1964b). The drawback of such group behaviour is the presence of ingroup-outgroup mechanisms, of which prejudice is arguably the most notable. It is well-established that even forming artificial 'minimal' groups can lay the basis for prejudicial behaviour (e.g., Tajfel & Turner, 1986). This categorisation of individuals into 'us and them' is associated with emotional labels of appropriate valence. These emotional labels readily impact on intergroup processes with important social consequences (Allport, 1954/1979). However, the emotional aspects of prejudice-related behaviour have been neglected in social cognition (Fiske, 2005, p. 48).

Thus, to fully understand how prejudice related mechanisms affect social behaviour requires the integration of emotion and cognition within the complexity of social interactions. Modelling such mechanisms in situations of complexity is difficult under laboratory conditions, however. One feasible approach to assess the inherent complexity of social cognition is through the use of decision-making paradigms. Indeed, some problem-solving experiments were specifically created to model human behaviour under conditions of complexity. An additional advantage of many of these recent measures is their intrinsic emotional component.

The introduction of this thesis begins by reviewing some of the literature on emotion and decision-making. This includes examples of how dysfunctional social cognition is expressed by patients with lesions to areas of the brain important for decision-making and emotion. Furthermore, some conceptual approaches that provide a theoretical basis for social cognition stemming from this focal lesion work are outlined. Then, the emotional basis of social attitudes is reviewed, summarising some of the initial findings of social neuroscience which provide an insight into the neural substrates of prejudice. This also covers some of the recent attempts to integrate the complexity of social behaviour into laboratory tasks that focus on mechanisms relating to prejudicial attitudes.

The six experiments contained in this thesis aim to improve on some of the limitations of previous work by assessing the consequences of prejudicial attitudes under conditions that are closer to dynamic real-world situations. This is achieved by investigating the effect of emotion-based attitudes on decisions under a situation of complexity, ambiguity, and over time using variants of the Iowa Gambling Task. Furthermore, the foundation of possible future work is laid in a small sample pilot study that examines how lesions to the medial regions of the frontal cortex alter performance on this new variant of the Gambling Task.

Emotion and real-world decision-making

> "Although every man believes that his decisions and resolutions involve the most multifarious factors, in reality they are mere oscillation between flight and longing"
>
> Hermann Broch (unsourced)

Until recently, emotion has been typically conceived as a disruptive influence on higher cognitive processes such as decision-making (Toda, 1980; Forgas & East, 2003). However, the contemporary view is increasingly illustrating the *importance* of emotion for optimal social judgement and decision-making (e.g., Arana et al., 2003; Damasio, 1994, 1999; Forgas & East, 2003; Ito & Cacioppo, 2001; Loewenstein et al., 2001; Pears et al., 2003; Peters & Slovic, 2000), most notably that patients with lesions to emotion-related brain regions (e.g. orbitofrontal cortex and amygdala) often exhibit poor social cognition and problem-solving (Bechara et al., 1994; Bechara et al., 1999; Damasio, Tranel, & Damasio, 1991; Eslinger & Damasio, 1985; Rogers et al., 1999; Rolls et al., 1994; Saver & Damasio, 1991; Shamay-Tsoory et al., 2003). Such observations have led to the suggestion that adaptive decision-making, especially under settings of great complexity and/or uncertainty is reliant on the use of emotion-based information (Bowman & Turnbull, 2004; Damasio, 1994, 1996; Damasio et al., 1991; LeDoux, 2000; Montague & Burns, 2003; Rogers et al., 1999). Recently, novel measures of emotion in decision-making have been developed, such as the Bangor Gambling Task (Bowman & Turnbull, 2004), Cambridge Gambling Task (Rogers et al., 1999), and the Iowa Gambling Task (Bechara et al., 1994).

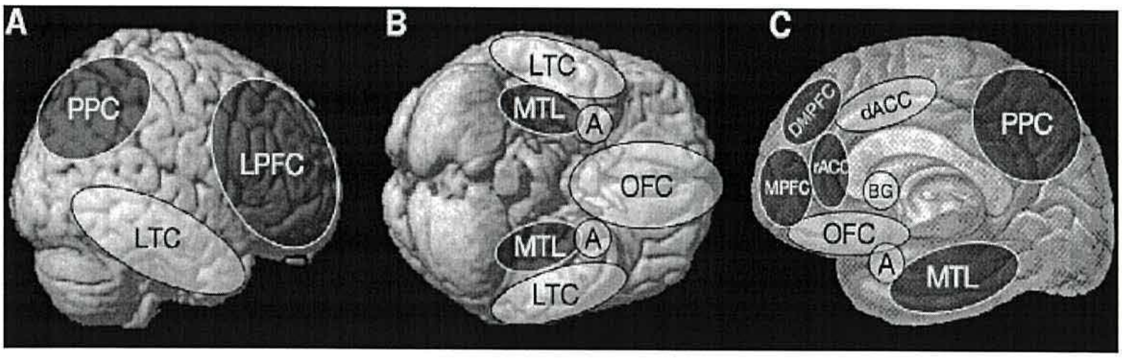


Figure 1. Important regions of the cortex for social cognition rendered from (a) lateral, (b) ventral, and (c) medial views. Areas highlighted include the posterior parietal cortex (PPC); lateral temporal cortex (LTC); lateral prefrontal cortex (LPC); medial temporal lobe (MTL); amygdala (A); orbitofrontal cortex (OFC); medial prefrontal cortex (MPC); basal ganglia (BG); rostral anterior cingulate cortex (rAAC); dorsomedial prefrontal cortex (DMPFC); and dorsal anterior cingulate cortex (dACC). Figure reproduced with permission from Elsevier (Sapute & Lieberman, Brain Research, 1079, 2006). Copyright Elsevier (2006).

An important finding from studies using tasks of complex decision-making is that areas involved in higher cognition, such as the orbitofrontal cortex, may be necessary for anticipatory functions that underpin social evaluation (e.g. Bechara et al., 1997), whereas lower subcortical areas (e.g., amygdala) are involved in the more reflexive processes of real-world decision making (e.g., Bechara et al., 1999; Sapute & Lieberman, 2006; see Figure 1).

Decision-making paradigms like the Iowa Gambling Task require learning through emotional feedback, sometimes called 'emotion-based learning' (Bowman, Evans, & Turnbull, 2005). This involves the establishment and modification of behaviour based on emotionally significant information acquired from previous experience. One aspect of this type of learning is the formation of flexible reward-response associations which enables the optimum actions to be engaged and so avoiding the most aversive outcomes. Such processes are therefore essential to maximise reproductive fitness (Rolls, 1999). Reward processing is fundamental to emotion-based learning and, therefore, this section will begin with a basic review of some of the fundamental studies focusing on relevant neural substrates (e.g., amygdala, orbitofrontal cortex, ventral striatum). This will set the stage for a review of work highlighting the importance of emotion in decision-making and social cognition.

Neural substrates of reward processing

Two areas of the cortex that are consistently shown to be important in emotional and social behaviour are the amygdala and orbitofrontal cortex (e.g., Adolphs, 2001, 2003; Brothers, 2002). As far back as the late 19th century, lesions of the primate temporal cortex were shown to result in aberrant social cognition (Brown & Shafer, 1888); however, it was the work of Kluver and Bucy (1937, 1939) that fully integrated the effect of lesions in this brain region into neuroscience. Primates possessing extensive lesions of the temporal cortex became fearless, investigated objects orally rather than with their hands, and exhibited hypersexuality. Subsequently, Weiskrantz (1956) demonstrated that the social dysfunction found in 'Kluver-Bucy syndrome' could be induced by focal lesions to the amygdala. A comparable disruption to social behaviour was found after lesions to the orbitofrontal cortex in primates (Butter, McDonald, & Snyder, 1969; Butter & Snyder, 1972). Thus, the amygdala and orbitofrontal cortex have long been linked to effective social cognition.

Of the neural regions known to be involved in emotional processing, the amygdala is perhaps the most studied (Killcross, 2000). Rather than being a homogenous structure, the amygdala consists of several functionally distinct nuclei. However, they are readily grouped into three major regions, the most important of which are the centromedial (CMA) and the basolateral nuclear groups (BLA). The BLA receives sensory information relevant for incentive motivation from various regions of the brain. Stimulus-affect associations can be stored by the BLA influencing physiological responses via the CMA - which connects to, for example, the hypothalamus and central grey. The BLA also influences complex instrumental behaviours via pathways to the ventral striatum and orbitofrontal cortex (e.g., Cardinal, Parkinson, Hall, & Everitt, 2002), and also has an essential function in the affective modulation of hippocampal- and caudate-dependent memory systems (Hamman, 2001; McGaugh, 2002).

Differential amygdala activation to rewarding and punishing stimuli has been demonstrated in a number of single-neuron studies (e.g., Ono & Nishijo, 1992; Rolls, 1992). Furthermore, studies in monkeys have indicated similar activity in instrumental learning tasks, particularly when behaviour is erroneous and results in aversive outcomes (Schoenbaum, Chiba & Gallagher, 1998). However, the abilities of the BLA are thought to be generally restricted to the evaluation of primary reinforcers and the initial learning of stimulus-reinforcement associations (Pickens et al., 2003; Rolls, 1992, 1999). Thus, the amygdala appears to be a core area for the initial processing of data concerning primary and secondary reinforcers. That is, fundamental emotional learning.

The orbitofrontal cortex (OFC) is also strongly implicated in emotion and is suggested to integrate emotional responses with visceromotor activity and sensory input (Rolls, 1999). The OFC has been shown to represent the reward value of food, for instance, monkeys will work for electrical stimulation of the orbitofrontal cortex only when hungry (Mora, Avrith, Phillips, & Rolls, 1979). Neurons in the OFC have illustrated the ability to rapidly reverse their responses when learned stimulus-reward associations have been similarly reversed (Rolls, 1992; Rolls, Critchley, Mason, & Wakeman, 1996). Moreover, the OFC contains neurons that; fire differentially for reward and punishment; evaluate the incentive value of particular stimuli; and signal the omission of an expected reward (Gallagher, McMahan & Schoenbaum, 1999; Rolls, 1996; Thorpe, Rolls, Maddison 1983; Schoenbaum et al., 1998). OFC neurons have also been shown to alter in response to episodes of learning with reinforcers (e.g., Gallagher, McMahan, & Schoenbaum, 1999; Schoenbaum, Chiba & Gallagher, 1999).

Consistent with the previous work is the evidence that OFC lesions in monkeys disrupt reward-related learning (e.g., Iversen & Mishkin, 1970; Izquierdo, Suda, & Murray, 2004), particularly when reward contingencies are reversed (Dias, Robbins, & Roberts, 1996), or incentive value reduced (Butter, Mishkin, & Rosvold, 1963). However, rather than the OFC being the site of stimulus-reward association reversals, it may well enable reversals in other regions of the brain, such as the amygdala (Schoenbaum & Roesch, 2005; Stalnaker, Franz, Singh, & Schoenbaum, 2007).

The BLA and OFC can be viewed as the executive control mechanism that evaluates salient stimuli and supports overt and covert emotional expression. Connections to the ventral striatum, particularly the nucleus accumbens (NAc; Cardinal, Parkinson, Hall, & Everitt, 2002; Haber, Kunishio, Mizobuchi & Lynd-Balta, 1995), are possible routes underlying covert emotional learning (Rolls, 1999). The NAc can be considered the "limbic-motor interface" (Morgenson, Jones and Yim, 1980), which underpins adaptive behavioural responses to environmental stimuli. Animal studies suggest that the NAc mediates responses to delayed rewards (Cardinal, et al., 2002), possibly via stored representations of previous reinforcer-relevant associations (Schultz, Tremblay & Hollerman, 2003). Moreover, the activity of striatal neurons is related to the value of expected rewards (Cromwell & Schultz, 2003), which can be readily reversed (Setlow, Schoenbaum, & Gallagher, 2003), much like the OFC. In fact, the reversal response of neurons in the ventral striatum is suggested to be mediated by the OFC (Rolls, 1999). The ventral palladium, which receives major connections from the ventral striatum, has also been implicated in the neural mechanisms underlying incentive motivation in animal studies (Tindell, Berridge, Aldridge, 2004), and may affect motivational processes by influencing connections to motor areas of the cortex (Haber, 2003).

Overall, these findings suggest that the OFC facilitates repeated relearning and reassessment of stimulus-reward associations optimising an organism's response to a constantly changing environment (Pickens et al., 2003; Rolls, 1996, 2000; Stalnaker, Franz, Singh, & Schoenbaum, 2007). As the orbitofrontal cortex has reciprocal projections to the BLA, it is likely that these connections enable updating of stimulus value initially processed by the amygdala (e.g., Pickens et al., 2003; Stalnaker, Franz, Singh, & Schoenbaum, 2007). The OFC may also influence behavioural output via connections to the ventral striatum. Therefore, animal studies suggest that the OFC has a crucial role in flexible goal-directed behaviour.

Human neuroscience of reward processing

The general findings in animal studies are consistent with human neuroimaging studies. For example, fMRI studies indicate differential OFC activity to rewarding and punishing stimuli (O'Doherty et al., 2001; Elliot, Friston, & Dolan, 2000). Human studies using the 'selective satiety' paradigm, where reinforcers (foods) are devalued through reaching satiety (Rolls, Rolls, Rowe, & Sweeney, 1981), show that this devaluing of stimuli is associated with OFC and amygdala activity (Kringelbach, O' Doherty, Rolls, & Andrews, 2003; O'Doherty et al., 2000).

Likewise, other studies show that the ventral striatum produces differential activations to rewards and punishments (Delgado et al., 2000; Elliot, Friston & Dolan, 2000; Knutson et al., 2005), particularly reward prediction and reward prediction error during emotion-based learning (O'Doherty et al., 2004; Pessiglione et al., 2006). Neuroimaging investigations also suggest that the ventral striatum and palladium may be involved in unconscious motivation (Pessiglione et al., 2007).

Again, these findings suggest that the amygdala and OFC track, represent, and update the incentive value of environmental stimuli, with the OFC promoting the rapid relearning of rewarding associations. Thus, the neural substrates underlying emotion-based learning would be expected to be important in situations requiring decisions under conditions of complexity and uncertainty. This kind of situation is especially common in real-world social behaviour. Indeed, studies with patients possessing lesions to these areas of the cortex provide crucial insights into neural substrates of social cognition.

Social & emotional behaviour following lesions of the human orbitofrontal cortex

Arguably, patients with lesions of the orbitofrontal frontal cortex have provided some of the most important advances in the understanding of complex social behaviour in recent times. Although the archetypal OFC patient, Phineas Gage, lived over 100 years ago, it was only in the last 30 years that the significance of his proposed lesion site and its associated behavioural impairments were highlighted (Damasio et al., 1994).

Phineas Gage was a foreman for a company involved in the construction of the American railroads in the mid-19th century who suffered a significant brain injury. Part of his duties involved the setting of explosives, and in 1848 this dangerous job finally took its toll. Distracted, he forgot to place a layer of sand above the explosive charge while setting the unstable package and struck rock. The resultant spark prematurely ignited the explosives and the tamping rod blasted through his left cheek, exiting the top of his skull, and apparently landing 30 yards away.

Remarkably, he survived the initial trauma and was seen to be conscious and speaking minutes later. He was then taken to be treated by the nearby doctor, John Martyn Harlow. Despite the fact that Gage suffered complications, he eventually recovered and Harlow noted that he seemed physically well with no reported head pain. Although, when documenting the injury, Harlow did note that Gage "…appears to be in a way of recovering if he can be controlled" (Harlow 1848/1999, p. 282), possibly foreshadowing his future difficulties. Phineas left Harlow's care and attempted to return to work sometime in 1849 (MacMillan, 2000, 2002). Before the accident Gage was a competent foreman, responsible and able. However, post-injury people noticed major changes in Gage's personality and behaviour. Following his death in 1860, Dr Harlow compiled his account of Gage's behavioural state in the *Journal of the Massachusetts Medical society* in 1868:

> Gage was fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, although untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart businessman, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was 'no longer Gage'.
> (Harlow, 1868, p. 339-340)

As a result of this altered demeanour, Gage never reclaimed his original position as a foreman in Vermont. Indeed, he is reported as having difficulty finding and keeping gainful employment for the remainder of his life. For a time he worked for P.T. Barnum's museum, showing his injury and the metre-long tamping iron. However, he apparently did work for several years as a coachman in Chile (MacMillan, 2000, 2002).

Phineas Gage provides the first documented case of the effects of a frontal lobe injury on social cognition. However, reports of Gage's post- and pre-injury behavioural status, and even the brain injury itself, are fairly vague (MacMillan, 2000, 2002). Although reconstructions of the injury and inferences from contemporary reports have led some to suggest that the trauma resulted in extensive bilateral damage of the ventromedial prefrontal cortex (Damasio et al., 1994), others question this interpretation (MacMillan, 2000; Ratiu et al., 2004).

Modern patients with injuries of the orbitofrontal cortex present a more reliable and detailed insight into their impaired social cognition, especially regarding their maladaptive social decision-making. For example, patient E.V.R. (Damasio, 1994; Eslinger & Damasio, 1985; Saver & Damasio, 1991) provides a well-documented case of the impact of significant lesions of the medial frontal lobes. Detailed examination illustrated his striking impairments of social behaviour which contrasted with his preserved intellectual abilities (non-emotional learning, memory, language, attention etc). E.V.R. was a successful 35 year old businessman, able father and husband. However, following the bilateral removal of his orbitomedial frontal cortex, due to meningioma, his social behaviour became atypical. He quickly lost his original job and those subsequent, became irresponsible with money (spending all his savings and becoming bankrupt), showed difficulty in making simple decisions, and his social relationships became strained (Damasio, 1994; Eslinger & Damasio, 1985). The behavioural outcome of damage to this area of the brain led Damasio to coin the term 'acquired sociopathy', due to the behavioural similarities between these two groups of individuals (Saver & Damasio, 1991).

Other reports of the consequences of damage to the medial region of the OFC are consistent with E.V.R.. For instance, these patients have been shown to exhibit inappropriate social behaviour such as kissing and hugging strangers (Rolls et al., 1994), and telling tasteless jokes (Stuss & Benson, 1984). Theory of Mind tests show that individuals with OFC lesions have impairments in inferring the mental states of other people (Beer et al., 2003; Blair & Cipolotti, 2000; Shamay-Tsoory et al., 2005; Shamay-Tsoory & Aharon-Peretz, 2007; Stone, Baron-Cohen, & Knight, 1998), which probably underlies failure on tests of empathy (Shamay-Tsoory et al., 2003). Moreover, these patients appear to show some deficits in making moral judgments (Ciaramelli, Muccioli, Làdavas & Pellegrino, 2007).

Patients with lesions of the OFC also show important emotional impairments such as difficulty in identifying facial emotions (e.g., Beer et al., 2003; Blair & Cipolotti, 2000; Hornak, Rolls, & Wade, 1996; Shaw et al., 2005) and a failure in generating skin conductance responses to emotional stimuli (e.g., Damasio, Tranel, Damasio, 1990, 1991). Thus, lesions of the OFC appear to lead to a number of important social and emotional deficits. However, the emotional impairment of these patients that had the greatest impact on the understanding of the neural basis of social cognition is that which underlies complex decision-making.

The role of affect in decision-making

Like many areas of cognitive psychology, the decision-making literature of the last few decades has generally viewed emotion as a minor interest, more a *destructive* influence than an integral component in the normal processes of human judgement (e.g., Toda, 1980; although, see, for example, Janis & Mann, 1977; Johnson & Tversky, 1983, for exceptions). However, more recently there has been a surge of interest in the importance of emotion in decision-making processes (e.g., Damasio, 1994; Forgas & East, 2003; Finucane, Peters, & Slovic, 2003). Much of this interest has focused on the impact of incidental affect, for example, background moods that are unrelated to the decision-making process itself (e.g., Clore, 1992; Isen, 1993; Lerner & Kelter, 2000). Although, probably most influential has been research showing that emotional dysfunction can have significant detrimental effects on the quality of decision-making (e.g., Damasio, 1994; Rahman et al., 2001).

As noted earlier, patients with lesions of the OFC, such as E.V.R., have been especially interesting due to their aberrant social cognition (Damasio, 1994; Eslinger & Damasio, 1985) and emotional deficits (Damasio et al., 1990, 1991; Hornak et al., 2003; Hornak, Rolls, & Wade, 1996; Shaw et al., 2005). In contrast to their intact intellectual abilities, this group of patients tend to make decisions that have a malign influence on their well-being and exhibit an inability to learn from these harmful decisions. Failure to hold down gainful employment, financial calamities, and strained relationships are a common aspect of their lives (e.g., Damasio, 1994; Dimitrov, Phipps, Zahn, & Graffman, 1999; Eslinger & Damasio, 1985). Additionally, these individuals can even show difficulty in making trivial decisions. For example, Damasio describes how even attempting to decide on a future appointment date became a chore for one patient:

> For the better part of a half-hour, the patient enumerated reasons for and against each of the two dates: previous engagements, proximity to other engagements, possible meteorological conditions, virtually anything that one could reasonably think about concerning a simple date...he was now walking us through a tiresome cost-benefit analysis, an endless outlining and fruitless comparison of options and possible consequences.
>
> Damasio (1994, p. 193)

The presence of both emotional deficits and impaired social decision-making, led Damasio to propose that patients with damage to the OFC, specifically the ventromedial prefrontal cortex (VMPFC), were unable to use emotions as a heuristic aid in decision-making (e.g., Damasio, 1994; Bechara, Damasio, Damasio, 2000).

The somatic-marker hypothesis

Real-life decision-making usually involves assessment, by cognitive and emotional processes, of the incentive value of the various actions available in particular settings. However, often situations require highly uncertain decisions between many complex and conflicting alternatives. Cognitive processes readily become overloaded under such circumstances, and may be unable to lead to a swift and adaptive outcome (Kahneman, 2003). The somatic-marker hypothesis proposes a mechanism by which emotional processes can guide (or bias) behaviour, particularly decision-making (Damasio, 1994; Damasio et al., 1991). Damasio suggests that somatic markers assist by simplifying the decision process, essentially acting as an 'affect heuristic' (Finucane, Peters, & Slovic, 2003). The somatic-marker hypothesis has met a mixed reception, but does provide an insight into the possible routes by which emotion can bias decision-making (see Dunn, Dagleish, & Lawrence, 2006, for a thorough review of its current status).

According to Damasio, reinforcing stimuli induce an associated physiological affective state relevant to that stimulus. These types of associations are stored as somatic markers, possibly in the VMPFC (Damasio, 1994). In future situations, pre-existing somatic-marker associations can be reinstated and readily bias cognitive processing. Thus, previous reward and punishment associated experiences with the relevant stimuli/options are summed to produce a net somatic state, which then directs (or biases) the selection of the most appropriate action (Damasio, 1999). This process can significantly simplify the decision process in settings of complexity and uncertainty. Indeed, such situations are a common feature of the social world.

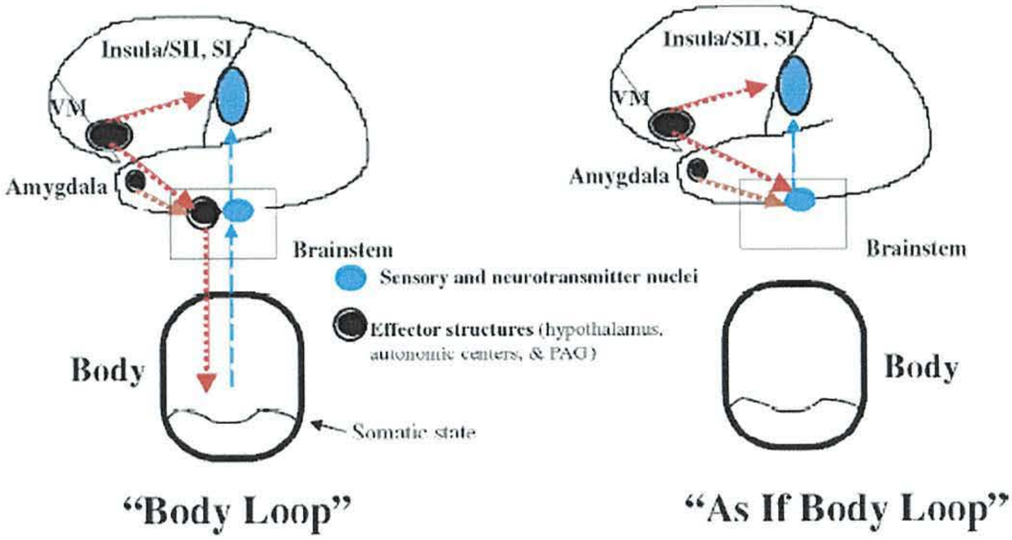


Figure 2. Diagrams illustrating the neural and somatic mechanisms proposed to underlie complex decision-making and social cognition in Damasio's somatic marker hypothesis. The 'body loop' mechanism includes a true input from the soma (left). Whereas the 'as-if' mechanism involves a neural representation of a previously experienced somatic state. Figure reproduced with permission from Elsevier (Bechara & Damasio, Games & Economic Behavior, 52 , 2005). Copyright Elsevier (2005).

The biasing of behaviour from somatic markers may occur overtly or covertly (e.g., Bechara, Damasio, & Damasio, 2000; Bechara & Damasio, 2005). Covert influences on behaviour are suggested to be underpinned by the brainstem and ventral striatum. Overtly, somatic markers would directly influence higher cortical cognitive processing. Furthermore, somatic markers may involve a true somatic state (i.e. bodily response; 'body loop') or a neural representation of a previous somatic state (i.e. no bodily response; 'as-if body loop'; see Figure 2). Bechara et al. (1999;

Damasio, 1999) suggest that the amygdala and VMPFC are essential components of this hypothesised mechanism, and therefore damage to either structure will disrupt the processes underpinning somatic-marking.

Testing the Somatic Marker Hypothesis

In a quest to produce a simple neuropsychological tool that would adequately assess the obvious deficits in emotional processing, decision-making, and social skills of individuals with VMPFC lesions (Damasio, Tranel & Damasio, 1991; Rolls et al., 1994), Bechara et al. (1994) created the Iowa Gambling task (IGT). Their aim was to produce "[a] task which simulates in real time, personal real-life decision-making relative to the way it factors uncertainty of premises and outcomes, as well as reward and punishment" (p. 8).

The IGT requires participants to freely select cards from one of four decks, each of which possess a complex contingency of financial rewards and punishment. Two decks supply small financial gains but even smaller losses ('good' decks), whereas the other two decks provide larger gains but even larger losses ('bad' decks). Advantageous decision-making on the Gambling Task is revealed by learning to forego the larger immediate financial rewards provided by the bad decks, in favour of the smaller but consistent long-term gains of the good decks (see Chapter 2 for a review of IGT studies).

The new task performed as expected under experimental conditions when comparing a group of participants with VMPFC lesions to non-lesion controls. Generally, all participants initially selected across the four decks until attracted by the larger gains of the bad decks. However, typical non-lesion controls started to learn that the high paying decks were ultimately disadvantageous in the long-term. In response to this, control participants generally started to switch to, and choose preferentially from, the lower paying good decks, and only on rare occasions selected from the bad decks. In contrast, the VMPFC participants did not indicate the same pattern of learning and persisted in choosing preferentially from the bad decks, leading to large financial losses. Thus, the behavioural performance of this group of patients mirrored the poor decision-making common in their everyday lives.

To provide a much needed objective physiological indicator of the poor behavioural performance on the IGT by patients with VMPFC lesions, Gambling Task studies were conducted using skin conductance responses (SCRs). SCR enabled a measure of autonomic changes to the somatic state during the imposed rewards and punishments (e.g., Bechara et al., 1997). The SCR measurements indicated that both groups of participants produced autonomic responses when rewards and punishments were received, although the VMPFC participants' SCRs were of a lower magnitude than the non-lesion controls. However, the major finding of these studies was that the controls gradually developed anticipatory SCRs when contemplating choosing a card from the bad decks, whereas, the VMPFC participants indicated no comparable anticipatory SCRs throughout the task. The explanation provided by Bechara et al. (1996) for the lack of anticipatory SCRs was that these individuals could not alter their somatic state in relation to their experience with reinforcers. This was suggested to be due to a dysfunctional VMPFC which, as proposed by Damasio, Bechara and colleagues, is essential for guiding behaviour towards the optimal decisions under situations of complexity and uncertainty.

A later study assessing the effect of amygdala lesions on IGT performance yielded further support for the somatic-marker hypothesis (Bechara et al., 1999). Participants with bilateral amygdala lesions showed both impaired performance on the IGT and no evidence of anticipatory SCRs. However, important differences between VMPFC and amygdala lesion participants were evident; namely, the amygdala group also failed to produce reward and punishment SCRs. Bechara et al. (1999) cite this as evidence that the amygdala and VMPFC perform different but complementary roles in the process of 'somatic marking'.

Bechara et al. (1997; see Figure 3) involved collecting subjective information from the participants regarding their understanding of the nature of the task. The investigators defined four distinct stages of the participants' experience of the IGT.

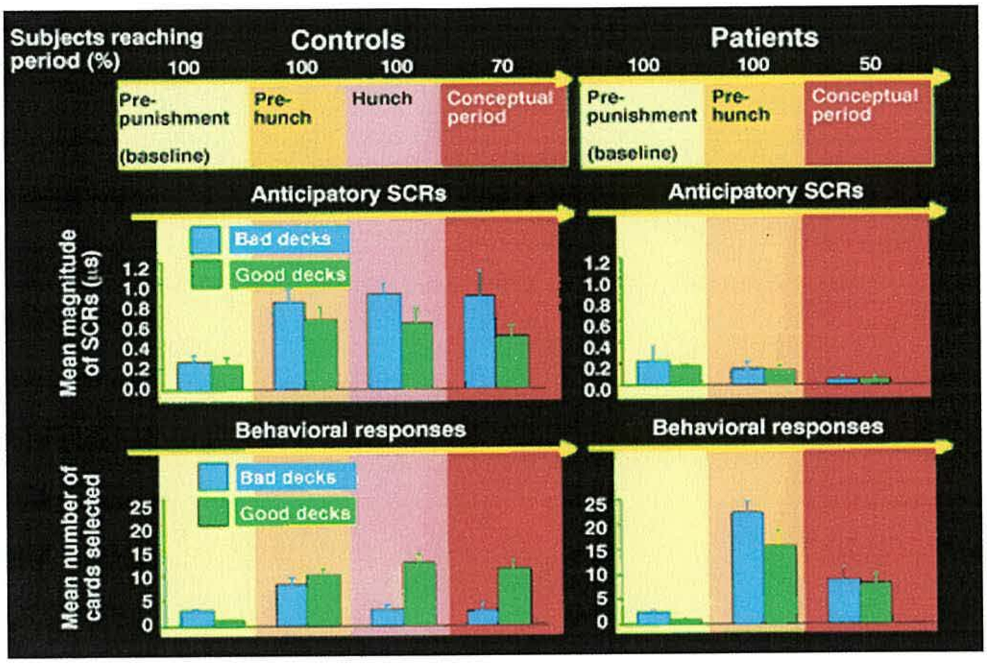


Figure 3. Behavioural and physiological data from Bechara et al. (1997) for control participants (left) and VMPFC patients (right). Top box shows the task phases which represent the level of explicit knowledge of optimal strategy. The hunch stage is when participants correctly expressed basic, but uncertain, knowledge of the good and bad decks (ca. selections 50-80). No patients reached this stage, although some did reach an understanding of the optimal strategy (conceptual stage). Discriminating anticipatory SCRs developed during the pre-hunch in normal participants, which were absent in all stages for patients. Reproduced with permission from AAAS (Bechara et al., 1997) Copyright AAAS (1997).

The first stage was deemed the pre-punishment stage, during which no punishments had been received and no anticipatory SCRs produced; the pre-hunch stage involved experience of some losses and the initial development of anticipatory SCRs to the bad decks; the hunch stage occurred after approximately 50 cards with a proportion of participants realising that some decks were riskier than others, anticipatory SCRs were produced for both bad decks; the conceptual stage occurred following 80 cards, 70% of the controls understood the task nature - namely, that long-term, two decks were good but the other two were risky.

Subsequent choices of conceptually aware participants were from the good decks, and significantly greater SCRs were produced when contemplating selections from the risky decks compared to the 'safe' decks. Three of the controls failed to reach the conceptual phase but all still performed well. Conversely, three VMPFC participants gained conceptual awareness of the contingency but ignored their explicit knowledge of task nature, and still preferred to select cards from the bad decks. Bechara et al. suggested that as anticipatory SCRs preceded conceptual awareness, somatic markers can aid cognitive processing of uncertain and unpredictable decisions at an implicit level.

As noted earlier, Damasio's theory has attracted criticism (Dunn, Dagleish, & Lawrence, 2006; Rolls, 1996, 1999 2005); however, it does focus on some of the *neural* mechanisms that may well underlie the biasing of behaviour from pre-existing affective phenomena, such as prejudicial attitudes. The orbitomedial PFC (including the ventromedial PFC) seems particularly relevant in this regard, as this area has been suggested to be involved in both social cognition and emotion-based learning. For example, overcoming prejudice requires reversal of pre-existing emotional associations underlying the well-established negative evaluations. Indeed, a recent study did show that evaluative conditioning can ameliorate prejudicial attitudes (Fazio & Olsen, 2003). In this regard, of considerable interest is the recent proposal that the ventromedial PFC might be involved in the application of social knowledge (Grafman, 1995; Milne & Grafman, 2001).

The ventromedial prefrontal cortex and social knowledge

Earlier, lesions of the ventromedial PFC were shown to commonly result in significant disruption of social behaviour while preserving intellectual abilities (e.g., Damasio, Tranel, & Damasio, 1990; Eslinger & Damasio, 1985; Hornak et al., 1996; Rolls et al., 1994). However, studies with one patient in particular, E.V.R., indicated that lesions to this area of the cortex had little effect on measures of explicit social cognition (Saver & Damasio, 1991). This finding suggests that although these patients are unable to apply socially relevant knowledge in the social world, they can still access and apply it in some laboratory tests of social cognition.

More recent studies question this interpretation (Dimitrov, Grafman, & Hollnagel, 1996; Mah, Arnold, & Grafman, 2005). For example, Dimitrov, Grafman, & Hollnagel (1996) showed that some patients with VMPFC lesions do exhibit impaired ability to use socially relevant knowledge. Such findings led Grafman (1994, 1995; Milne & Grafman, 2001) to propose that the VMPFC can be viewed as 'a repository of social knowledge that is required for managing personal interaction' (Milne & Grafman, 2001, p. 1).

Thus, lesions to this area of the frontal lobe would be expected to disrupt access to social knowledge and result in aberrant social behaviour. Milne and Grafman (2001) tested this hypothesis by assessing a group of patients with lesions of either the ventromedial or dorsolateral PFC on a gender version of the Implicit Association Test (IAT; Rudman & Kilianski, 2001). As stereotypes are readily considered a form of social knowledge, this approach could be expected to provide a valuable insight into the effects of frontal lesions on socially salient information. Individuals without access to socially learned gender stereotypes should show significantly less implicit stereotyping compared to those with intact access to this well-embedded social schema.

The results were in accordance with Grafman's proposal. Compared to those without VMPFC lesions, those patients with these lesions exhibited a much reduced IAT effect. One explanation of these findings is as proposed by Grafman (1994; 1995; Milne & Grafman, 2001), that lesions to the VMPFC hinder access to socially relevant knowledge, in this case, gender stereotypes. The results of Phelps et al. (2000), where amygdala activity was positively correlated with implicit race bias on the IAT, lead Milne & Grafman (2001) to further suggest that the amygdala and VMPFC are involved in a network underlying the 'processing of social cues and knowledge' (p. 6).

However, one issue that was overlooked in Milne and Grafman's study is the presence of reversal learning in the IAT. One important aspect of IAT methodology is that the effect is produced by comparing response times between the stereotypically congruent association (i.e. Male-Strong; Female-Weak) and the incongruent association (Male-Weak; Female-Strong). This is achieved in two separate experimental blocks, with a *reversal* practice block in between aiming to weaken the original learned association. It is quite possible that these results are confounded by associations learned in the initial block, as deficits in reversal learning of affective associations are one of the more well-established outcomes of VMPFC lesions (e.g., Rolls et al., 1994; Fellows & Farah, 2003). Thus, the inflexibility of learned affective associations as an explanation for Milne & Grafman's data is more consistent with current understanding of VMPFC function. Although this does raise the important question as to how this area of cortex (i.e. the orbitofrontal cortex) contributes to the formation and flexibility of social attitudes that are known to be laden with affect (Allport, 1954/1979).

Emotion and social attitudes

> Many southerners have confessed to me, for instance, that even though in their minds they no longer feel prejudice towards blacks, they still feel squeamish when they shake hands with a black. These feelings are left over from what they learned in their families as children
> (Pettigrew, 1987, p. 20)

Other human beings are the most important objects in the world with which we interact, and accurately evaluating other people is essential for optimal social behaviour. However, the social world is remarkably complex, and as cognitive 'misers' or 'motivated tacticians' (Fiske, 2004) we tend to categorise and simplify our understanding of other people: most obviously by classifying them into groups. Indeed, Allport's (1954/1979) proposal that pre-judgement of other people is a normal social process, rather than some personal aberration, showed considerable foresight. Half a century later, the role of such pre-existing biases in social cognition is well-established (Devine, 1989; Fiske, 2005; see Fiske, 1998, for a review).

Whilst the application of simplifying mechanisms is a sound approach for efficient human cognition, heuristic processes are not always effective, and may underlie many forms of inaccurate and apparently irrational decision making (e.g., Tversky & Kahneman, 1974; Kahneman, Tversky, & Slovic, 1982). The unnecessary over-reliance on these error-prone mechanisms is further complicated by the prospect that these pre-existing biases may, in many circumstances, lie beyond conscious awareness (e.g., Devine, 1989; Fazio, Jackson, Dunton, & Williams, 1995). The increased focus on covert prejudice has sparked a growing interest in the neurobiological basis of prejudice and an awareness of the importance of emotion-based, and emotion-regulating, neural processes. However, it seems that Allport (1954/1979) had laid the basis for these findings decades earlier in stating, "...defeated intellectually, prejudice lingers emotionally" (p. 328). Accordingly, this section will begin by outlining some characteristics of social attitudes. Subsequently, discussion will turn to recent studies providing a basic understanding of the neural substrates underlying prejudicial behaviour. Finally, an evaluation of some recent investigations of social attitudes will be presented.

The emotional nature of prejudice and attitudes

It has long been understood that social categorisation of outgroups is saturated with affect (Allport, 1954/1979), and contemporary views continue to conceive intergroup bias as an emotionally mediated process (Cottrell & Neuberg, 2005; Fiske et al., 2002; Smith, 1993. This is intrinsic to the conception of prejudice as a positive or negative evaluation of a target object (e.g., Allport, 1954/1979; Mackie & Smith, 1998). However, emotion and affect have, to an extent, been neglected in social categorisation and prejudice (Fiske, 2005), possibly due to the focus on the more cognitive aspects of social behaviour.

The contemporary view of the structure of attitudes involves a triad of components: affective, cognitive, and behavioural/conative (Zanna & Rempel, 1988; Eagly & Chaiken, 1998). Thus, the cognitive component includes thoughts and beliefs about the target; the affective focuses on feelings and emotional responses; and the behavioural on actions, past and present. Although all three components are essential to fully account for attitudes, in contrast to the classic tripartite model (Katz & Stotland, 1959; Rosenberg & Hovland, 1960), particular attitudes may be developed and/or expressed through a single component (Chaiken, Pomerantz, & Giner-Sorolla, 1995; Eagly & Chaiken, 1998).

The primary response to objects, however, may be predominately emotion-based (e.g., Bargh & Chartrand, 1999; Ortony, Clore, & Collins, 1988; Zajonc, 1980). Furthermore, it is now well-established that, in many circumstances, affect has a greater impact on attitudes than cognition (Eagly, Mladinic, & Otto, 1994; Esses, Haddock, & Zanna, 1993; Miller & Tesser, 1986). Indeed, the cognitive representations underlying stereotyping can be enhanced (e.g., Esses & Zanna, 1995) or moderated (e.g. Dovidio et al., 1998) by emotion. Similarly, studies show that, while emotion facilitates the formation of prejudice (DeSteno et al., 2004), it can also help to ameliorate these same attitudes (Brown & Hewstone, 2005). Moreover, at an individual level susceptibility to the formation of negative emotional associations may underpin racial bias (Livingston & Drwecki, 2007).

Recent studies have now begun to uncover the complex nature of emotion in intergroup behaviour, showing that, rather than attitudes being uniform evaluations of one particular valence, emotions may differ qualitatively according to group (e.g., Cottrell & Neuberg, 2005). Moreover, that attitude objects may evoke both negative and positive evaluations (e.g., Cacioppo & Berntson, 1994). For example, Cottrell and Neuberg showed that although Asian Americans, African Americans, and Native Americans are all negatively evaluated by European Americans, the groups can be differentiated by the specific types of negative emotion they evoke (e.g. African Americans evoked significantly more fear/anxiety than either of the other outgroups).

Traditionally, attitudes were conceived as being positioned along a bipolar dimension of valence (Thurstone, 1928). More recent conceptions accept that in many cases objects may evoke both positive and negative evaluations, suggesting the existence of attitudinal ambivalence (Caccioppo & Bernston, 1994; Preister & Petty, 1996). Conflicting evaluations may under certain circumstances require integration into an overall weighted attitude using a relatively taxing deliberative processing (e.g., Jonas, Diehl, & Brömer, 1997; van Herrevald et al., 2000; van Herrevald et al., 2004). However, a more efficient process involving the retrieval of pre-existing evaluations relating to known objects is suggested to suffice in most situations (e.g., Bargh, Chaiken, Govender, & Pratto, 1992; Chaiken & Bargh, 1993; Fazio & Olsen, 2003).

Although knowledge about the structure and function of attitudes has progressed considerably over the last 50 years, the central role for emotions in generating and maintaining prejudicial attitudes remains widely accepted, but surprisingly neglected (Fiske, 2005 p. 48). Indeed, the complexity and range of influence of emotions in social behaviour is now being uncovered. One advance that had a major impact on the modern view of attitudes and prejudice is the distinction between implicit and explicit processes (e.g., Devine, 1989; Greenwald & Banaji, 1995; Wilson, Lindsey, & Schooler, 2000).

The dual process view of prejudice

Over the last 40 years, legislative changes protecting the rights of minorities have coincided with a change in attitudes to minority groups, at least when measured by explicit self-report (e.g., Greeley & Sheatsley, 1971; Schuman, Steeh & Bobbo, 1985). However, despite a reduction in the extent of self-reported racial prejudice, there appears to be no associated decrease in racially-aggravated crime, which in some instances is found to be on the increase (Criminal Prosecution Service, 2006). It may be that because prejudice has become socially undesirable our society has moved to more covert, subtle, and indirect expressions of prejudicial behaviour (e.g., Devine, 1989; Fazio, Jackson, Dunton, & Williams, 1995). However, recent community surveys do show that perceptions of increasing racial bias in England and Wales have reached record levels over the last few years (Department for Communities and Local Government, 2007).

Contemporary social psychology has attended to the distinction between the implicit and explicit forms of racial bias, with implicit processes viewed as being unconscious and automatic, remaining even when egalitarian social norms are publicly accepted (Devine, 1989; Fazio et al, 1995). Thus, some people can explicitly and sincerely support egalitarian principles, but still hold negative feelings and attitudes towards minority groups that lie outside of full conscious awareness (Devine, 1989; Dovidio et al., 1997; Dovidio & Gaertner, 1998; Fazio, Jackson, Dunton, Williams, 1995). Others may not personally endorse these social norms, yet explicitly act in a way that conforms to public expectations (e.g., Dovidio & Gaertner, 1998). In most circumstances these subtle automatic biases remain fairly well-controlled (Monteith, Ashburn-Nardo, Voils, & Czopp, 2002; Richeson et al., 2003). However, they may still have an important influence on aspects of social behaviour (e.g., Correll et al., 2007; Hugenburg & Bodenhausen, 2003, 2004).

Since the initial suggestion of an implicit-explicit distinction in prejudicial processes (Devine, 1989), several methods to indirectly measure implicit biases have been developed (e.g., Dovidio et al., 1997; Fazio et al., 1995; Olsen & Fazio, 2003; Greenwald, McGhee, & Schwartz, 1998). The Implicit Association Test (IAT) has become the foremost of these measures (Devine, 2001; Greenwald, McGhee, & Schwarz, 1998), due to its high predictive validity on various criterion measures of prejudice (e.g. judgements, choices, behaviours, and physiological responses; McConnell & Leibold, 2001; see Poehlman, Uhlmann, Greenwald, & Banaji, submitted, for a review).

Thus, modern attitudes to minorities may be more complex than previously thought, for instance, involving a tension between negative automatic biases and positive controlled reactions: so-called 'aversive racism' (Dovidio & Gaertner, 1998; Greenwald & Banaji, 1995). This increased focus on covert prejudice has sparked a growing interest of the neurobiological basis of prejudice and an awareness of the importance of emotion-related, and emotion-regulating, neural processes.

Social neuroscience of prejudice

Recently, the tools of neuroscience have been applied to understand the neural correlates underlying racial prejudice and related processes (Eberhardt, 2005; Cunningham & Zelazo, 2007). Consistent with the likely importance of emotion for prejudice (e.g., Amodio, Devine, & Harmon-Jones,, 2003), studies clearly show the involvement of the amygdala in the processing of race-related information (e.g., Hart et al., 2000; Cunningham et al, 2004; Wheeler & Fiske, 2005), including the finding that amygdala activity was positively correlated to implicit bias (as measured by the IAT; Phelps et al., 2000). Moreover, Lieberman et al. (2005; see Figure 4) showed that European *and* African American participants exhibited enhanced amygdala activity to Black faces, suggesting this response was more than a response to novelty (c.f. Hart et al., 2000).

The involvement of the amygdala in other forms of social judgement is also well-established (e.g., Adolphs, 1999; Winston, Strange, O'Doherty, & Dolan, 2002). For example, individuals with bilateral lesions to the amygdala where found to judge faces as more trustworthy and approachable than a group of non-lesion control, this particular deficit was most obvious in faces rated most negatively (Adolphs, Tranel, & Damasio, 1998). Thus, the amygdala appears to be involved in the processing of many forms of socially salient stimuli.

However, emotional and affective processes are not *restricted* to this area of the medial temporal lobe (Davidson & Irwin, 1999). For example, a recent study (Phelps, Cannistrasi, Cunningham, 2003) suggests that bilateral amygdala lesions may have *no* effect on implicit bias, as measured by the IAT. Indeed, Brothers' (1990) seminal essay identified the orbitofrontal cortex, temporal cortex, and anterior cingulate cortex, along with the amygdala, as candidate structures for the neural basis of social cognition.

A series of additional functional imaging studies demonstrate that other brain areas likely to be important for the expression of prejudice are also neural regions that *manage* and *regulate* core emotion systems. For example, Lieberman et al. (2005) differentiated between verbal encoding (determining race) and perceptual encoding (matching best-fit faces; see Figure 4) in an fMRI study of race-based processing.

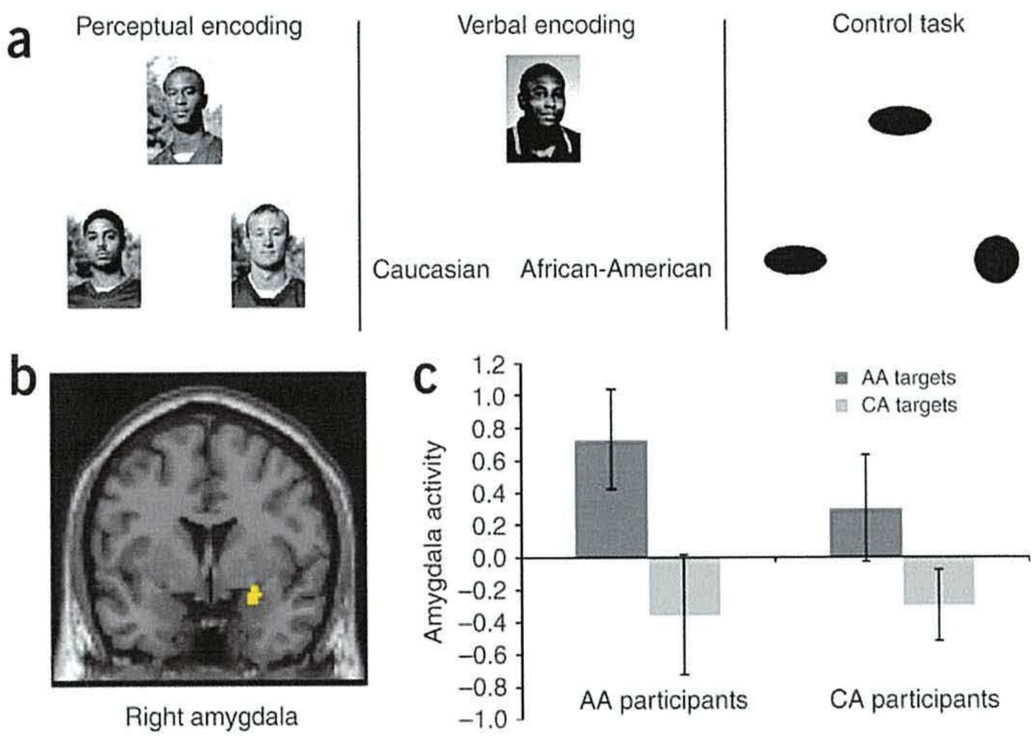


Figure 4. Task and amygdala responses.
(a) Examples of perceptual encoding, verbal encoding, and control task used. (b) This region of the amygdala showed enhanced activity when viewing Black faces in both experimental conditions across participants regardless of race. (c) Differences in right amygdala signal intensity in each participant group for race of stimuli during perceptual encoding condition. Reprinted by permission from Macmillan Publishers Ltd: Nature Neuroscience (Lieberman et al., 2005, 8, 720-722), copyright 2005.

Their results showed that during verbal encoding of race, the right ventrolateral prefrontal cortex appeared to play an inhibitory role by modulating the amygdala (see Figure 5). This finding is consistent with the proposed inhibitory function of this area of the frontal cortex (e.g., Aron, Robbins, & Poldrack, 2004).

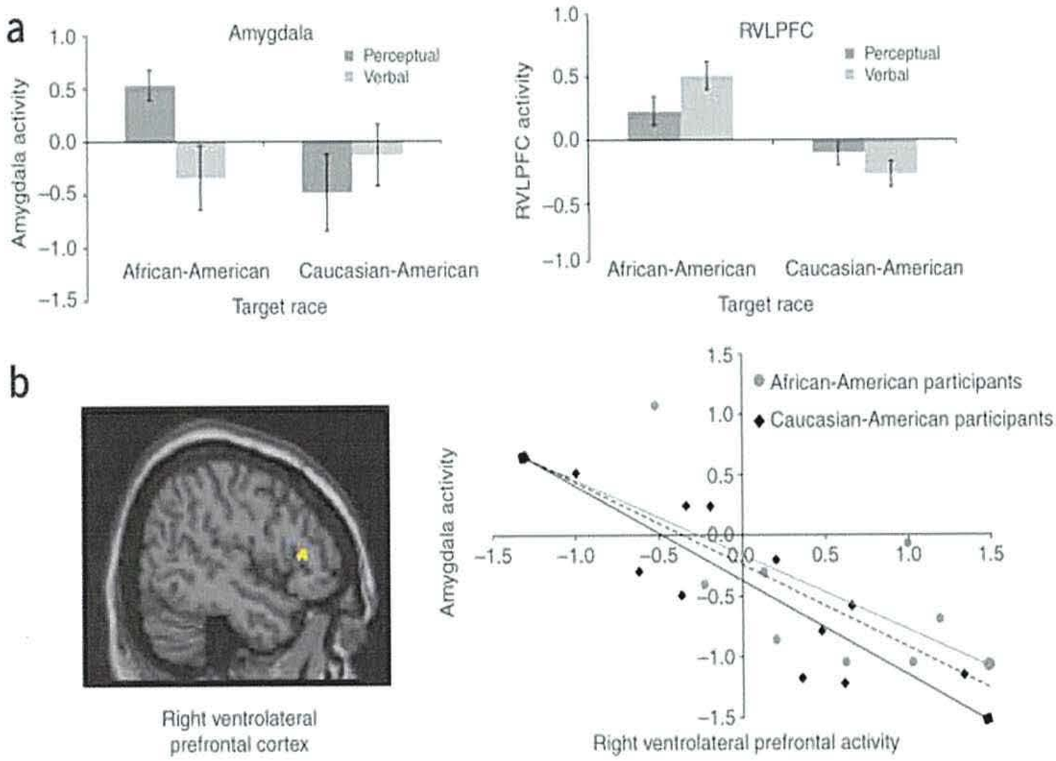


Figure 5. Amygdala and RVLPFC responses to target race and encoding task.
(a) Amygdala and right ventrolateral PFC activity for both participant groups in both experimental conditions. (b) Correlations between Amygdala and RVLPFC activity for African American faces (Dashed line – all participants; diamond markers – European American; circle markers – African American). Reprinted by permission from Macmillan Publishers Ltd: Nature Neuroscience (Lieberman et al., 2005, 8, 720-722), copyright 2005.

Richeson et al. (2003) indicated a similar inhibitory role for right dorsolateral prefrontal cortex (DLPFC). In this particular investigation, individuals expressing high levels of implicit race bias were found to show greater right DLPFC and right anterior cingulate cortex (ACC) activity when viewing novel black faces. Moreover, right DLPFC activity predicted impairment on a Stroop task. These results have been interpreted as showing 'resource depletion', whereby people who hold negative evaluations of racial outgroups are forced to utilise executive resources to regulate emotional biases during social interaction. Use of this executive control would enable suppression of pre-existing racial bias to conform to prevailing social norms (also see Richeson & Shelton, 2003).

Consistent with Lieberman et al. (2005) and Richeson et al. (2003), Cunningham et al. (2004) found activation in the right DLPFC, right VLPFC, and the ACC when European Americans consciously viewed black faces. Whereas, when the same faces were presented implicitly (30ms), response was predominately found in the amygdala, again suggesting that these regulatory areas are used to control and inhibit negative race evaluations.

One neural area that is consistently implicated in social cognition is the medial prefrontal cortex (MPFC; see Amodio & Frith, 2006 and Lieberman, 2006, for reviews). The anterior rostral region of the MPFC is found to be involved in tasks that require self-knowledge (e.g., Ochsner et al., 2004), person perception (e.g., Gobbini, LeibenLuft, Santiago, & Haxby, 2004), and mentalising (e.g., Grezes, Frith, & Passingham, 2004). Therefore, it is unsurprising that studies show MPFC activity when viewing faces of outgroup members (Harris & Fiske, 2006a), including those of different race (Wheeler & Fiske, 2005). Most remarkably, Harris and Fiske (2006a, 2006b) found that some outgroups (e.g., homeless people) invoked MPFC activity comparable to that of inanimate affective objects, so that certain groups appear to have become 'dehumanised'.

Thus, neurobiological studies suggest the integration of reflexive and reflective processes in social evaluation, with an important role for emotion and emotion–regulating neural processes. However, behavioural investigations of prejudice-related processes have been somewhat hampered by the use of relatively simple stimulus-driven methodologies. These typically fail to capture the complex nature of social biases with sufficient ecological validity.

Real-world complexity and social biases

An understanding of how pre-existing attitudes affects judgements and decisions, and how these attitudes are formed and altered by experience, is essential for a thorough insight into social behaviour. Adequate methods to account for the complexity and ambiguity of the social world are sparse due to difficulties in maintaining a suitable degree of experimental control.

Some studies involve basic stereotypical judgements, for instance, investigating how racial bias alters the perception of facial affect (Hugenburg & Bodenhausen, 2003, 2004). In Hugenburg and Bodenhausen (2003) this was achieved using a technique where faces were morphed from happiness to anger, and *vice versa*. Participants were required to signify the moment they perceived the onset/offset of anger. Their results showed that European American participants were quicker to perceive anger in a Black face, than in a face of their own social group. Furthermore, implicit prejudice was found to be positively correlated to this biasing of facial perception. This type of bias might have important consequences in speeded judgements, such as shoot/no-shoot situations and weapon identification (e.g., Correll, Park, Judd, & Wittenbrink, 2002; Correll et al., 2007; Payne, 2001). While such studies provide a valuable insight into how prejudice infuses into lower level cognitive processes, particularly in situations of uncertainty and ambiguity, it is unclear how such automatic biases transfer into the *complexity* of everyday real-world interactions.

Other studies have assessed the formation and malleability of implicit attitudes and prejudice (Fazio, Eiser, & Shook, 2004; Olsen & Fazio, 2006; Gregg, Seibt & Banaji, 2006; see Blair, 2002, for review). Gregg, Seibt, and Banaji (2006) investigated the formation and reversal of social attitudes. This involved the association of either positive or negative information with two pseudo-social groups. The initial association phase showed that self-reported and implicit attitudes congruent to the imposed group valence were readily induced. However, when an attempt was made to reverse the initial attitudes, they found that the implicit preferences were particularly resistant to change, whereas self-reported attitudes were readily reversed. Thus, in this case, implicit attitudes tended to be inflexible (although, see Blair, 2002) indicating an asymmetry between the explicit and implicit forms of attitude.

Fazio, Eiser, and Shook (2004) were particularly interested in the formation of attitudes over time under conditions that allowed participants to freely explore the nature of a number of novel objects. The task involved learning about the valence of a series of 'beans' with varying physical characteristics (number of spots) which provided positive or negative 'energy' outcome feedback. This essentially resulted in approach or avoidance behaviour. The results of a series of experiments showed that participants readily learned and formed attitudes related to the valence of the objects. Moreover, they also found that learning was more effective for objects with negative valence than those with positive, and that negative attitudes were more likely to generalise to different but similar novel objects. Indeed, the study was a good demonstration of negativity bias (e.g., Baumeister et al., 2001) in the formation of attitudes.

The role of pre-existing affective bias in complex decision-making

Thus far, this review has stressed the importance of emotion in two areas of psychology that have been viewed as fairly distinct, although both are integral to human social behaviour. The emotional basis of social attitudes has been established for decades (e.g., Allport, 1954/1979), although, until recently, neglected (Fiske, 2005, p. 48). With emotion now seen as one of the many essential psychological processes underlying decision-making (e.g., Damasio, 1994), it is possible to use such knowledge and approaches from the decision-making literature to improve on limitations found in studies of real-world social cognition.

Complexity

One issue that was raised earlier in the review of the social cognition literature was the difficulty in assessing the impact of social attitudes, such as prejudice, under experimental conditions adequately modelling the complexity of everyday life. It appears that many previous investigations of racial bias and attitudes have predominately used simple contingency relationships, or relatively basic social judgements. These typically involve the mapping of social groups to simple good-bad valence measures, where the magnitude of the negative and positive valence is uniform (e.g., Fazio, Eiser, & Shook, 2004; Gregg, Seibt, & Banaji, 2006).

For example, in the Gregg, Seibt, and Banaji (2006) study of implicit biases for pseudo-social groups, the groups were depicted in either an *exclusively* positive or negative light, whereas real-world social cognition involves encountering agents that may possess *varying* affective valence, and even both good and bad characteristics (c.f. Cunningham et al., 2003; Cacioppo & Bernston, 1994).

Ambiguity and ambivalence

A second characteristic of the simplicity of previous investigations has been their absence of ambiguity over time. For example, in the Fazio, Eiser, and Shook (2004)

'BeanFest game', each bean possesses either positive or negative incentive value that remains consistent across the duration of the task. Again, real-world social evaluation involves encountering agents that develop, and ultimately come to possess, ambiguous and ambivalent characteristics (e.g., Cacioppo & Bernsten, 1994; Cunningham et al., 2003). Thus, an appraisal of a well-known individual (such as Tony Blair) may well evoke both negative and positive affective evaluations, potentially producing a net weighted attitude.

Newer measures of decision-making ability have employed more ecologically valid and sophisticated contingency relationships. For example, the widely employed Iowa Gambling Task (IGT; Bechara et al., 1994) was specifically designed to capture the complex and ambiguous emotional histories that characterise everyday human interactions. However, more ecologically rich measures such as the IGT have not yet been employed to study prejudice-related processes.

The IGT aims to assess the complexity, and high level of uncertainty, common in social cognition (e.g., Bechara et al., 1994). The task relies on the development of object-related affect, via the personal experience of financial reward and punishment (Bowman, Evans, & Turnbull, 2005; Maia & McClelland, 2005), with decisions based on objects (decks) that at the outset possess *no* affective value. However, it has long been assumed that the majority of environmental stimuli elicit emotion in a rapid, uncontrolled, and perhaps unconscious, fashion (e.g., Zajonc, 1980). Moreover, in situations of ambiguity, real-world decisions are readily influenced by *pre*-existing affective biases, of which the most obvious example is racial prejudice (e.g., Dovidio & Gaertner, 2000). The IGT may well provide a suitable method of assessing the effect of such socially derived emotional biases under complex conditions.

In sum, the current literature assessing how pre-existing attitudes affect social decisions has a number of limitations, principally these are related to the question of ecological validity, in that the research findings do not model both the complexity and ambiguity that is central to real-world interactions. Importantly, these studies also lack an explicit link to the role of emotion in prejudice. These limitations can be overcome by the use of measures such as the Iowa Gambling Task, which was specifically designed to model the complexity and ambiguity common to social decision-making. This tool also has the advantage of being embedded in a developing literature on the neurobiology of emotion-based decision-making.

The present series of investigations assess how pre-existing attitudes affect behaviour using the Iowa Gambling Task, where the incorporation of emotional labels allows modelling of the effects of prejudice on complex decision-making over time, under conditions of complexity and ambiguity. Firstly, Chapter 2 will include a pertinent review of the Iowa Gambling Task itself. Next, a study assesses how emotionally salient pictures might bias decision making (Chapter 3; Experiment 1). In this initial investigation, stimuli were taken from the International Affective Picture System (IAPS; CSEA, 2001) and associated with the task decks. The second phase assesses how socially salient stimuli bias complex decision making by using faces of African and European descent (Chapter 4; Experiment 2). A subsequent experiment examines whether decision-making biases produced during the race variant of the Iowa Gambling Task correlate with well-established measures of explicit and implicit racial bias (Experiment 3). A third set of investigations assess how non-race social stimuli affect performance on this variant of the Gambling Task (Chapter 5). In these experiments the emotional bias is induced by manipulating facial attractiveness (Experiment 4) and trustworthiness (Experiment 5). The final experiment is a study involving a small sample of patients with lesions of the orbitofrontal cortex on the emotionally salient IAPS variant of the Gambling Task (Chapter 6; Experiment 6).

Chapter 2

The Iowa Gambling Task: An interface between affect and cognition

A man of intelligence feels what others can only know

(Montesquieu, 1892, p. 135)

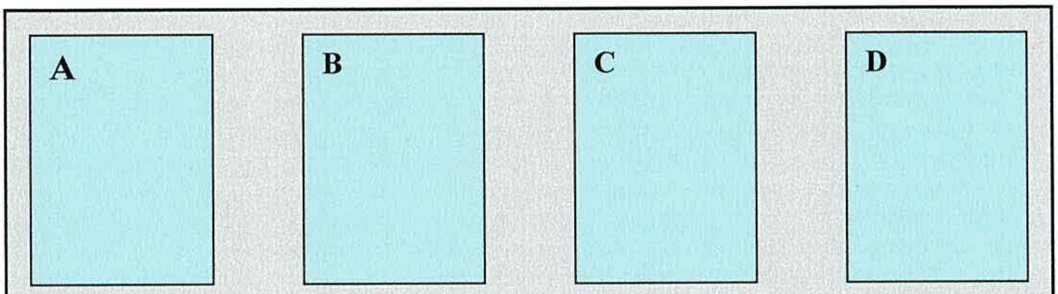
The extent and utility of conscious control in decision-making has been questioned in recent years, notably expressed in studies showing that complex decisions made with little explicit deliberation appear to produce high ratings of post-decision satisfaction (Djiksterhuis, Bos, Norgren, & van Baaren, 2006; Wilson et al., 1993). Similarly, learning on the Iowa Gambling Task (IGT) is suggested to be enhanced by implicit affective biases (e.g., Bechara et al., 1994; Bechara et al., 1997). The IGT appears to successfully tax a form of executive function that had been difficult to measure with conventional neuropsychological tasks (Bechara et al., 1994; Damasio, 1994). A wide range of neurological (e.g., Anderson, Bechara, Tranel, Damasio, Damasio, 1996) and psychiatric populations (e.g., Schmitt, Brinkley, & Newmann, 1999) have now been examined using the IGT, often highlighting deficits in decision-making abilities. Indeed, the IGT has been a fertile tool for research in the last decade (see Dunn, Dagleish, & Lawrence, 2006, for a recent review).

As experiments contained in this thesis depend on variants of the IGT, this chapter will aim to provide a thorough review of studies using this decision-making paradigm. However, first, the nature of the task itself is discussed. Secondly, studies focusing on the contributions from affective and cognitive processes will be reviewed. This section will show how emotion is fundamental to decision-making in the IGT. Third, will be a review of the clinical studies which speak to the cognitive and affective influences important to the IGT; and, finally, discussion will turn to studies assessing the influence of individual differences on IGT performance.

The Iowa Gambling Task

As reviewed in Chapter one, individuals with lesions of the orbitofrontal cortex can exhibit profound disturbances in social behaviour, but, in contrast, show normal performance in classic tests of executive function (Damasio, 1994; Eslinger & Damasio, 1985; Saver & Damasio, 1991). Noting problems in both decision-making and emotional dysfunction in this group of neurological patients, the Iowa group created the IGT as a means to measure their deficits in social cognition (Bechara et al., 1994; see Chapter 1). The task aims to mimic real-world decision-making by presenting a problem space that involves a high degree of uncertainty derived from a complex contingency of rewards and punishments.

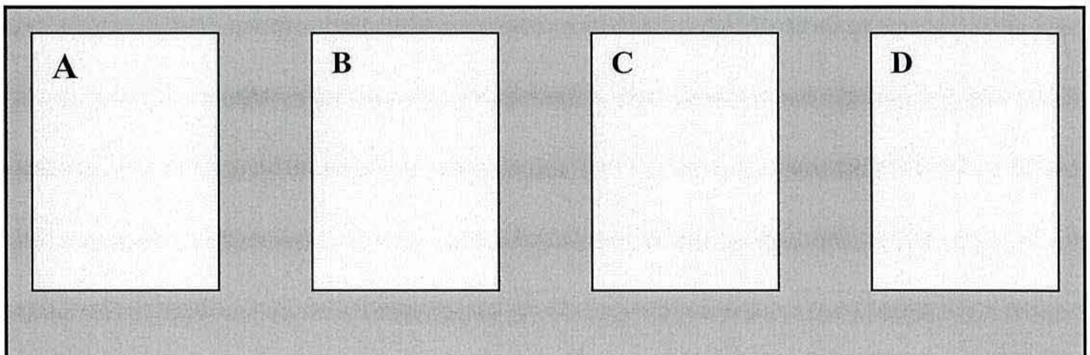
The original task involves four individual card decks (labelled A, B, C, and D) consisting of 40 almost identical cards, bar the colour of the faces, either red or black. The participants are provided with $2000 of facsimile money which they are told to treat as real money. The game requires the selection of one card at a time, from any deck, until requested to stop (after 100 cards). Each card turned always results in a gain of money; however, on occasion a card may also invoke a loss of money. A card may be chosen from any deck and the participants may change deck at any time. The aim of the task is to maximise net financial outcome. The participants are naïve to how much any card may provide in gain or loss, the exact schedule of outcome for all decks, and that the task is completed after 100 card turns.



Deck	Net Gain (10 trials)	Frequency Punishment
A	-$250	50%
B	-$250	10%
C	+$250	50%
D	+$250	10%

Figure 6. Representation of the Iowa Gambling Task with overall financial incentives for 10 card blocks. Participants are required to make 100 card selections. Each deck provides a consistent reward on every trial: The disadvantageous decks, A and B, lead to rewards of $100 on each selection; the advantageous decks, C and D, lead to a smaller gain of $50 on each selection. Punishment vary according to deck, with a single punishment associated with decks B ($1250) and D ($250), and more frequent punishments on decks A ($150 to $350) and C ($25 to $75). Performance is measured by comparing selection from decks C and D to decks A and B (i.e. [C+D]-[A+B]), leading to an overall net score. A learning profile is determined by net score over each of five 20 card blocks.

results in a gain of money; however, on occasion a card may also invoke a loss of money. A card may be chosen from any deck and the participants may change deck at any time. The aim of the task is to maximise net financial outcome. The participants are naïve to how much any card may provide in gain or loss, the exact schedule of outcome for all decks, and that the task is completed after 100 card turns.



Deck	Net Gain (10 trials)	Frequency Punishment
A	-$250	50%
B	-$250	10%
C	+$250	50%
D	+$250	10%

Figure 6. Representation of the Iowa Gambling Task with overall financial incentives for 10 card blocks. Participants are required to make 100 card selections. Each deck provides a consistent reward on every trial: The disadvantageous decks, A and B, lead to rewards of $100 on each selection; the advantageous decks, C and D, lead to a smaller gain of $50 on each selection. Punishment vary according to deck, with a single punishment associated with decks B ($1250) and D ($250), and more frequent punishments on decks A ($150 to $350) and C ($25 to $75). Performance is measured by comparing selection from decks C and D to decks A and B (i.e. [C+D]-[A+B]), leading to an overall net score. A learning profile is determined by net score over each of five 20 card blocks.

Intrinsic to the task is that two decks (C and D) are advantageous in the long-term and, conversely, the other two decks (A and B) have disadvantageous long-term outcomes. However, the bad decks provide the larger initial gains, $100 win per card, but also result in large unpredictable losses. Thus, in a ten card selection from decks A or B, the participant will gain $1000 but also lose $1250, resulting in a total loss of $250 (see Figure 6). Card selection from decks A or B will only produce a reward of $50; however, the losses are also comparably smaller, losing only $250 for the ten card set - an overall gain of $250. The only major difference between each of the good and bad decks is the schedule of losses, as the total loss is the same for each set. Thus, decks A and C consist of smaller but more frequent losses (50% frequency), whereas, decks B and D produce larger but less frequent losses (10% frequency).

The optimal strategy is for participants to select cards from decks C and D. However, early in the game participants tend to be attracted to the large rewards provided by decks A and B. Therefore, participants must forego large immediate rewards and learn to select from the decks supplying a smaller but consistent net positive outcome. Numerous studies show that performance depends on the integration of cognitive and affective processes, particularly that deficits in either function can lead to impaired performance on the IGT (e.g., Bechara et al., 1998; Fellows & Farah, 2005a; Manes et al., 2002). However, the greatest impact of studies using the IGT is the consolidation of emotion as an adaptive influence in decision-making in many circumstances (e.g., Damasio, 1994; Finucane, Slovic, Peters, 2003).

Affect and cognition in the Iowa Gambling Task

Complexity and uncertainty are common aspects of the social world, which the IGT aims to model within a laboratory-based paradigm. The complexity of the IGT is a consequence of the high level of information requiring conscious tracking and the uncertainty of decision outcomes. As outlined above, the information comes in the form of a complex contingency of financial rewards and punishments, ensuring each of the four objects in the problem space become laden with affect (e.g., Bowman, Evans, & Turnbull, 2005; Wagar & Dixon, 2007). Moreover, the task involves a high degree of uncertainty, as the exact outcome of each card selection is unknown. This uncertainty essentially comes in two forms: decisions under ambiguity and decisions under risk (e.g., Brand, Recknor, Grabenhorst, & Bechara, 2007). Early in the task decisions are ambiguous because information about the rewarding properties of the decks is incomplete, and therefore outcomes have no defined probabilities. Later in the task participants have gained a greater understanding of the rewarding properties of task objects, thus risky decisions dominate because outcome probabilities are more defined. As both complexity and uncertainty are common to the real-world, the IGT is a good model of real-world social decision-making.

The complexity and uncertainty intrinsic to the IGT makes it difficult for participants to track and recall the exact outcome of prior decisions as the task progresses (e.g., Bechara et al., 1998). In fact, many *normal* participants fail to fully grasp the contingency even at completion (e.g., Adinoff et al., 2003; Crone et al., 2004). As the task contingency is to an extent opaque[1], successful performance is facilitated by affective guidance (e.g., Bechara et al., 1997; Damasio, 1994; Bowman, Evans, & Turnbull, 2005; Wagar & Dixon, 2007). Thus, as participants experience the incentive properties of the task objects over time, the decks acquire a relative affective value - the good decks evoke positive affect, and the bad decks negative affect. These affective 'labels' are suspected to guide decision-making above and, perhaps, below the level of conscious awareness (e.g., Bechara et al., 1997; Bowman, Evans, & Turnbull, 2005; Damasio, Adolphs, & Damasio, 2003; Wagar & Dixon, 2007).

Crucial support for the proposed action of covert affective biases is provided by investigations of the IGT that include physiological measures. Therefore, this section will start by discussing experiments showing the formation of anticipatory skin conductance responses (SCRs) during the IGT. These physiological responses are suggested to discriminate between good and bad choices before conscious knowledge of the optimal strategy develops (e.g., Bechara et al., 1996; Bechara et al., 1997; Bechara et al., 2001). Next, discussion will move to studies supporting the primacy of affect and the importance of affective guidance on the IGT (e.g., Bowman, Evans, & Turnbull, 2005; Maia & McClelland, 2004; Wagar & Dixon, 2007). As decision-making requires a synthesis of cognitive and affective functions, this will be followed by a review of the small number of neuroimaging studies

[1] Although this is challenged in some quarters (Maia & McClelland, 2004), it is likely that the task can be considered opaque in that participants do not have a robust understanding of task contingency early in the task, but can express affective characteristics of the task objects (see later).

investigating the neural correlates of decision-making on the IGT (e.g., Patterson et al., 2002). Closing this section will be a review of studies investigating the role of working memory in the IGT (e.g., Turnbull, Evans, & Bowman, 2005; Hinson, Jameson, & Whitney, 2002).

Anticipatory physiological responses

The presence of larger anticipatory SCRs before choices from bad decks compared to good decks has been replicated in several IGT experiments (e.g., Bechara et al., 1999; Carter & Smith-Pasquilini, 2004; Oya et al., 2005; Suzuki et al., 2003; Tomb, Hauser, Deldin, & Caramazza, 2002; Wagar & Dixon, 2007). Moreover, Carter and Smith-Pasqualini (2004) found that anticipatory SCRs for bad decks correlated to the amount of money won/lost on the task (also see Oya et al., 2005).

In contrast, Suzuki et al. (2003) found that appraisal SCRs (those following reward/punishment feedback) were more predictive of performance on the IGT. This investigation also found that while anticipatory SCRs were present, they were consistent over the task suggesting no development over time and experience. This is problematic for the proposal that these somatic signals develop from prior emotional experiences with target objects (c.f. Bechara et al., 2002). Indeed, it appears that successful performance on the IGT may not even rely on the development of anticipatory SCRs (e.g., Crone et al., 2004).

Some IGT studies show that a proportion of normal control participants fail to demonstrate adaptive decision-making, performing as poorly as patients with lesions of the OFC (e.g., Bechara et al., 2001; Bechara & Damasio, 2002; Crone et al., 2004). Remarkably, many of these poorly performing control participants still developed anticipatory SCRs comparable to successful decision-makers (Bechara & Damasio, 2002). Bechara and Damasio (2002) suggest that these participants can be considered risk-takers or gamblers, and likely use cognitive deliberation to supersede implicit emotional biases.

Crone et al. (2004) assessed the physiological responses of a normal population on a variant of the IGT, and separated the participants into three groups based on overall task performance: good, moderate, and poor. Consistent with previous studies (e.g., Bechara et al., 1999; Carter & Smith-Pasqualini, 2004), good performers developed anticipatory SCRs and heart rates that discriminated between financially good and bad decks. However, both moderate and poor performance groups failed to produce discriminating anticipatory responses (see Figure 7). Thus, it appears that anticipatory SCRs are *not* essential to successful performance on the IGT, but may index enhanced adaptive decision-making in a subgroup of individuals.

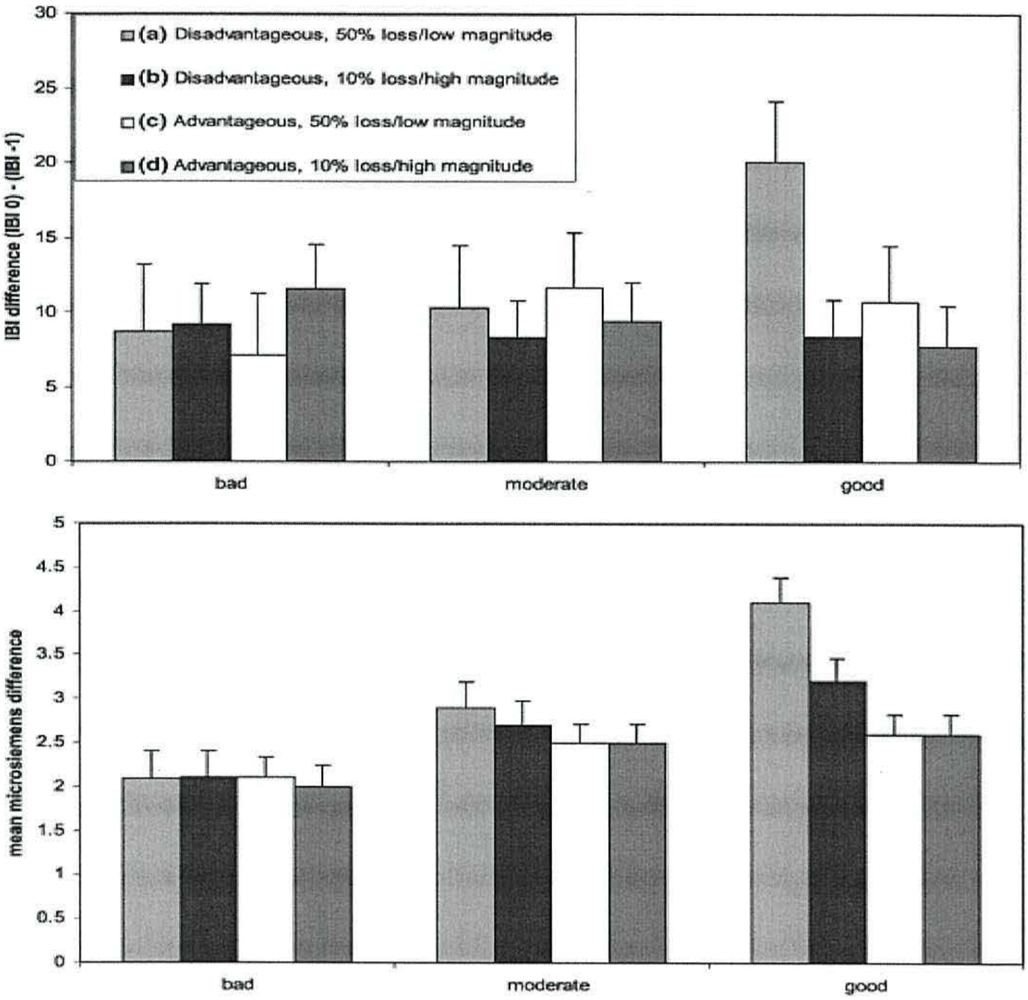


Figure 7. Anticipatory heart rate (top) and skin conductance response (bottom) associated with decisions from each of the decks (a, b, c, and d). Participants were divided into groups of bad, moderate, and good performance on the Iowa Gambling Task. Only the good decision-makers expressed significant deck discriminating anticipatory responses. Reproduced with permission from Blackwell Publishers Ltd (Crone et al., 2004). Copyright Blackwell Publishers Ltd (2004).

In sum, there is some conflict between the investigations that have collected physiological data. Many studies show the expected anticipatory SCRs (e.g., Bechara et al., 1999; Hinson et al., 2002; Oya et al., 2005; Tomb et al., 2002; Suzuki et al., 2003), which in some cases are related to overall task performance (Carter &

Smith-Pasqualini, 2004; Wagar & Dixon, 2007). In contrast, one study found that successful performance can occur without anticipatory SCRs (Crone et al., 2004), and another that in some individuals anticipatory SCRs are not predictive of adaptive decision-making (Bechara & Damasio, 2002). Deciphering these somewhat conflicting findings may require a better understanding of the influence of individual differences on the IGT (see later). However, there remains the possibility that anticipatory SCRs are not actually related to the development of affective biases during the task.

An alternate explanation of the increased autonomic arousal preceding selection in the IGT was proposed by Tomb et al. (2002). They assessed whether anticipatory SCRs were the result of dissociations between the magnitude of decisions for good and bad decks, rather than a guiding affective signal. To examine this, Tomb et al. investigated two versions of the IGT with contrasting decision magnitudes. The first version used the original task contingency where the bad decks possessed higher magnitude choices (high reward-high punishment) and the good decks lower magnitude choices (low reward-low punishment). The second version used a reverse relationship, the good decks offered higher magnitude choices (high reward-high punishment) than the bad decks (low reward-low punishment).

As expected, using the original contingency anticipatory SCRs formed in a similar way to other studies, with higher SCRs preceding selections from bad decks (e.g., Bechara et al., 1996; Bechara et al., 1997; Bechara et al., 2001). However, in altered form higher SCRs preceded choices from the good decks, suggesting that the *magnitude* of decision-related incentive underlies anticipatory SCRs in the IGT.

In response to these findings, Damasio, Bechara, and Damasio (2002) claim that the affective signals that guide decision-making can precede both disadvantageous and advantageous decisions. Therefore, the high anticipatory SCRs for good choices in the Tomb et al. study may be indicative of positive implicit biasing. Alternatively, they suggest that high SCRs could result from a negative affective state warning of the large punishment associated with the good decks, which is ultimately overridden by conscious awareness of deck affective value.

Thus, to clarify the conflicting results from the physiological studies of the IGT, further assessment with other techniques that could afford a clearer insight into contributions from anticipatory positive and negative affect would be worthwhile (e.g., electromyography). This is because one of the limitations of SCR is that it essentially measures autonomic arousal, and is therefore unable to differentiate between the valence of affective state (e.g., Bouscien, 1992; Dunn, Dagleish, & Lawrence, 2006). However, the other major strand of support for affective guidance on the IGT is provided by studies showing that normal participants begin to make adaptive choices *before* they express conscious knowledge of the optimal task strategy (e.g., Bechara et al., 1997; Wagar & Dixon, 2007).

The primacy of affect in the Iowa Gambling Task

To support the proposal that implicit affective biases guide decisions on the IGT, it is essential to show that good choices can be made prior to explicit knowledge of the optimal task strategy. The Iowa group have made strong claims about the influence of covert affective bias in the gambling task, for example, Tranel, Bechara, and Damasio (1999) suggests that "in normal individuals non-conscious biases guide reasoning and decision-making behaviour" (p. 1055). However, the evidence put forward to support this position is questionable, some of which comes from the presence of anticipatory SCRs that supposedly precede conscious knowledge of task rules. As noted earlier, the significance of this physiological data is unclear, but does affective guidance actually precede conscious knowledge in the IGT?

Bechara et al. (1997) presented the first evidence of non-conscious guidance by asking participants about their understanding of the IGT as the task progressed. Thus, every 10 cards after the initial 20 card block, participants were asked two questions: "Tell me all you know about what is going on in this game?" and "Tell me how you feel about this game?". They found that by approximately 50 card selections, normal participants expressed a 'hunch' that decks A and B were the riskier choices. By card 80, many participants had a good understanding about the task contingency. Because deck discriminating anticipatory SCRs developed before the hunch stage, the Iowa group inferred that non-conscious biases were guiding adaptive decision-making. However, the examination of explicit knowledge of the task in Bechara et al. (1997) was quite superficial. The probing questions of Maia and McClelland (2004) afford a more detailed understanding of the influence of conscious awareness in the IGT, and consequently challenge the claims made by the Iowa group.

As noted by Maia and McClelland (2004), it is well-established that open-ended questions fail to fully tap the explicit knowledge of participants during experiments (e.g., Cleeremans, Destrebecqz, & Boyer, 1998; Shanks & St John, 1994). In experiments purported to show influences from implicit learning, this is readily overcome by using more sensitive and probing questions of explicit knowledge. Using this approach, Maia and McClelland revealed that advantageous performance on the IGT is associated with greater explicit guidance than previously acknowledged (e.g., Bechara et al., 1997). Thus, participants possessed basic conscious awareness of the affective properties of the decks by 20 cards. This alone would provide a basis for choice strategy. By 50 cards, around 80% of the participants knew that decks C and D were the good decks. Furthermore, they found that participants can actually hold a good understanding of the nature of the decks, but still show exploratory behaviour leading to what are considered disadvantageous decisions.

In a similar vein, Bowman, Evans, and Turnbull (2005) demonstrate that participants start to report awareness of the affective values of task decks after only 20 selections. This investigation simply involved the participants subjectively rating the 'goodness/badness' of each deck on a Likert-style scale every 20 cards. By 40 selections, good decks were rated significantly more positive than bad decks. Therefore, in this case, participants can explicitly report the affective quality of the decks during what the Iowa group view as the 'pre-hunch' phase (e.g., Bechara et al., 1997). This has been confirmed in other studies using the same method of tapping subjective awareness during the IGT (Cella et al., 2007; Evans et al., 2005).

Thus, it appears that participants have more explicit knowledge of the incentive values of task objects earlier than originally claimed by Bechara et al. (1997). The question was still open, however, as to whether affect precedes cognition on the IGT. Maia and McClelland show that by the 50th card selection most participants had a good explicit understanding of the optimal task strategy. Whereas Bowman et al. (2005) found that by the 40th selection most participants could explicitly express the affective qualities of the decks, which is comparable to 'level one' knowledge in the Maia and McClelland study. In both studies, the affective qualities of the decks started to emerge after the first 20 card block. A period exists therefore (before 40 cards) where conscious, and perhaps non-conscious, affective guidance may be primary.

A recent investigation by Wagar and Dixon (2007) also addressed the issue of affective influences in the IGT. This study employed the Maia and McClelland (2004) and Bechara et al. (1997) methods of probing conscious awareness on the IGT in two experiments. One of the criticisms raised by Maia and McClelland was that early in the task the best strategy from the participant's perspective differs from the overall optimal task strategy. Thus, in the initial phase participants gain greater net outcomes from the bad decks, however, as the task progresses net outcomes change and the good decks provide the best outcomes. Accounting for this, Wagar and Dixon determined three distinct phases within the task: (i) In phase 1, both bad decks provide the best outcome; (ii) in phase 2, one bad and one good deck provides the best outcome; (iii) in phase 3, drawing cards from good decks provides the best outcome. Wagar and Dixon consider the shift from phase 2 to 3 as the earliest period during which conscious knowledge of the optimal strategy can develop.

Using this approach they demonstrate that conscious awareness of optimal strategy develops between blocks 4 and block 6 (of a 10 block experiment), with a median of 44 cards in their two experiments. Wagar and Dixon's behavioural data show that around 70% of the selections during phase 2 were from the advantageous decks, suggesting decisions were guided without conscious knowledge of the optimal strategy. The authors propose that the influence of affective guidance on decision-making is the best explanation of this finding.

Further support for the presence of affective guidance is gained from the SCR measures collected in the Wagar & Dixon (2007) experiments. Consistent with Bechara et al. (1997) they found that higher anticipatory SCRs preceded choices from the bad decks. Of more significance, they also found that the difference between anticipatory SCRs for good and bad decks was positively correlated with the difference between good and bad choices during phase 2 – the period where conscious knowledge of optimal strategy is proposed to be absent.

In sum, the evidence is unclear as to whether non-conscious affective guidance enhances decision-making on the IGT, as originally claimed by the Iowa group (e.g., Bechara et al., 1997; Tranel et al., 1999). It seems clearer, however, that some form of affective guidance does play an important role in advantageous decisions early in the task (Bowman et al., 2005; Maia & McClelland, 2004; Wagar & Dixon, 2007). Thus, the task objects likely acquire an affective value *before* explicit awareness of the optimal strategy develops. The affective value of task objects will be experienced as an affective state during evaluative phase of the decision-making process. This is akin to the 'how-do-I-feel-about-it' heuristic that is an important component of the 'affect-as-information' theory found in the social cognition literature (e.g., Schwarz & Clore, 1996; Wyer, Clore, & Isbell, 1999). This period of reflection on subjective affect would provide a basis for emotions to guide adaptive decision-making in situations of complexity and uncertainty. Whether this process is actually non-conscious is unclear. However, as Montesquieu (1892) noted, there is a difference between *feeling* and *knowing*. Accordingly, from the evidence outlined above, it appears that affect is likely to convey important information during Gambling Task decision-making.

Neuroimaging studies

In the preceding section evidence supporting the primacy of affect in the IGT was outlined. Further support for the affective basis of the IGT is provided by neurological (e.g., Bechara et al., 1998; Damasio et al., 1994; see later) and neuroimaging studies (Fukui et al., 2005; Patterson, Ungerleider, & Bandetti, 2002), both of which show involvement of neural systems underlying emotional behaviour.

Several investigations using neuroimaging techniques have assessed the neural correlates underlying IGT performance in normal participants (Bolla et al., 2004; Ernst et al., 2002; Fukui et al., 2005; Patterson et al., 2002). For example, a PET study demonstrated neural differences between the sexes when performing the IGT (Bolla et al., 2004; see later). Another PET study showed the expected activity in the right OFC and DLPFC, but also found activations in the anterior cingulate cortex, insula, and thalamus in the right hemisphere, and cerebellum in the left (Ernst et al., 2002).

Using fMRI, Fukui et al. (2005) investigated the differences in neural activity between safe (decks C+D) and risky (decks A+B) decisions and found significant activity only in the medial prefrontal cortex. Furthermore, they also showed correlations between MFC activity during risky decisions and overall task score. However, there was no relationship between MFC activity during safe decisions and overall IGT score. In many ways this is surprising as the remaining fMRI study does show OFC activity during the IGT (Patterson et al., 2002), with correlations between right VMPFC activity and SCR changes. However, neuroimaging studies using other decision-making paradigms have demonstrated activity in a similar region of the MFC (e.g., Akitsuki et al., 2003; Critchley, Mathias, & Dolan, 2001).

Thus, neuroimaging studies show that performance on the IGT recruits brain regions implicated in both emotion (e.g., VMPFC) and cognition (e.g., DLPFC). This is entirely consistent with an affective component in IGT performance, but also confirms that cognitive functions do play a role in this task. Indeed, although Bechara et al. (1998) demonstrate an asymmetry between VMPFC and DLPFC brain lesions on the IGT, lesions to the DLPFC have been shown to result in impairment on the IGT (e.g., Manes et al., 2002). One DLPFC function which should be important to a task of decision-making is working memory, which would enable task-relevant information to be held and manipulated in mind (Goldman-Rakic, 1992; Krawcyzk, 2000).

The role of working memory

Although performance on the IGT is enhanced by affective guidance, this does not negate the importance of cognitive processes such as working memory. To be sure, it would be surprising to find that a task requiring the tracking of a complex contingency of gains and losses would be completely independent of working memory. Later some studies reviewing the effect of lesions of regions of the brain underpinning working memory will be discussed (e.g., Bechara et al., 1998; Manes et al., 2002). Here, however, studies examining the influence of working memory on the IGT in normal populations will be reviewed.

A well-established method of investigating the influence of working memory (WM) on experimental paradigms is through loading executive resources with a secondary task, while performing the primary task of interest (e.g., Baddeley, 1996). A number of studies have used such a dual-task approach to examine the importance of the working memory in the IGT (Dretsch & Tipples, 2007; Hinson, Jameson, Whitney, 2002; Jameson, Hinson, & Whitney, 2004; Turnbull et al., 2005).

Jameson, Hinson and Whitney (2002), for example, examined the effect of three secondary tasks on performance of on a modified IGT. This modification used four options (c.f. decks) which led to good (1 option), bad (2 options), and neutral (1 option) financial gain. The secondary tasks included articulatory suppression (loading phonological loop), digit maintenance (loading WM), and keypad task (no WM load). Their results showed that performance was impaired only in the digit maintenance task. Furthermore, they also found that discriminating anticipatory SCRs failed to develop during the WM load condition. These results suggest that WM does play an important role in decision-making on the IGT. Although the task used by Jameson, Hinson, and Whitney (2004; Hinson, Jameson, & Whitney, 2002) was not the classic IGT, results using the original IGT clearly show that WM resources are necessary to successful performance (Dretch & Tipples 2007; Pecchinenda et al., 2006; Turnbull et al., 2005).

For instance, Turnbull et al. (2005) assessed the original version of the IGT in a dual-task experiment involving three conditions: no secondary task, articulatory suppression, and random number generation. The results showed no significant differences between the three conditions, although there was a trend towards better performance in the no secondary task condition. Consequently, in this case it appears that WM has some minimal contribution to IGT performance. However, the secondary tasks used in this investigation were relatively modest forms of WM loading. Experiments using more taxing secondary tasks have more clearly demonstrated impaired performance on the IGT (e.g., Dretsch & Tipples, 2007; Pecchinenda, Dretsch, & Chapman, 2006).

For example, Pecchinenda, Dretsch, and Chapman (2006) used the original version of the IGT in a dual-task experiment that included two levels of WM loading involving digit maintenance. In the low WM condition, 5 digits requiring short-term storage were ordered sequential, whereas in the high WM condition, the 5 digits were ordered randomly. Results showed a striking impairment of performance in the high WM condition. Consistent with this, Dretsch and Tipples (2007) found a similar effect on the IGT using the reverse contingency 'inverted' version (i.e., variable rewards, consistent punishment; Bechara, Tranel, & Damasio, 2000) with the same WM load conditions.

In sum, studies using dual-task paradigms indicate that working memory has important contributions to performance on the IGT, and that the relative extent of

WM load mediates the impairment of performance. Therefore, it appears that successful performance on the IGT also depends on influences from cognitive processes, along with the previously discussed affective processes. In addition to the evidence for affective guidance on the IGT in studies with control participants, the impaired performance of patients with lesions that lead to emotional deficits consolidate the support for the importance of emotion in adaptive decision-making (Bechara et al., 1994; Bechara, Damasio, Damasio, 2000; Damasio, 1994). Indeed, as noted earlier, the IGT was specifically developed to measure the impaired social decision-making found in particular groups of neurological patients.

Iowa Gambling Task Performance in Clinical Populations

In Chapter 1, some of the findings from initial IGT studies with neurological patients were discussed in the context of the somatic-marker hypothesis. For example, patients with lesions to the VMPFC (e.g., Bechara et al., 1994; Bechara et al., 1997) and amygdala (e.g., Bechara et al., 1999) show a striking impairment on the IGT. As both of these regions are well-established components of the emotion system of the brain, these studies provide important support for the proposal that, rather than emotion being a disruptive influence on decision-making (e.g., Toda, 1980), emotion is integral to adaptive reasoning in many circumstances. Furthermore, these investigations provide crucial support for the requirement of emotion-based learning in the IGT.

Many recent studies using the IGT have shown impaired affective decision-making in clinical populations, and so this section will discuss some of the findings in these groups. This section will begin by outlining neurological studies indicating the potential importance of lesion lateralisation. Then, observations from psychiatric populations will be reviewed; this will focus on patients with schizophrenia due to the large number of studies in this group. Finally, the discussion will move to investigations with groups of substance abusers, many of whom show similar poor decision-making to neurological patients with OFC damage. Observations from these populations support the proposal that while the integrity of cognitive and affective systems are important for decision-making, a degree of asymmetry exists between these systems.

The prefrontal cortices and laterality

As the prefrontal cortex (PFC) is a heterogeneous structure consisting of distinct functional regions, Bechara et al. (1998) attempted to dissociate working memory functions, residing in the dorsolateral (DL) cortex, from decision-making processes which depend on the ventromedial (VM) cortex. This was achieved by using participants with lesions in different sectors of the PFC who were assessed using the IGT and a working memory task (delay). The results indicated interesting dissociations in performance.

The DL groups (right and left) indicated normal performance on the IGT, although, only the right DL were impaired on the working memory task. Both VM groups (anterior and posterior) and were significantly impaired on the IGT, however, the posterior VM group illustrated deficits in working memory performance. These findings suggest the VM sector of the prefrontal cortex is crucial to the integrity of complex decision-making, and also show how the laterality of PFC lesions is important in the functional deficits produced.

A later study by Manes et al. (2002) produced the first insight into the effect of more specific lesion sites on IGT performance. Their participants had either focal unilateral lesions of particular regions of the PFC (orbitofrontal, dorsolateral, or dorsomedial) or 'large' lesions (lesion involving two or more of the three PFC regions), whereas, participants involved in the Iowa group studies possessed lesions that extended past the boundaries of the OMPFC. In contrast to the Iowa group studies, the orbitofrontal participants expressed no impairments on the IGT. However, the dorsolateral, dorsomedial, and large lesion groups were impaired. Manes et al. suggested that the restricted focal lesions of their orbitofrontal participants accounted for this outcome.

Shortly after the Manes et al., the Iowa group also published a study specifically focusing on the effect of lateralised frontal lesions on decision-making which was suggested to account for the discrepancies found in the earlier data. Tranel, Bechara, and Denberg (2002) assessed the importance of laterality of VM lesions on IGT performance and showed that only right VMPFC lesions caused impaired performance on the IGT. Furthermore, this group of participants developed no anticipatory SCRs. However, left VMPFC lesions did not impair IGT performance or the development of anticipatory SCRs. Moreover, only the right VMPFC participants exhibited profound impairments in social and interpersonal behaviour, consolidating the significance of this study. Tranel et al. also provided an explanation for the seemingly anomalous results of Manes et al.'s study; the orbitofrontal group involved in the Manes et al. sample consisted almost entirely of orbitofrontal lesions of the left hemisphere and that, therefore, the results were compatible with their findings.

Consistent with this, Clark et al. (2003) examined a large sample of patients with unilateral frontal lobe lesions ($N = 41$; 20 left hemisphere, 21 right hemisphere) and found that right-sided lesions produced the most profound impairment on the IGT. However, in this study left-sided lesions did show a trend towards impaired affective decision-making. In the right hemisphere frontal lesion group, total lesion volume and lesion volume outside the VMPFC was found to correlate with impairment on the IGT.

In sum, the lesion studies using the IGT reflect how adaptive decision-making relies on integration of both cognitive and affective processing (e.g., Bolla et al., 2004; Fellows, 2004; Fellows & Farah, 2005a; Krawczyk, 2002). Lesions of the right and, to a lesser extent, the left PFC produce impairments on the IGT (Clark et al., 2003; Manes et al., 2002; Tranel et al., 2002). Further, the integrity of the VM and DL regions of the PFC are important for successful performance on this task of affective decision-making. Fellows and Farah (2005a) suggest that lesions of the VMPFC may underlie a deficit in affective shifting, whereas lesions of the DLPFC likely underpin a working memory deficit on the IGT (Bechara et al., 1998). Thus, it appears there is an asymmetrical relationship; lesions of the VMPFC can impair decision-making independent of working memory deficits (Bechara et al., 1998).

In addition to the recent neurological studies linking the OFC to effective emotion-based decision-making on the IGT (e.g. Bechara et al., 1997; Bechara et al., 1998), many investigations have revealed significant impairments in a wide range of psychiatric disorders (e.g., Best, Williams, & Coccaro, 2002; Cavedini et al., 2002; Toplak et al., 2005) and substance dependent individuals (e.g., Bechara & Damasio, 2002; Rotherham-Fuller et al., 2004; Verdejo-Garcia, Perales, & Perez-Garcia, 2007c). As abnormalities of the frontal cortex are associated with many of these conditions (e.g., Franklin et al., 2002; Wolkin et al., 2003), these results bolster the claim that the OFC is critical for performance on the IGT.

Psychiatric disorders

Investigations using the IGT have demonstrated impairments in affective decision-making in numerous psychiatric populations, including obsessive-compulsive disorder (Cavedini et al., 2002), attention deficit-disorder (Toplak et al., 2005), mania (Clark et al., 2001), and anorexia nervosa (Cavedini et al., 2004). However, the most studied condition is schizophrenia (e.g., Cavallaro et al., 2003; Beninger et al., 2003; Bark et al., 2005; Evans et al., 2005; Wilder et al., 1998) and, therefore, deserves particular attention. Moreover, studies on patients with schizophrenia provide further insight into the importance of the orbitofrontal cortex for performance in the IGT, and affective decision-making in general.

Schizophrenia is a distressing chronic psychiatric disorder that results in substantial emotional deficits (e.g., Tremeau, 2006). Furthermore, the disorder is associated with significant dysfunction of the prefrontal cortex, including abnormalities of the DLPFC (e.g., Weinberger & Berman, 1996; Gur et al., 2000) and OFC (e.g., Andreasen et al., 1997; Gur et al., 2000). Indeed, the degree of social dysfunction exhibited by patients with schizophrenia appears to be related to ventral frontal morphology (Chemerinski et al., 2002). However, schizophrenia is a heterogeneous condition with various signs and symptoms, multiple subtypes, well-established problems in robust diagnosis (e.g., Tsuang, Stone, & Faraone, 2000), and high co-morbidity with other psychiatric disorders (e.g., Green et al., 2003). Furthermore, patients are exposed to a diverse range of pharmacological interventions. These issues could be expected to complicate investigations with this clinical group; therefore, it is not surprising to find somewhat mixed findings from investigations of schizophrenic populations on the IGT.

In several studies patients with schizophrenia have been shown to be impaired on the IGT compared to a control group (Bark et al., 2005; Beninger et al., 2003; Kester et al., 2006; Lee et al., 2007; Ritter et al., 2004; Shurman, Horan, & Nuechterlein, 2005; Sevy et al., 2007). For instance, Shurman et al. (2005) assessed the performance of 39 patients with schizophrenia and reported impaired performance compared to a control group of 10 participants. Likewise, Lee et al. (2007) demonstrated that a group of 23 stable patients with schizophrenia were impaired on the IGT, but performed normally on the Game of Dice Task, a test of cognitive decision-making (Brand et al., 2005). Furthermore, Lee et al. found that schizophrenia also resulted in deficits on the Simple Reversal Learning Task (SRLT; Farah & Fellows, 2003, 2005a). However, although patients with lesions of the VMPFC are impaired on the SRLT (Farah & Fellows, 2003, 2005a), the performance of patients with schizophrenia on the IGT was unrelated to reversal learning deficits. Thus, Lee et al. infer that schizophrenic patients show impairments of affective decision-making, which is dissociated from deficits in simple reversal learning.

In contrast, a number of studies report that patients with schizophrenia show no deficits on the IGT (Cavallaro et al., 2003; Evans et al., 2005; Rodriguez-Sanchez et al. 2005; Turnbull et al., 2006; Wilder et al., 1998). Wilder et al. (1998), for example, found that a group of 12 patients with schizophrenia and no co-morbid substance use disorder performed normally on the IGT. Moreover, Turnbull et al. (2006) found no impairments in IGT performance between 21 patients with chronic schizophrenia and 21 age- and education-matched controls. However, during a novel extension of the IGT involving three contingency shifts, higher levels of negative symptoms of schizophrenia were associated with failure to respond to the shifting incentives. This shifting impairment was shown to be unrelated to measures of cognitive set-shifting, such as the Wisconsin Card Sorting Task, suggesting a possible deficit in affective shifting.

Many other studies confirm that WCST scores are not correlated to IGT performance within this clinical population (Lee et al., 2007; Ritter et al., 2004; Rodriguez-Sanchez et al., 2005; Shurman et al., 2005; Wilder et al., 1998), which suggests that performance on the IGT is unrelated to deficits in cognitive set-shifting. Consistent with this, Rodriguez-Sanchez et al. (2005) demonstrate that stable first-episode patients with a schizophrenic spectrum disorder were significantly impaired on the Trail-Making Test and other tests of DLPFC function (FAS fluency test, backward digits), but performed normally on the IGT. Therefore, we might presume that the integrity of OFC-related functions is unaffected in the early stages of schizophrenia.

Although the IGT results in schizophrenic populations are mixed, it appears that many studies support the proposal that performance is highly reliant on an affective component, which can be dissociated from the cognitive impairments associated with this condition (Lee et al., 2007; Ritter et al., 2004; Rodriguez-Sanchez et al., 2005; Shurman et al., 2005; Wilder et al., 1998).

As noted earlier, patients with schizophrenia exhibit high co-morbidity with other clinical disorders (Green et al., 2003). One of the more significant is the high incidence of substance abuse amongst the schizophrenic population. Although cannabis abusing patients with schizophrenia showed no extra impairment to those with no concurrent substance abuse on the IGT (Sevy et al., 2007), substance abuse has well-established associations with abnormal function of the OFC (e.g., London et al., 2000; Volkow et al., 1991; Volkow & Fowler, 2000; for a review, see Dom, Sabbe, Hulstijn, & van den Brink, 2005). Therefore, impaired performance on the IGT is likely to result from substance dependence and abuse.

Substance abuse and dependence

Ostensibly, substance abusing individuals show comparable behaviour to patients with lesions of the medial OFC. Most notably expressed by the way in which they tend to make decisions that are driven by immediate rewards in spite of the high risk of later negative consequences (e.g., favouring the immediate high of the drug over the risk of long-term negative social, physical, and psychological consequences). Moreover, several studies demonstrate that substance dependency is associated with dysfunction of the OFC (e.g., Franklin et al., 2002; Volkow et al., 1991; Volkow & Fowler, 2000). For example, the OFC is implicated in the neural mechanisms of drug expectancy (e.g., Stapleton et al., 1995) and craving (e.g., Grant et al., 1996).

Thus, as expected, substance dependent individuals are generally shown to be impaired on the IGT, including abusers of cocaine and stimulants (Bartozokis et al., 2000; Bechara et al., 2001; Bechara & Damasio, 2002a; Bechara & Martin, 2004; Bolla et al., 2003; Grant et al., 2000; Monterosso et al., 2001; Quednow et al., 2007; Verdejo-Garcia et al., 2007a; Verdejo-Garcia et al., 2007b; Verdejo-Garcia et al., 2007c), marijuana (Lamers et al., 2006; Verdejo-Garcia et al., 2007c; Whitlow et al., 2004), alcohol (Bechara et al., 2001; Bechara & Martin, 2004; Mazas, Finn, & Steinmetz, 2000), and opiates (Lyvers & Yakimoff, 2003; Petry, Bickel, & Arnett, 1998; Rotherham-Fuller et al., 2004).

For example, Verdejo-Garcia et al. (2007c) compared the IGT performance, over two sessions, of 25 day abstinent cocaine and marijuana abusers to a matched (e.g. education, IQ, socioeconomic status) control group. The experimental groups were selected to be a particularly pure group of users of each drug, excluding those with a previous or current dependence on other drugs. Although, the results found no significant differences between the substance abusers and controls in session 1 (cocaine abusers showed a trend towards poor performance), cocaine abusers showed poor improvement over the two sessions. Marijuana abusers did show a relatively low level of improvement in the second session compared to controls, however, this was non-significant, consistent with another study showing absence of deficits in abstinent marijuana abusers (Quednow et al., 2007). Moreover, Vedejo-Garcia et al. demonstrated a dose-response relationship, with longer term and higher dose abusers of both substances showing lower total scores over the two sessions. This confirms the findings of other studies showing that neurocognitive deficit is related to the level of abuse of cocaine and marijuana (Bolla, Rothman, Cadet, 1999; Bolla et al., 2002, 2005).

This dissociation between the performance of cocaine and marijuana abuse may reflect the neural differences found in imaging studies involving the IGT in these two groups (Bolla et al., 2003, 2005; Ersche et al., 2005). Thus, cocaine users show hyperactivation of the right OFC and ventral striatum, and less activation in the right DLPFC and left MPFC (Bolla et al., 2003) during the IGT, compared to controls. Whereas, marijuana users show less activity in the right OFC and DLPFC, and less activity in the cerebellum, compared to controls (Bolla et al., 2005).

Therefore, as the OFC and ventral striatum are strongly implicated in incentive motivation, cocaine users may exhibit exaggerated responses to rewarding stimuli. This would explain the preference for the risky high reward decks on the IGT, even on a second trial. Vedejo-Garcia et al. (2007a) suggest that, as heavy marijuana users show enhanced activity in brain regions implicated in working memory and on-line task monitoring (posterior cingulate and parahippocampal) when performing the IGT, deficits in these individuals may be related to an inability to track and recall shifting incentives. This is consolidated by other studies that demonstrate deficits on tasks of working memory in marijuana users (e.g., Pope et al., 2003).

Thus, comparable to data on psychiatric and neurological patients, substance abuse can lead to a degree of impairment on IGT decision-making, through deficits in either affective or cognitive components. This is consistent with Bechara and Martin (2004) who also demonstrate an asymmetry between working memory and affective deficits on the IGT with a population of polysubstance abusers.

The Iowa Gambling Task in Normal Populations

Recent studies have found significant dissociations in performance in non-clinical populations on the Iowa Gambling Task. These include education (Evans, Berry, & Turnbull, 2004), gender (e.g., Overman, 2004; Reavis & Overman, 2001), and anxiety (e.g., Carter & Smith-Pasqualini, 2004). Such individual differences may provide an explanation as to why a significant proportion of normal participants show impaired performance on the IGT (e.g., Bechara et al., 2001; Bechara & Damasio, 2002; Crone et al., 2004).

Anxiety & mood state

Anxiety has a well-established impact on information processing, particularly by biasing attention (Macleod & Matthews, 1991; Mogg & Bradley, 1998). For example, enhanced detection latencies have been found for threat-related stimuli compared to neutral stimuli, specifically for highly anxious individuals (Bradley et al., 1998; Macleod & Mathews, 1988). Anxiety also has significant effects on the quality of decision-making, for instance, Raghunathan and Pham (1999) show how state anxiety led to risk-aversion in gambling decisions. Studies using the IGT have found a similar influence of incidental affect (e.g., Suhr & Tsandis, 2007; Schmitt, Brinkley, & Newmann, 1999)

Schmitt, Brinkley, and Newmann (1999) assessed the theoretical relationship between psychopathy and IGT. Although there were no significant differences between the IGT performances of prisoners with high and low levels of psychopathic behaviour, this study found that trait anxiety did affect learning on the IGT. Thus, high trait anxious participants selected more cards from the advantageous decks (C+D) than low trait participants. This led the authors to infer that high trait anxious participants were risk-averse on the IGT. Consistent with this, Carter and Smith-Pasqualini (2004) found a significant positive correlation between neuroticism (N) score on the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1991) and the total amount of money won or lost on the IGT.

An influential neuropsychological theory of anxiety, proposed by Gray (1982, 1987; Gray & McNaughton, 2000), suggests that anxiety is the result of an overactive behavioural inhibition system (BIS), which is mediated by the amygdala and septo-hippocampal system (Davidson, Jackson, & Kalin, 2000; Gray & McNaughton, 2000[2]). In accordance with Gray's theory (1982, 1987), Peters and Slovic (2000) found that a measure of BIS activity was negatively correlated with the number of selections from the high loss decks in a variant of the IGT. Conversely, a measure of extraversion was positively correlated with selections from the high gain decks. Moreover, van Honk et al. (2002) showed that participants scoring high on BAS but low on BIS activity using the BIS/BAS scale (Carver & White, 1994), performed poorly on the IGT compared to those scoring high on BIS but low on the BAS scale.

[2] In the most recent model (Gray & McNaughton, 2000), the behavioural inhibition system is conceived as mediating the resolution of goal conflict, rather than reactions to aversive stimuli. The Fight-Flight-Freeze system (FFFS) underlies responses to all aversive stimuli, with the BIS operating during periods of goal conflict/ vigilance/anxiety, and mediates punishment sensitivity.

In contrast, Franken and Muris (2005) found that performance on the IGT was related to BAS scores, but not BIS scores.

However, Suhr and Tsandis (2007) show that these findings may be more complicated than a simple BIS-BAS distinction. The main method of measuring BIS/BAS activity is via Carver and White's (1994) BIS/BAS scale, but there is criticism of the psychometric basis of this questionnaire. The BAS scale, for example, might well measure distinct and only moderately correlated constructs (e.g., Huebreck, Wilkinson, & Cologon, 1998; Smillie, Jackson, & Dalgleish, 2006). Furthermore, the BIS scale appears to be correlated to negative affect and, conversely, the BAS scale is correlated to positive affect (Heubreck et al., 1998). Hence, the relationship between performance on the IGT and BIS/BAS scales may be more suggestive of incidental mood state than Gray's neurobiological model. This would be consistent with the wider decision-making literature, which clearly shows how incidental affect can influence decision-making (e.g., Clore, 1992; Isen, 1993; Raghunathan & Pham, 1999). Indeed, Suhr and Tsandis (2007) show that whilst 'fun-seeking' (a BAS subscale) influences IGT performance, *incidental* emotional state effects are important.

Gender

Gender differences on the IGT are now well-established (Bolla et al., 2004; Overman, 2004; Overman et al., 2004; Overman & Reavis, 2001). In the Overman studies, females were found to exhibit an aversion to the high frequency loss decks compared to males. The clearest indicator of their poor performance is the preference for cards from the low frequency but highest punishment deck (only 1 punishment of £1250 per 10 cards). Overall, males are found to outperform females from adolescence to old age (12-60 years; Overman, 2004; Overman et al., 2004; Overman & Reavis, 2001). However, during childhood the reverse effect has been found, with girls outperforming boys between 3 and 6 years old on a simplified version of the IGT (Garon & Moore, 2004).

Bolla et al. (2004) replicated the behavioural findings on the IGT, but also indicated that this dissociated performance may be related to differences in activity in the prefrontal cortex. Using PET scanning they showed how males had greater activity in the right lateral OFC (ventrolateral PFC) than females, whereas females were found to have greater activity in the left DLPFC than males. This distinction in neural activity provides an adequate explanation of sex differences on the IGT because, as indicated previously, it seems that the integrity of the right OFC in particular is essential to performance (e.g., Manes et al., 2002; Tranel et al., 2002). Furthermore, some neuroimaging studies show structural differences between males and females within regions of the frontal lobe implicated in decision-making on the IGT (e.g., Wood, Heitmiller, Andreasen, & Nopoulos, 2008).

A more recent study (Overman et al., 2006) investigated other possible reasons for sex differences on the IGT, finding that it was not due to differences in emotional arousal, mathematical ability, or reversal learning. They did find indirect support for the neuroimaging results of Bolla et al. (2004) however, showing that contemplation of personal moral dilemmas enhanced IGT performance in females to a level comparable to male participants. The medial frontal areas of the brain are implicated in the deliberation of personal moral dilemmas (e.g., Greene et al., 2001). Thus, Overman et al. propose that the presence of moral deliberation enhanced OFC activity leading to improved IGT performance in females. Such findings confirm that optimal performance on the IGT requires a balance between emotional (e.g., OFC) and cognitive (e.g., DLPFC) processing (e.g., Bolla et al., 2004; Fellows, 2004).

Development and aging

As noted earlier, performance on the IGT differs between the sexes during childhood, with females outperforming males up to 6 years old, whereas males outperform females thereafter. As complex decision-making depends on the integrity of the prefrontal cortex (Damasio, 1994; Fellows, 2004; Krawczyk, 2002), the fact that this area of the brain matures slowly until adulthood (e.g., Benes, 2001; Giedd, 2004; Gogtay et al., 2004; Paus et al., 2001) would suggest that performance on tasks such as the IGT should alter across the lifespan. Indeed, Garon and Moore (2004) show how an understanding of a simplified IGT improved with age in young children. This progressive enhancement of decision-making ability on the IGT is found to continue through to young adulthood (Crone & van der Molen, 2004; Crone & van der Molen, 2007; Hooper, Luciana, Conklin, & Yarger, 2004; Overman, 2004). Further, Crone & van der Molen (2007) demonstrated that anticipatory autonomic responses produced during the Gambling Task differed with age.

However, as the whole PFC is undergoing maturation across childhood (e.g., Giedd, 2004; Gogtay et al., 2004) the improvement in decision-making ability could be due to enhancement of either cognitive or emotional abilities, or both. With this in mind, Hooper et al. (2004) investigated the relationship between performance on tasks that recruit DLPFC and the IGT. Their study showed that performance on the IGT across childhood was not predicted by ability on tasks of working memory or behavioural inhibition. Consistent with this, Crone and van der Molen (2004) found that performance on tasks of inductive reasoning and working memory was unrelated to decision-making on the IGT. These investigations suggest that maturation of the VMPFC is most critical to the development of emotion-based learning during childhood.

The maturation of the prefrontal cortex through to adulthood is mirrored by its structural decline in old age (West, 1996, 2000). This decline with age is also suggested to be reflected in IGT performance (Denburg, Tranel, & Bechara, 2005; Denburg, Recknor, Bechara, & Tranel, 2006). In both Denburg investigations, a significant proportion of older participants (ca. 35% of 56-85yrs) showed poor decision-making on the IGT. Furthermore, the impaired participants lacked the normal discriminatory anticipatory SCRs that are commonly found on the IGT (Denburg et al., 2006). Comparisons between the groups who performed well and those impaired found no differences in any other aspect of cognitive ability, suggesting a focal deficit in VMPFC-mediated emotional learning.

Education and Intelligence

Although the Iowa group claimed that education and intelligence was not an influential factor on IGT decision-making (e.g., Bechara et al., 2000a, 2000b; Bechara et al., 2001; Bechara & Martin, 2004), Monterosso et al. (2001) found that IQ was positively correlated with performance. Likewise, Rodriguez-Sanchez et al. (2005) found that success on the IGT was positively correlated to both years of education and intelligence. In contrast, another study has showed that formal schooling may have an important, but paradoxical, influence on emotion-based learning (Evans, Kemish, & Turnbull, 2004). This investigation showed that participants who had continued education past 16 years old actually performed worse than those with no higher education in the latter stages of the IGT. Further investigation is required to clarify the inconsistent relationship between intelligence, education, and IGT performance.

Summary

Decision-making is a multi-component process requiring, for example, the manipulation of relevant information, weighing of rewards and punishments, recall of previous experiences, flexibility to changing circumstances, progression to future goals, action planning, and so on. All these components require integration to provide the most optimal action in a particular situation which in many circumstances is an intrinsically complicated mechanism. Recent studies of decision-making have begun to provide a more detailed understanding of the neuroscientific basis of this process than was previously available (e.g., Fellows, 2004; Krawczyk, 2002). The Iowa Gambling Task (IGT; Bechara et al., 1994) has made a substantial contribution to this advance, most notably by consolidating awareness of the importance of emotion for decision-making (e.g., Bechara, Damasio, & Damasio, 2000).

The IGT is a good simulation of real-world decision-making processes, involving not only decisions under risk, but also decisions under ambiguity (e.g., Brand et al., 2007). Furthermore, the IGT provides a complex shifting contingency over time, requiring exploration and learning through experience. Although other tasks can be considered to provide a better psychological dissection of the decision-making process (e.g., Fellows, 2004), the IGT affords an ecologically rich problem space.

Consistent with other research (for a review, see Krawczyk, 2002), studies using the IGT show that both emotion and cognition are both essential to adaptive decision-making (e.g., Bechara et al., 1998; Pecchinenda, Dretsch, & Chapman, 2006; Wagar & Dixon, 2007). Thus, lesions to areas of the brain underpinning emotional (e.g., Bechara et al., 1994; Bechara et al., 1997) and cognitive (e.g., Fellows & Farah, 2005; Manes et al., 2002) inputs to decision-making appear to lead to impairments on the IGT. Moreover, a corpus of studies with non-lesion clinical/sub-clinical patients (e.g., Bechara & Martin, 2004; Lee et al., 2007; Rodriguez-Sanchez et al., 2005) and normal participants (e.g., Bolla et al., 2004; Ernst et al., 2002; Fukui et al., 2005; Hinson et al., 2002) confirm that decision-making in the IGT requires a balance between cognition and affect. In fact, affective states are likely to support adaptive decisions in the early period of the IGT (e.g., Bowman et al., 2005; Maia & McClelland, 2004; Wagar & Dixon, 2007).

The affective nature of decisions in the IGT provides an opportunity to examine the effects of pre-existing emotional biases on complex decision-making. Indeed, some recent studies suggest that pre-existing affect may alter performance on the IGT (Suhr & Tsandis, 2007; Hinson et al., 2006). Thus, Suhr and Tsandis highlight the importance of incidental affect on the IGT. Of more interest to this thesis is the recent investigation of Hinson et al. (2006). This study involved associating pre-existing affect with modified IGT decks in the form of emotional words. Their results demonstrated that incongruent affective labelling (good word-bad deck; bad word-good deck) impaired performance, whereas congruent association enhanced IGT decision-making in normal participants.

The impact of affective bias that predates the IGT has received minimal attention, this is central to the studies presented here, as prejudice can readily be considered a pre-existing affective label. Therefore, this thesis will contain investigations using a similar manipulation to Hinson et al. (2006), but in this case by firstly associating more affectively salient visual stimuli on the original IGT and, furthermore, by extending this technique to the realm of pre-existing social biases.

In addition, the IGT involves an intrinsic affective shift, where initially learned associations require reversal for adaptive behaviour. In many ways, overcoming prejudice is similar. Prejudice is based in a negative evaluation of particular targets (e.g., Allport, 1954/1979); therefore, overcoming prejudice requires a reversal of this affectively-laden label. Experiments contained in this thesis also assess the flexibility of affective biases, with rewarding properties shifting across time, but from a starting point which is affectively laden, rather than neutral. Moreover, decision targets in the IGT possess inherently ambivalent characteristics. This scenario is more indicative of the real-world, where most objects rapidly and automatically evoke affective states (e.g., LeDoux, 1996; Zajonc, 1980). This series of experiments aim to provide a greater understanding of the influence of prejudice on social cognition using a task simulating real-world conditions of complexity, ambiguity, and ambivalence.

Chapter 3

Pre-existing affective bias in the Iowa Gambling Task

Given the extensive overlap between cognitive and affective neural systems (e.g., Panksepp, 1998), it is of no surprise that findings in social cognition show that emotion can readily infuse the decision-making process (e.g., Forgas & East, 2003). There have been a number of attempts to measure these effects (e.g., Schwarz & Clore, 1983; Forgas, 1990) suggesting that people monitor the valence and intensity of their feelings towards decision targets (i.e., feelings-as-information; Schwarz & Clore, 1996). An important distinction stressed by this literature is that affect can be sourced either from an evaluation of the target itself (i.e., integral affect), or influenced by background mood state or another target unrelated source (i.e., incidental affect; Bodenhausen, 1993; Bodenhausen, Mussweiler, Gabriel, & Moreno, 2001; Finucane, Peters, & Slovic, 2003; Lerner & Keltner, 2000; Pham, Cohen, Pracejus, & Hughes, 2001). Integral affect may be the result of actual, perceived, or even imaginary characteristics of the target object. Whereas, incidental affect may be due to temporary mood states, trait affective states (e.g., anxiety), or transferred from another unrelated source (e.g., Cohen, Pham & Andrade, 2007).

A further distinction within the category of integral affect was outlined by Bodenhausen (1993; Bodenhausen, Mussweiler, Gabriel, & Moreno, 2001). These two categories distinguish between *chronic* and *episodic* integral affect. The chronic form is related to affect elicited by the target of a judgment or decision which is of a pre-existing nature. Prejudice would be considered a source of chronic integral affect. Whereas, the episodic form of integral affect is associated with affect sourced from an evaluated target during a particular situation. For instance, although an individual may possess a negative attitude towards a particular outgroup, an interaction with a category exemplar may be of a positive nature. Thus, chronic and episodic integral affect can be distinct (Bodenhausen et al., 2001).

Integral affect has been proposed to have four important roles in decision-making (Peters, Lipkus, & Diefenbach, 2006). Thus, integral affect can act as a form of information about particular decision targets; a 'spotlight' which directs attention towards important features and data which are salient to a decision; a 'common currency' which enables the features of qualitatively different decision targets and related information to be more readily compared (c.f., Cabanac, 1992; Montague & Berns, 2002); and, finally, to motivate cognitive processing and action. Therefore, integral affect appears to be an important component of adaptive social cognition.

Affect from incidental and integral sources is likely incorporated into an online affective state that can bias decision-making (Cohen, Pham & Andrade, 2007; Damasio, 1994; Finucane, Peters, & Slovic, 2000; Loewenstein, Weber, Hsee, & Welch, 2001). The influence of incidental affect on judgment and decision-making is well-established with, for example, gains in the flexibility and openness of problem-solving in positive mood states (e.g., Isen, 2001) and risk-aversion in states of anxiety (e.g., Lerner & Keltner, 2000; Raghunathan & Pham, 1999).

However, the primacy (e.g., LeDoux, 1996; Zajonc, 1980) and importance of integral affect for judgment and decision-making has been less well investigated (Finucane, Peters, & Slovic, 2003; Pham et al., 2001). Moreover, there have been few studies that have assessed integral affective bias in decision-making on tasks with high levels of complexity and uncertainty - although questions of this sort are highly relevant for real-world decision-making (e.g., Bechara et al., 1994).

Integral affect in the Iowa Gambling Task

One recent study which investigated what can be considered integral affect on a modified IGT is Hinson et al. (2006). This experiment involved associating affectively salient words with task objects in a 3 deck variant of the IGT. The decks provided either 'good' (+25), 'bad' (-25), or 'neutral' (0) financial outcomes. The bad deck gave large gains, but even larger losses, and the good deck gave small gains, but even smaller losses. The association between the incentive value of the task objects and the affective value of the words was either congruent (good-good; bad-bad) or incongruent (good-bad; bad-good). The results showed that affective biasing had a striking effect on decision-making; more selections were made from the good decks in the congruent condition from the outset and increased across time. In contrast, in the incongruent condition choices from bad decks outnumbered those from the good decks throughout the task. Thus, incongruent affective bias resulted in a significant disruption of task performance, whereas the congruent association enhanced decision-making. Furthermore, the participants in the incongruent condition developed no discriminating anticipatory SCRs.

The findings of Hinson et al. (2006) suggest that pre-existing affect can have an important biasing effect on decision-making, essentially by guiding decisions in situations of complexity. The pre-existing affective labels can be considered a form of chronic integral affect, whereas the developing affective nature of the task objects can be viewed as episodic integral affect (Bodenhausen, 1993; Bodenhausen et al., 2001). The present study also assessed whether the addition of integral affective labels would modulate emotion-based learning, developing a variant of the original IGT where objects (the card decks) are associated with an emotional label from the outset of the task. In this case, visual stimuli from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001) were linked with each deck. We manipulated the association in two conditions, which were either incongruent or congruent to the financial properties of the decks. In the incongruent condition, pleasant stimuli were associated with financially disadvantageous (Bad) decks, and *vice versa*. The stimuli were custom-designed for each participant based on subjective experience data. Furthermore, a control condition which used unrecognisable digitally morphed affective stimuli assessed whether the addition of visual stimuli was sufficient to disrupt performance.

Therefore, an incongruent association between emotional label and the task rewarding properties would be expected to result in less advantageous decision-making and *vice versa* for a congruent association, even though the participants were explicitly informed that the integrated label was irrelevant to the financial contingencies of the task.

Experiment 1: Emotional Bias in a task of Affective Decision-making

Method

Participants

48 participants (42 female), aged 19-37yrs ($M = 20.1$, $SD = 2.92$) and with no history of neurological or psychiatric disorder, were obtained via a student participation panel at the University of Wales, Bangor. The participants were randomly allocated to one of three experimental conditions; Incongruent ($n = 16$), Congruent ($n = 16$), and Control ($n = 16$). The participants were given credit for partial course fulfilment.

Procedure

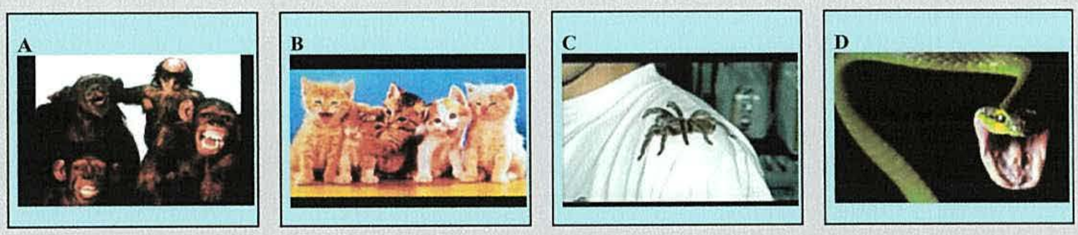
Selecting IAPS images. One set of 30 slides was produced, containing pictures negative (10) and positive (20) in affective valence but matched for arousal. They were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001; CSEA, 2001; see Appendix 1b). An independent measures t-test indicated that the positive slides were significantly rated more pleasant than the negative slides on the IAPS normative ratings (t (28) = 29.48, $p < .001$), and matched for arousal ratings (t (28) = -0.12, $p > .05$).

The slides were subjectively rated by each participant on three Likert scales for pleasantness, fear, and sadness (see Appendix 1c). Four slides were selected based on these ratings for use in the later Gambling Task. The two slides rated most unpleasant, and two rated most pleasant, were selected. A paired-samples t-test of participants pleasantness responses showed a significant difference, (t (47) = -33.472, $p < .001$), between the pleasant and unpleasant IAPS slides.

Skin conductance responses (SCR) were used to ensure that the selected stimuli produced appropriate autonomic arousal. SCRs were recorded via a BIOPAC 100MA/GSR100 constant voltage system (0.5V) and acquired with Acqknowledge 3.5 software for offline analysis. Disposable self-adhesive isotonic wet gel electrodes were attached to the palmer surfaces of the distal phalanxes of the first and third fingers of the participant's non-dominant hand. Peak SCR amplitude was recorded 1-7 seconds after stimuli onset. Data could not be collected from 8 participants ($n = 40$). A paired samples t-test indicated a significant difference between the SCR amplitudes for pleasant and unpleasant slides (t (39) = 4.652, $p < .001$). The subjective ratings were the primary method of selection.

The Iowa Gambling Task Variants. The majority of materials utilized are identical to the original Iowa Gambling Task study (Bechara et al, 1994); however, the facsimile money was in British denominations of £5, £10, £20, and £50 (Bowman & Turnbull, 2003). These variants of the Gambling Task involved associating four affective stimuli from the International Affective Picture System

(IAPS; Lang, Cuthbert, & Bradley, 2001) with the card decks. In this variant of the IGT, the decks are associated, labelled and named with the affective stimuli from the IAPS picture set. There were three experimental conditions which manipulate how the stimuli are associated with each deck. In the *Incongruent* condition the advantageous decks were associated with unpleasant stimuli (e.g. Deck C- Snake; Deck D- Spider), and disadvantageous decks associated with pleasant stimuli (e.g. Deck A- Monkey; Deck B- Kittens). The *Congruent* condition used the reverse association (i.e. pleasant pictures with advantageous decks and *vice versa*; see Figure 8).



Deck	Net Gain (10 trials)	Frequency Punishment
A	-£250	50%
B	-£250	10%
C	+£250	50%
D	+£250	10%

Figure 8. Representation of the Affective Labelling Iowa Gambling Task variant with overall financial incentives for 10 card blocks. Decks were labelled with either Congruent (good picture-good decks, bad picture-bad decks) or Incongruent (as illustrated in the above diagram; bad picture-good decks, good picture-bad decks) affective visual stimuli. Participants were required to name each deck according to the associated picture (e.g. kitten, snake etc).

In the affective congruency conditions the stimuli were placed directly on top of the decks, with the participant required to name the decks according to their associated stimuli (e.g. "A kitten card") and forced to touch the card to remove the gambling card beneath the pictures. The slide was then replaced to its original position (see Appendix 1d for task instructions).

In the Control condition the arrangement was akin to the emotional conditions with the pictures on top of the decks. However, these slides consisted of a digitally morphed version of four original slides, such that the content of the particular slide could not be observed. The participant was required to name the decks as in the original IGT. This acted as a control condition, as the decks had minimal pre-existing affective bias as in the original IGT. The contingency pattern of the original task was retained in all conditions.

Trait Anxiety. All participants were required to complete a questionnaire consisting of the Trait Anxiety scale of the STAI-Y2 (Speilberger, 1983). Overall mean trait anxiety score for the participants in each contamination condition were not significantly different ($F\ (2, 47) = 1.625, p > .05$), with an overall mean trait score for the 48 participants of 39.4 ($SD = 6.71$).

Design

The experiment consisted of a mixed between- and within-subjects design and utilised a one-way ANOVA for analysing overall performance. The one-way ANOVA involved a factor of Congruency condition (between-subject, 3 levels) with a dependent variable of overall task score. The repeated-measures ANOVA included factors of task variant Congruency (between –subjects; 3 levels) and task Block (within-subjects; 5 levels). The dependent variable the mean block score of advantageous cards minus disadvantageous cards for each block of 20 cards (i.e. [(C+D)-(A+B)]). Correlations between mean STAI trait anxiety scores and overall IGT scores were performed.

Results

Overall Analysis

As in Bechara et al. (1994), participant's overall performance was calculated using the equation [(C+D)-(A+B)], which provides an index of their overall choices. Thus, a high overall score indicated an advantageous selection strategy, with more good deck cards chosen. Mean overall scores for each of the three experimental conditions were calculated and suggested a difference in overall selection strategy (see Figure 9), such that performance was worse in the Incongruent condition compared to Congruent and Control condition.

A one-way ANOVA, with Congruency condition as the between-subject factor, indicated that these differences in overall selection strategy were significant (F (2, 47) = 11.886, $p < .001$, $\eta^2 = .35$). Post-hoc analysis showed significant differences between the Incongruent condition and Congruent ($p < .001$) and Control ($p < .001$) conditions. There was no significant difference between the Control and Congruent conditions ($p > .05$).

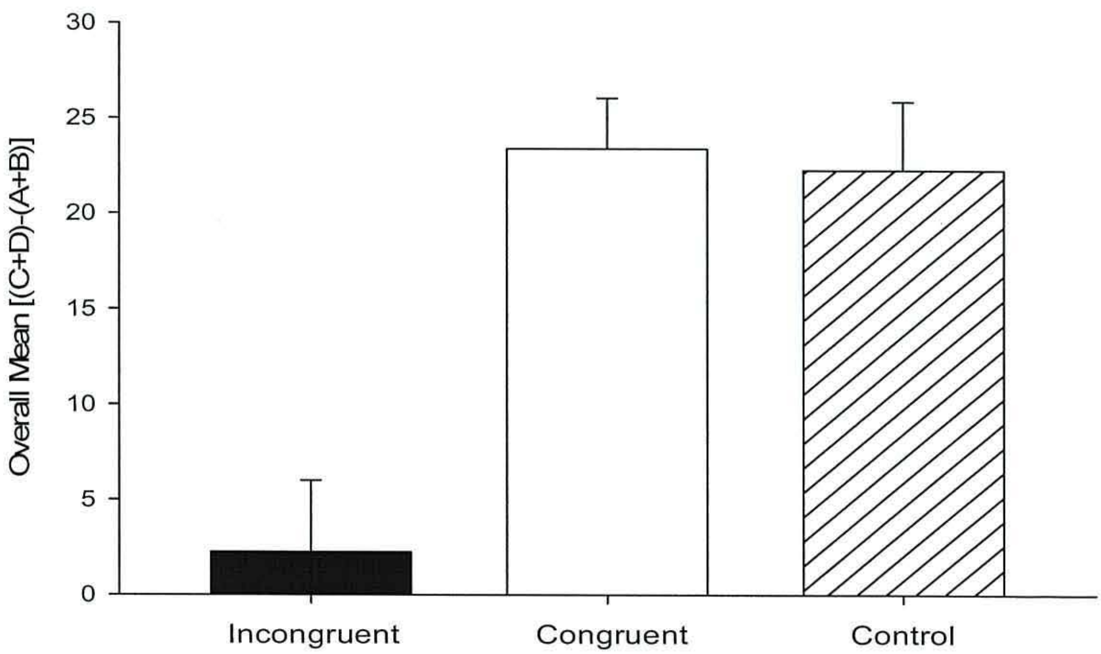


Figure 9. Mean Overall Score for the three conditions (Error bars indicated one Standard error). Performance in the Incongruent condition was significantly lower than in the Congruent and Control conditions.

Analysis by block

As in the original Gambling Task (Bechara et al., 1994), the 100 card selections were split into five equivalent blocks of 20 cards, and an overall block score calculated from the equation [(C+D)-(A+B)]. The results (see Figure 10) showed that the participants learned in all three conditions, but that performance on the Incongruent condition was below that attained in the Congruent and Control conditions in all blocks.

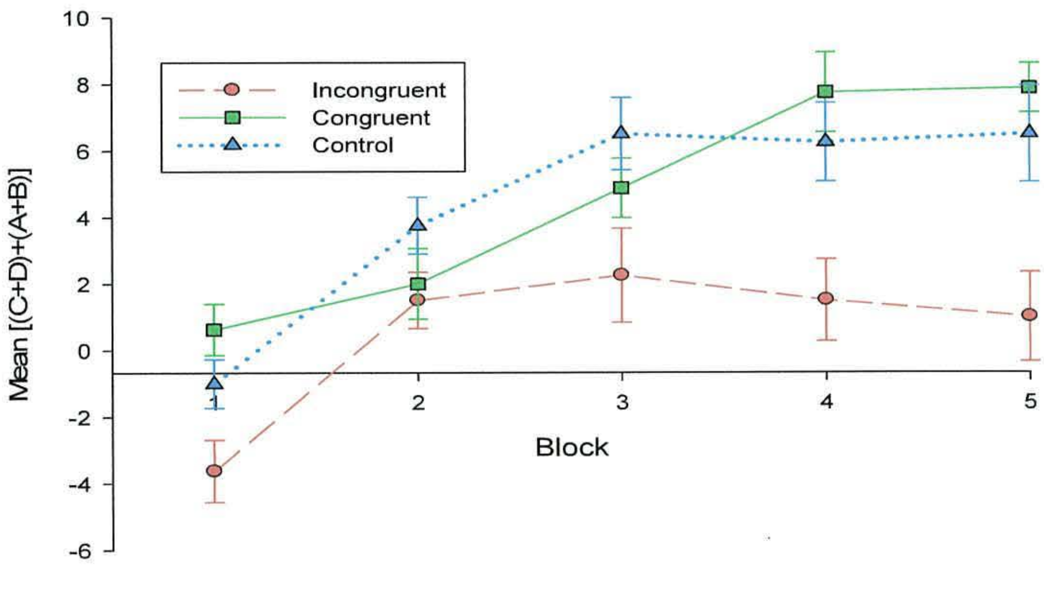


Figure 10. The mean card selection profiles for the Incongruent (n = 16), Congruent (n = 16), and Control (n =16) conditions. Error bars indicate the Standard Error of the Mean (*SEM*). There was limited learning in the Incongruent condition compared to the Congruent and Control conditions.

A mixed ANOVA with factors of condition (between-subjects; 3 levels) and Block (within-subjects; 5 levels) showed a significant effect of Congruency, (F (4, 45) =

11.886, $p < .001$, $\eta^2 = .35$), a significant main effect of Block, (F (4, 180) = 25.787, $p < .001$, $\eta^2 = .34$), and a significant interaction (F (8, 180) = 2.227, $p = .027$, $\eta^2 = .09$).

Bonferroni post –hoc analyses indicated significant differences between the Incongruent and both Congruent ($p < .001$), and Control ($p < .005$), but no significant differences between the Congruent and Control conditions ($p > .05$). Independent t-tests suggested significant differences between the Incongruent and Control conditions (*ds* > 0.8) at block 1, block 3 ($p < .05$), block 4, and block 5 ($p < .01$); and between the Congruent and Incongruent conditions (*ds* > 1.2) at block 1, block 4 ($p < .005$), and block 5 ($p < .001$).

Relationship between Trait Anxiety and IGT performance

Analyses of trait anxiety scores from the STAI (Speilberger, 1983) revealed a borderline significant positive correlation, $r = .385$, $p = .071$, with overall performance on the IGT in the Control condition (see Figure 11). Although non-significant at $p = .05$, there was a trend towards a negative correlation in the Incongruent affective labelling condition ($r = -.317$, $p = .116$), less so in the Congruent condition ($r = -.243$, $p = .182$).

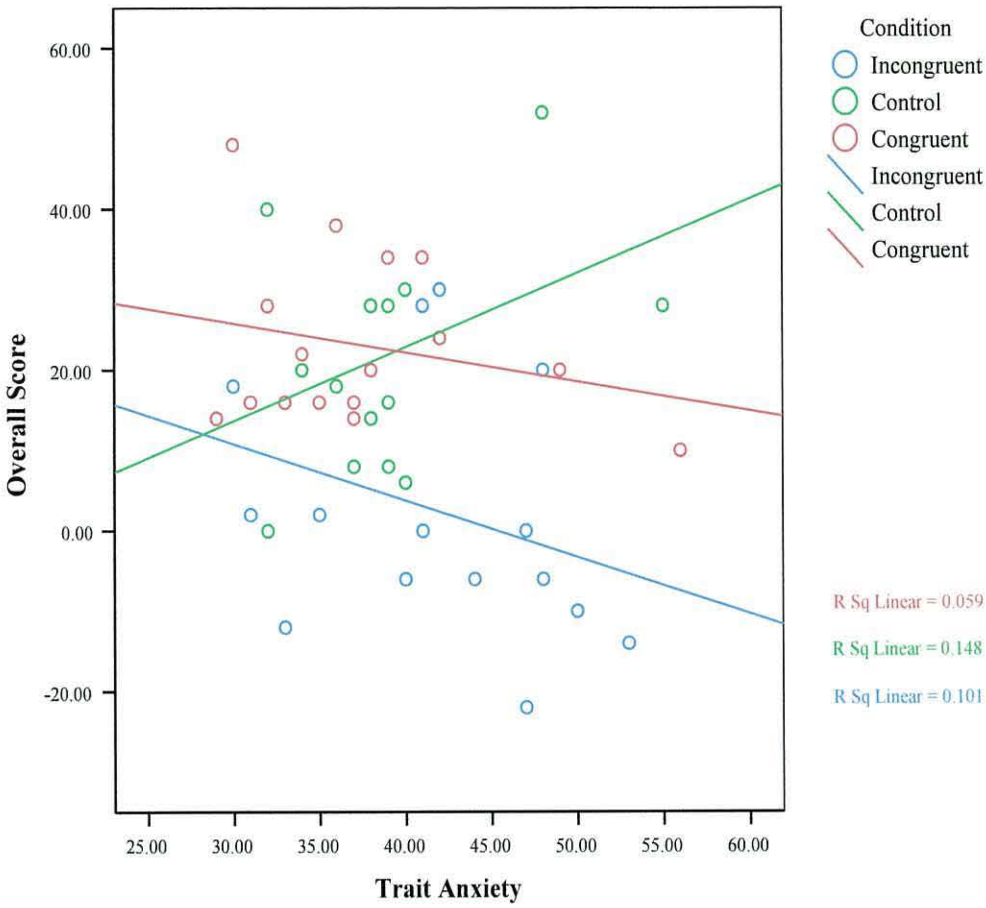


Figure 11. Correlations ($N = 16$) between trait anxiety (as measured by the STAI; Speilberger, 1983) and overall score [(C+D)-(A+B)] on the Iowa Gambling Task in each of the three conditions. Although no correlations were significant, the relationship was borderline significant in the Control condition (p =.071) and a trend towards significance was present in the Incongruent condition (p =.116).

Discussion

Experiment 1 examined the effects of integral affective bias on a complex decision-making task modelling real-world problem-solving. Participants showed some learning in all conditions, beginning at levels close to chance, with a growing preference for selections from the advantageous decks, consistent with many previous findings (e.g., Bechara et al. 1994; Bowman & Turnbull, 2003).

The addition of incongruent emotional labels to individual decks significantly reduced the magnitude of learning on the task, such that participants were more likely to choose objects (decks) with a positive emotional label, even when this was financially disadvantageous. Notably, this emotion-related bias was sustained throughout the entire task, despite an explicit instruction that the label was irrelevant to its financial aims. This finding is consistent with a range of studies showing that emotion can disrupt decision-making (e.g., Raghunathan & Pham, 2001; Shiv et al., 2005), and supports the notion that affective guidance is an important influence in the IGT (e.g., Wagar & Dixon, 2007).

Surprisingly, however, the addition of *congruent* emotional labels did not have a significant effect on learning, with both control and congruent label groups showing roughly similar performance. This finding is inconsistent with the Hinson et al. (2006) investigation, who found some enhancement of performance in a congruent condition. This is most likely a result of important differences between the two experiments. Thus, this investigation was based on the original 4 deck IGT with identical contingencies. Whereas the Hinson et al. study used a 3 deck variant of the IGT (good, bad, neutral), along with altered contingency. For example, in the Hinson et al. variant of the IGT the bad and neutral decks possess not only lower net incentives, but also higher frequency punishment ($p = .5$) than the single good deck ($p = .2$). These differences would surely underpin easier learning of the advantageous deck, especially when guided by the helpful pre-existing affective guidance found in the congruent condition.

The finding in the current experiment suggests a striking imbalance between the congruency of the intrinsic affective labels, and the emerging incentive properties of emotion-based learning. This finding is consistent with a range of results in the field of social cognition which indicate that information *conflicting* with pre-existing biases, such as attitudes and stereotypes, is processed in a different fashion than non-conflicting information (Ditto & Lopez, 1992; Ditto, Scepansky, Munro, Apanovitch, Lockhart, 1998; Sherman, Stroessner, Conrey, & Azam, 2005). Indeed, individuals have been shown to interpret information in a way that confirms their pre-existing attitudes of other people (e.g., Darley & Gross, 1983; Schaller, 1992).

These findings may be analogous to the real-world effect whereby pre-existing affective labels, for example in circumstances of racial prejudice, appear to distort the ability to judge without bias (Correll, Park, Judd, & Wittenbrink, 2002; Dovidio & Gaertner, 2000; Norton, Vandello, & Darley, 2004). This effect appears to hold true even when participants claim that they have *no* explicit knowledge of such prejudice (e.g. Greenwald, McGhee, & Schwarz, 1998). In the context of the present findings, it is important to note that prejudice-related effects are greatest when decisions are ambiguous, rather than simple and straight-forward (e.g., Correll, Park, Judd, & Wittenbrink, 2002; Dovidio & Gaertner, 2000; Hodson, Dovidio, & Gaertner, 2002; Hugenburg & Bodenhausen, 2004). However, the decision-making bias in this experiment was persistent, readily infusing into the more risky decisions found later in the task. As the Iowa Gambling Task is specifically designed to investigate decision-making under circumstances of complexity and ambiguity/uncertainty (Bechara et al., 1994; Shiv et al., 2005), it appears to be a useful tool for investigating prejudice.

A final issue of interest relates to the role of individual differences in emotion. Analysis of the effects of trait anxiety on Gambling Task performance in the control condition replicated previous findings that show higher levels of anxiety are associated with more successful performance (Carter & Smith-Pasqualini, 2004; Schmitt, Brinkley, & Newmann, 1999). This is likely a consequence of enhanced risk-aversion (e.g., Raghunathan & Pham, 1999). However, in the incongruent condition, the opposite effect was true, with high trait anxiety associated with a trend towards disrupted performance.

It may be that this paradoxical result is due to the conflicting patterns of emotional labelling associated with objects (decks), for instance, that two were simultaneously negatively labelled, yet behaviourally rewarding, and *vice versa*. Thus, participants with high trait anxiety would likely experience a tension between the negative outcomes associated with the financially disadvantageous decks (i.e., their risk-aversion) and the integrated negative label on the advantageous decks – with the emotional labels providing a more salient affective cue. Participants with low trait anxiety appear to be better able to tolerate and regulate these conflicting affective signals. This would be consistent with existing literature suggesting that individuals with high levels of trait anxiety tend to focus excessively on irrelevant unpleasant stimuli in the environment (Gray, 1985; Mogg & Bradley, 1998). These findings suggest that, whilst paying attention to emotional experiences is often advantageous in decision-making, over-reliance on some classes of emotion, or difficulty regulating these emotional experiences, may be disadvantageous.

However, it is clear that labelling decks with emotion-generating pictures is not the only, or perhaps even the optimal, method of achieving high levels of ecological validity on this task. Perhaps a variant of the Gambling Task in which the decks are labelled as *people* would be a useful move in this direction (c.f. Turnbull, Berry, & Bowman, 2003). For example, it would be interesting to investigate whether racially diverse faces as deck labels would produce a similar result to that of the present study. Chapter 4 will investigate this possibility.

Chapter 4

The influence of racial bias on complex decision-making

As noted in Chapter 1, race has been shown to influence evaluation and judgements of targets and their behaviours (e.g., Blair, Judd, & Fallman, 2004; Correll et al., 2007; Duncan, 1976; Hodson, Dovidio, & Gaertner, 2002; Dovidio et al., 1997, see Fiske, 1998, for a review). For example, Duncan (1976) showed how a shove by an African-American was judged more aggressive than by a European-American. Likewise, Correll et al. (2007) demonstrate how race-based processing can lead to biases in decisions to shoot.

These findings are not surprising considering studies suggest that racial cues are processed by the brain rapidly and automatically (Cunningham et al., 2004; Ito & Urland, 2003), and are likely to readily infuse and contaminate judgements. Thus, Ito & Urland report that race-related ERPs were found after only approximately 120ms, which was more rapid than gender-related ERPs (ca. 180ms). Moreover, the N100 response was larger for black faces than white, suggesting greater allocation of attentional resources to outgroup stimuli. It appears, therefore, that race-based information is well-placed to be a salient affective cue in decision-making. However, as current social norms prescribe non-prejudicial behaviour (Kluegal & Smith, 1986), this initial automatic response would be expected to be modulated in many circumstances.

Consistent with this, Cunningham et al. (2004), demonstrate that when racially diverse faces are presented implicitly (30ms), amygdala activity was greater for Black faces than for White faces, suggesting an emotion-based response. Furthermore, the implicit amygdala response was related to performance on a measure of implicit racial bias (i.e., Implicit Association Test; Greenwald, McGhee, & Schwarz, 1998; see later), confirming a previous study by Phelps et al. (2000). However, when the same faces were presented explicitly (525ms), the differential amygdala activity disappeared, and was replaced by greater activity in frontal brain regions probably involved in the regulation of emotional responses (i.e., dorsolateral, anterior cingulate, and ventrolateral PFC).

Implicit race bias has also been shown to have a core affective component through another experimental paradigm (Amodio, Devine, & Harmon-Jones, 2003). Taken together, these studies suggest that rapid and automatic implicit affective race bias is generally regulated by top-down frontal activity. Indeed, Richeson and Shelton (2003; Richeson et al., 2003) have found support for a resource depletion model of racial bias, whereby implicit racial bias is moderated by executive resources enabling people high in implicit race bias to conform to social norms.

Race-based decision-making under ambiguity

This tension between automatic emotion-based race responding and social norms is capably explained by the notion of 'aversive' racism (Gaertner & Dovidio, 1986). Thus, people can hold negative automatic racial biases which can show in indirect ways, but still consciously and sincerely endorse racial equality (Gaertner & Dovidio, 1986, Dovidio & Gaertner, 1998). This suggests that 'aversive racists' experience an uncomfortable ambivalence between these competing conscious and non-conscious influences. Therefore, to maintain their non-prejudiced image, such aversive racists will tend to show discriminatory behaviours in situations where bias is readily justifiable to themselves and others. In situations were clear and unambiguous actions and decisions are defined, prejudicial behaviour is less likely to be exhibited. However, when biases can be rationalised or justified, for example, in situations of ambiguity, discriminatory behaviours may be expressed (Dovidio & Gaertner, 1998, 2000; Gaertner & Dovidio, 1986; Hodson, Dovidio, & Gaertner, 2002; Norton, Sommers, Vandello, & Darley, 2006).

For instance, Dovidio and Gaertner (2000) demonstrate that although self-report racial prejudice fell in the 10 year period between 1989 and 1999, subtle discriminatory employment decisions could be still be observed. Thus, when Black job applicants were clearly the best option, they were offered the position. Conversely, when a Black applicant was the worst option, they were refused the position. However, when a Black applicant's qualifications and experience were ambiguous, racial bias was present – Black applicants were less likely to be successful compared to White applicants. Dovidio and Gaertner (2000) suggest that as the decisions were ambiguous and the best outcome less defined, racially biased judgements could be justified on the basis of credentials.

Likewise, Hodson, Dovidio, and Gaertner (2002) confirmed that decisions under ambiguity were more affected by race bias than clear and unambiguous decisions in a university admissions paradigm. Participants were provided with two sources of information regarding applicant's academic abilities – College Board scores and High School achievement. Their results showed that individuals with higher levels of self-reported racial prejudice were more likely to make discriminatory decisions under ambiguity (i.e. conflicting academic abilities), than those with low self-reported prejudice. High prejudiced individuals, moreover, were found to weight particular decision-related characteristics to justify their biased racially motivated judgments. Thus, under ambiguous conditions, the academic information that provided the lowest credential for Black students was weighted as more important for the decision compared to when the same qualification was the highest credential in other Black students. Therefore, participants high in racial prejudice were altering the weighting of the academic information in a way that disadvantaged Black students in conditions of decision-related ambiguity.

Norton, Sommers, Vandello, and Darley (2006) also showed alterations in the weighting of information in a university admissions paradigm. Consistent with Hodson et al. (2002), in situations of ambiguity, people scoring high on a self-report measure of explicit prejudice were less likely to select a Black student, although this effect was not statistically significant. However, across all participants, a Black student was *more* likely to be selected than a White student, suggesting the presence of positive discrimination within their population. Moreover, academic information was also weighted differentially depending on the race of the applicant. Although, overall, the criteria were weighted to justify positive discrimination, individuals high in prejudice were more likely to use weighting of criteria to justify their decision.

In sum, it is quite clear that in situations of ambiguity racial bias can have a crucial effect on social judgments. Individuals high in racial prejudice are found to be more likely to discriminate in such circumstances, basing this motivated bias in selective weighting of conflicting criteria. Although the previous studies clearly show a racially motivated bias, using the technique in Experiment 1 will allow a novel insight into the effect of racial bias on emotion-based learning by using a task specifically created to measure decisions under complexity and ambiguity, over time, and with shifting affective qualities.

This Chapter includes two investigations of how racial attitudes alter affective decision-making behaviour using the Iowa Gambling Task, where the incorporation of emotional labels allows the modelling of the effects of prejudice under a dynamic and complex scenario. Experiment 2 investigated whether racially-salient stimuli bias complex decision-making using Black and White faces. Experiment 3 assessed whether decision-making biases produced in this race variant of the Iowa Gambling Task correlate with well-established measures of explicit and implicit racial bias.

Experiment 2: The effect of racially salient labelling on Iowa Gambling Task decision-making

Method

Participants

40 White-European participants (27 female), aged 19-42yrs ($M = 24.5$, $SD = 5.27$) and with no history of neurological or psychiatric disorder, were obtained via a student participation panel at the University of Wales, Bangor. The participants were randomly allocated to one of two experimental conditions; incongruent ($n = 20$), congruent ($n = 20$)[3]. The participants were either given credit for course fulfilment or nominal financial compensation.

Procedure

Selecting Facial stimuli. One set of 21 face slides was produced, containing male Black (6) and White (15) faces. They were selected from the MacBrain NimStim face database (Tottenham et al., 2002[4]) and the A-face database (McKimmie & Chalmers, 2002; see Appendix 2a). All faces were frontal views with neutral emotional expressions.

[3] One participant in the congruent condition failed to complete the subjective experience questionnaire as required. Therefore, investigation 2 involves 19 participants in the congruent condition. Furthermore, SCR data for 3 participants during the face rating phase could not be collected due to technical problems.

[4] Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set.

The slides were subjectively rated by each participant on three Likert scales for attractiveness, trustworthiness, and distinctiveness. Four slides were selected based on these ratings for use in the later Gambling Task; this included two Black and two White face slides with comparable mid-scale subjective ratings. A paired-samples t-test of participant's subjective face ratings showed no significant difference between attractiveness (t (39) = -1.669, p = .103), distinctiveness ratings (t (39) = 1.098, p = .279), or trustworthiness (t (39) = -.936, p = .355) ratings for the faces selected from each racial category.

Skin conductance responses (SCR) were used to assess whether the selected stimuli produced autonomic arousal. SCRs were recorded via a BIOPAC 100MA/GSR100 constant voltage system (0.5V) and acquired with Acqknowledge 3.5 software for offline analysis (see Experiment 1 for more details). A paired samples t-test indicated no significant difference between the SCR amplitudes for black and white faces (t (36) = -.307, p = .761).

The Iowa Gambling Task Variants. The majority of materials utilized were identical to Experiment 1; however, the stimuli associated with the Gambling Task decks were White and Black faces from the preceding selection phase. Furthermore, subjective experience data was collected during the IGT. Decks were rated after each 20 card block on a Likert-style questionnaire using a subjective affect scale of 'goodness/badness' from 0 (very bad) to 10 (very good; Bowman, Evans, & Turnbull, 2005; see Appendix 2d) .

There were two experimental conditions which manipulated how the stimuli are associated with each deck. In the *Incongruent* condition the advantageous decks were associated with outgroup stimuli (e.g. Decks C & D – Black faces), and disadvantageous decks associated with ingroup stimuli (e.g. Decks A & B- White faces). The *Congruent* condition used the reverse association (i.e. White faces with advantageous decks and *vice versa*; see Figure 12).

Deck	Net Gain (10 trials)	Frequency Punishment
A	-£250	50%
B	-£250	10%
C	+£250	50%
D	+£250	10%

Figure 12. Representation of the Affective Labelling Iowa Gambling Task race variant with overall financial incentives for 10 card blocks. Decks were labelled with either Congruent (White face-good decks, Black face-bad decks) or Incongruent (as illustrated; Black face-good decks, White face-bad decks) racial stimuli. Participants were required to name each deck in a socially relevant manner (e.g. Mr A).

In the two conditions the stimuli were placed directly on top of the decks, with the participant required to name the decks in a socially salient manner (e.g. for deck A, named as 'Mr A') and forced to touch the card to remove the gambling card beneath the pictures. The slide was then replaced to its original position. As in Experiment 1, the contingency pattern of the original task was retained in both conditions.

Design

The experiment consisted of a mixed between- and within-subjects design and utilised an independent t-test between of Congruency condition (between-subject, 2 levels) and a dependent factor of overall task score, and repeated-measures ANOVA with factors of Congruency (between-subjects; 2 levels) and Block (within-subjects; 5 levels). The independent variable will be the Congruency of the IGT labelling, the dependent variable the mean block score of advantageous cards minus disadvantageous cards for each block of 20 cards (i.e. [(C+D)-(A+B)]). A similar analysis was performed for the subjective experience data, with data reduced using the same formula (i.e. [(C+D)-(A+B)]).

Results

Investigation 1: Behavioural IGT data

Overall Analysis. Participant's overall performance was calculated using the equation [(C+D)-(A+B)], which provides an index of their overall choices. Thus, a high overall score indicated an advantageous selection strategy, with more good deck cards chosen. Mean overall scores for each of the two experimental conditions were calculated indicating that the Congruent condition ($M = 23.3$, $SD = 17.49$) possessed the most advantageous overall performance and the Incongruent the least ($M = 7.8$, $SD = 23.95$; see Figure 13).

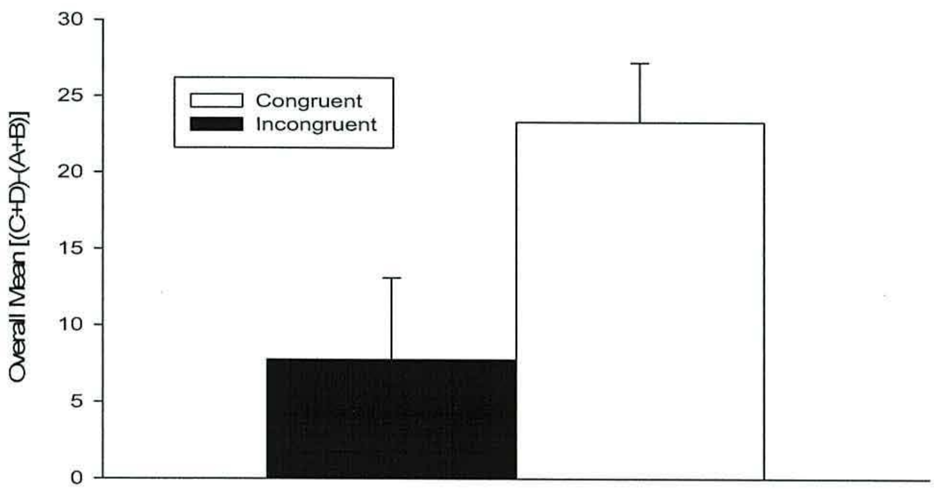


Figure 13. Mean overall task scores for the two race Congruency conditions (Error bars indicated 1 *SEM*). Significantly more selections were made from the disadvantageous decks in the Incongruent condition (Black faces-good decks, White faces - bad decks).

An independent t-test indicated that these differences in overall selection strategy were significant ($t\ (38) = 2.345$, $p = .024$, $d = .74$), with substantially more disadvantageous cards selected in the Incongruent condition.

Analysis by block. As in the original Gambling Task (Bechara et al., 1994), the 100 card selections were split into five equivalent blocks of 20 cards. An overall block score was calculated from the equation [(C+D)-(A+B)], illustrating how advantageous their deck preferences were during the five blocks and providing a profile of their emotion-based learning.

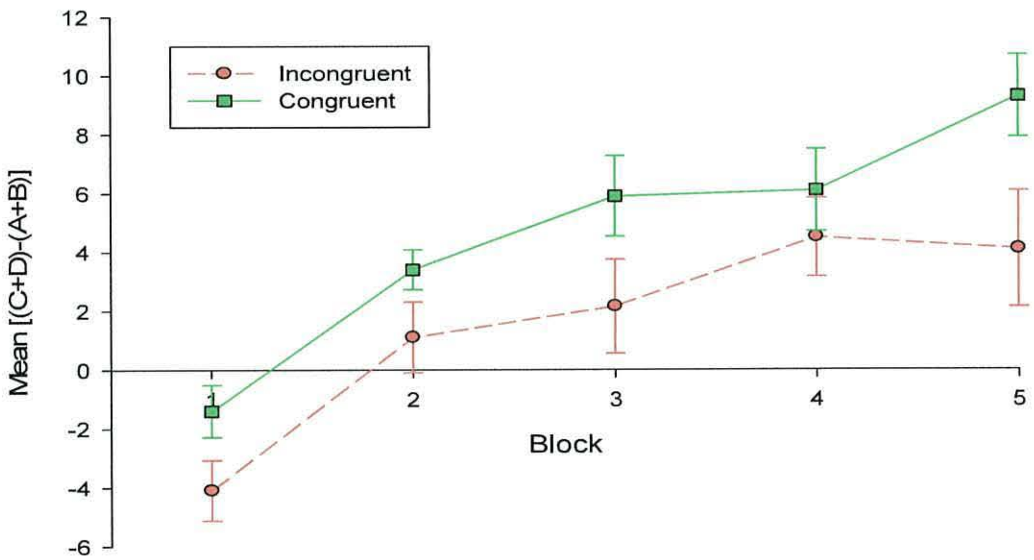


Figure 14. The mean card selection profiles for the Incongruent (n = 20) and Congruent (n = 20) conditions in the racial labelling version of the IGT (Error bars indicate 1 *SEM*). A selection bias was present in the Incongruent condition when compared to the Congruent condition.

The results showed that participants learned in both conditions, but that performance in the Incongruent condition was biased compared to that attained in the Congruent condition (see Figure 14).

A mixed ANOVA with factors of Congruency (between-subjects; 2 levels) and Block (within-subjects; 5 levels) with Greenhouse-Geisser corrections found a significant main effect of Block, (F (2.989, 113.334) = 23.820, $p < .001$, $\eta^2 = .38$) and no interaction between Block*Congruency, (F (2.982, 113.334) = .876, $p > .05$). A significant difference between Congruency conditions (F (1, 38) = 5.499, p = .024, $\eta^2 = .13$). Post-hoc independent t-tests showed significant differences between the Incongruent and Congruent conditions in block 5 ($p = .038$, $d = .68$), with borderline effects in block 1 ($p = .054$) and block 3 ($p = .083$).

Investigation 2: Subjective Experience Data

From the subjective experience data, an overall block score was calculated from the equation [(C+D)-(A+B)], as in Bowman et al. (2005). This shows an index of the participant's subjective deck preferences during each of the five blocks and providing an alternative profile of their emotion-based learning.

The results showed that from block 1 onwards participants the financially advantageous decks were rated progressively more favourable, but that subjective ratings in the Incongruent condition were lower in all blocks compared to that attained in the Congruent condition (see Figure 15).

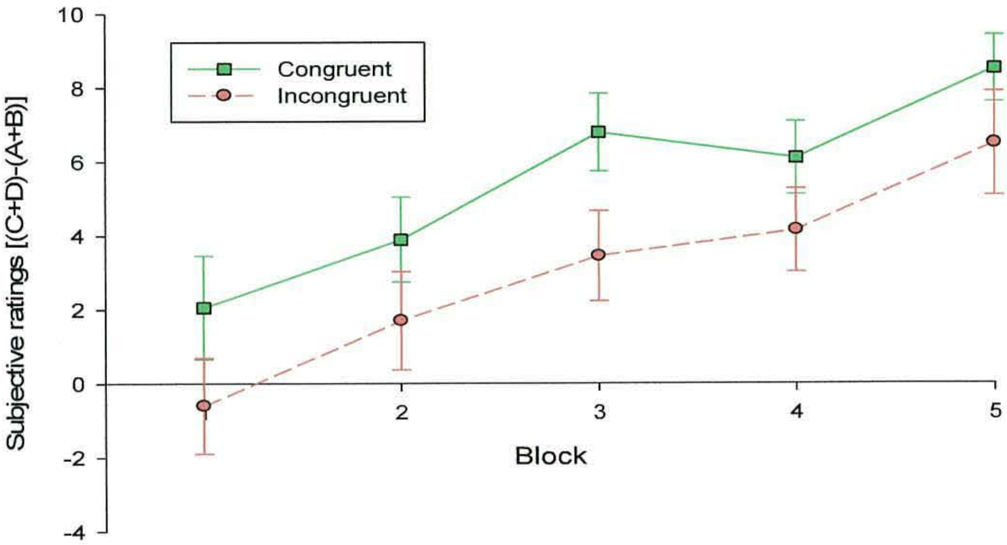


Figure 15. The mean subjective rating profiles for the Incongruent (n = 20) and Congruent (n = 19) conditions in the racial labelling version of the IGT (Error bars indicate 1 *SEM*). Participants rated good decks less favourably across all blocks in the Incongruent condition when compared to the Congruent condition.

A mixed ANOVA with factors of congruency (between-subjects; 2 levels) and block (within-subjects; 5 levels) found a significant main effect of Block, (F (2.853, 105.566) = 8.580, $p < .001$), no interaction between Block*Condition, (F (2.853, 105.566) = .179, $p > .05$), but a significant difference between congruency conditions (F (1, 37) = 4.145, $p = .049$). Post-hoc independent t-tests showed that there was a significant difference between the subjective ratings in the Incongruent and Congruent conditions in block 1 ($p = .049$) and block 3 ($p = .046$).

Discussion

Experiment 2 examined the effects of race-derived affective bias on Iowa Gambling Task decision-making. As in Experiment 1, participants showed learning in both conditions, beginning at levels close to chance, with a growing preference for selections from the advantageous decks. This finding was also consistent with many previous studies (e.g. Bechara et al. 1994; Bowman & Turnbull, 2003).

The addition of incongruent race-based labels to individual decks significantly reduced the magnitude of learning on the task, such that participants were more likely to choose cards from decks labelled with a White face, although this was financially disadvantageous. Experiment 1 had shown that an affective bias was sustained throughout the entire task; likewise, this experiment demonstrated that race-based labelling resulted in a similar persistent decision-making bias. This finding is consistent with a range of studies showing that race-related information can have a detrimental effect on judgements, particularly under situations of ambiguity (e.g., Doviodo & Gaertner, 2000; Hodson, Dovidio, & Gaertner, 2002; Hugenburg & Bodenhausen, 2003), however, this is the first experiment to show such an effect on a task as complex as the IGT.

This experiment also collected data relating to participant's subjective evaluation of the task objects, and showed increasing ratings of 'goodness' for the financially advantageous decks as in previous experiments (Bowman, Evans & Turnbull, 2005).

There was also a significant difference between subjective ratings in the two congruency conditions, with lower ratings in the incongruent labelling condition than the congruent labelling condition. Although this subjective bias was significant only in blocks 1 and 3, it does suggests that participant's affective evaluations of the task objects were altered in a comparable way to their actual choice behaviour.

Thus, Experiment 2 shows a clear and persistent biasing effect from race-related labelling and appears to lead clearly to the assumption that this bias is a consequence of *race*. However, there are other possible explanations, including other face-related social variables or low-level perceptual effects.

Explanations based on non-race effects

Although the stimuli were selected to be matched across participant's subjective ratings for attractiveness, trustworthiness, and distinctiveness, it is possible that these subjective responses were moderated due to social desirability effects. If such a process was present, this may well be important since, for example, processing facial attractiveness (e.g., Winston et al., 2007) and trustworthiness (Engell, Haxby, & Todorov, 2007; Winston, Strange, O'Doherty, & Dolan, 2002) have been shown to involve areas of the brain implicated in emotion. Later, Chapter 5 will address the influence of facial trustworthiness and facial attractiveness on affective decision-making.

There is also the possibility that some sort of low-level visual bias might account for this finding. One perhaps might speculate that the simple contrast or perceptual dichotomy between light and dark stimuli could produce an effect on IGT performance. Therefore, the relationship between race-based attitudes and performance on this version of the IGT must be examined further.

Competing race-based explanations

A race-derived bias in the incongruent condition might be due to either enhancement or disruption of decision-making in participants high in implicit race bias. The more obvious explanation would propose that individuals in high race bias would select less cards from the outgroup decks. In contrast, a counterintuitive enhancement of decision-making would suggest individuals high in race bias would select more cards from outgroup decks. These two race-based effects could result from distinct influences on Iowa Gambling Task decision-making, each will be outlined below.

The substantial effect of race labelling in the incongruent condition might be a consequence of biasing different aspects of the decision-making process: either pre- or post-decision, or both. For example, pre-decision, individuals high in race bias may be more likely to choose cards from the White face decks than Black face decks because of approach-avoidance biases mediated by affective guidance (Damasio, 1994; Schwarz & Clore, 1996; Wagar & Dixon, 2007). Thus, whilst contemplating the decision and evaluating task objects (i.e., decks), pre-existing race bias may result in a more negative affective weighting of the Black face decks and/or more positive affective weighting of the White face decks. This would lead to a greater biasing of selections away from the outgroup decks in individuals with higher race bias, which in the incongruent condition would lead to *worse* performance.

Post-decision, it is possible that the affective feedback (rewarding properties) from the decks is processed differentially for decks of each race. For instance, rewards may be perceived as less rewarding, and punishments more punishing from outgroup decks, and *vice versa* for ingroup decks. Similarly, from a more cognitive perspective, information that is inconsistent with pre-existing attitudes may be processed in a way that confirms those attitudes (e.g., Darley & Gross, 1983; Ditto et al., 1998; Ditto & Lopez, 1992; Edwards & Smith, 1996; Kunda, 1990; Lord, Ross, & Lepper, 1979; Sherman, Stroessner, Conrey, & Azam, 2005). For example, Darley and Gross (1983) demonstrated how differential social labeling (low or high social class) altered judgments of academic ability, even though identical information was provided. Motivated reasoning has been shown to occur in a way in which information that is consistent with attitude-based expectations is taken at face value. Whereas information that is inconsistent with pre-existing attitudes is of minimal influence in social decisions (i.e., confirmation bias; c.f. Nisbett & Ross, 1980) - with individuals often unwilling to fully examine such information (Brock & Balloun, 1967), or perhaps considering it flawed (Lord, Ross, & Lepper, 1979).

In sum, pre-existing social biases may lead to differential weighting of information received from the decks according to race. This biasing of deck properties would be expected to feed into the pre-decision process on subsequent IGT trails. Moreover, as noted earlier, race-based discriminatory decisions may be underpinned by differential weighting of decision-relevant information (Hodson, Dovidio, & Gaertner, 2002; Norton, Sommers, Vandello, & Darley, 2006). Thus, biased weighting of decision-related information is a plausible option to explain these findings. This form of decision-making bias would also lead to *worse* performance on the race variant IGT for individuals with high levels of racial prejudice.

Alternatively, perhaps it is also conceivable that individuals with high race bias actually perform more *effectively* than those with low race bias. Thus, as shown by Richeson and Shelton (2003; Richeson et al., 2003), Cunningham et al. (2004), and Lieberman et al., (2005) individuals appear to use areas of the frontal cortex to regulate emotional responses when processing race-related information at levels above conscious awareness. Perhaps the presence of a frontal lobe mechanism regulating negative implicit race bias might indirectly enhance the performance of individuals high in race bias, compared to those low in race bias (c.f. Overman et al., 2006).

Thus, a central limitation of Experiment 2 is that, although race appears to be an important influence, this conclusion remains somewhat speculative. Using other well-established techniques to measure race bias is the only approach to clarify whether the effect in Experiment 2 is mediated by race-based attitudes, rather than some non-race mechanism. This would also provide an opportunity to reduce the number of possible explanations of the 'incongruency' effect in this race labelled version of the IGT. Thus, correlations between measures of race bias and IGT performance might more clearly show whether race bias leads to better or worse performance. Therefore, Experiment 3 investigated the relationship between the race-based decision-making biases on this variant of the IGT and well-established measures prejudice, explicit and implicit.

Experiment 3: The relationship between race-related bias on the IGT and established measures of racial prejudice.

Chapter 1 provided an outline of how the social cognition literature makes a distinction between explicit and implicit prejudice, with the explicit form being measured by self-report questionnaires and related scales (e.g., feeling thermometers). A major weakness of self-report measures is the ease with which they are open to social desirability biases, such that people could readily present themselves as non-prejudiced to conform to social norms (e.g. Dovidio & Gaertner, 1986). Thus, explicit measures of racism found declines in racism across several decades (e.g. Dovidio & Gaertner, 1986; Greeley & Sheatsley, 1971; Schuman, Steeh & Bobbo, 1985), but explicit evidence of prejudicial behaviour remained (e.g., Dovidio & Gaertner, 1986; Devine, 1989). Rather than some form of spontaneous internally motivated shift towards egalitarianism, it was more likely that these declines in reported racism were a reaction to the change in social climate towards racist behaviour - best expressed in the introduction of legislation to protect ethnic minorities.

Therefore, more subtle self-report measures were introduced that attempted to bypass self-presentation biases and measure the more covert 'modern' (Modern Racism Scale; McConahay, Hardee, & Batts, 1981) or 'symbolic' (Symbolic Racism Scale; Henry & Sears, 2002) racism. These new definitions of racism were based on the proposal that racism had now become more indirect, being expressed symbolically via, for example, political attitudes (e.g., McConahay, 1986). Predictably, however, even this second generation of racism measures attracted considerable criticism for their transparency (e.g., Dovidio & Gaertner, 1986; Fazio, Jackson, Dunton, & Williams, 1995).

By the 1990s, the distinction between the explicit and implicit component of attitudes was becoming established (e.g., Devine, 1989; Greenwald & Banaji, 1995), providing the basis for new paradigms capable of tapping the implicit form of racial prejudice by measuring automatic evaluations of out-groups. Several different implicit techniques have been developed, for example, the Adjective Evaluation Task (Fazio et al., 1995), the Lexical Decision Task (Wittenbrink, Judd, & Park, 1997), and the Word Pronunciation Task (Kawakami, Dion, & Dovidio, 1998). All had successfully demonstrated the existence of a form of automatic race bias.

However, one task has become the most well-established and widely used measure of implicit racial prejudice - the Implicit Association Test (IAT; Greenwald, McGhee, & Schwarz, 1998). The IAT has been found to show high predictive validity on various criterion measures of prejudice (e.g. judgements, choices, behaviours, and physiological responses; McConnell & Leibold, 2001; see Poehlman, Uhlmann, Greenwald, & Banaji, submitted, for a review).

The IAT measures the strength of associations between examples of target conceptions (e.g. for racial attitudes; Black names *vs.* White names) and attributes of affective valence (i.e., positive *vs.* negative; laughter, hate). The task utilises counterbalanced blocks where the congruency of the association is altered, and the latency between response times for categorising exemplars of attributes and target concepts is determined. For instance, in the original Greenwald et al. (1998) investigation, European American participants were shown, on average, to more easily associate (i.e., faster categorisation RTs) Black names with negative attributes, than with positive. This paradigm has been applied to many types of implicit bias, ranging from self-esteem (Greenwald & Farnham, 2000) to consumer attitudes (Brunel, Tietje, & Greenwald, 2004).

Implicit measures confirm that prejudice appears to have become more indirect and subtle (e.g., Poehlman, Uhlmann, Greenwald, & Banaji, submitted); in fact, as noted earlier, some people can consciously support equality for minorities and view themselves as being non-prejudiced, but still express social biases in less obvious and more readily rationalisable ways (i.e., Aversive racists; Dovidio & Gaertner, 1998; Gaertner & Dovidio, 1986).

Experiment 3 investigates whether the decision-making bias on the race-based variant of the IGT can be related to various measures of racial attitudes. Participants completed measures of explicit prejudice, including the Modern Racism Scale (McConahay, Hardee, & Batts, 1981), Symbolic Racism Scale (Henry & Sears, 2002), and the Motivation to Respond with Prejudice Scales (Internal and External subscales; Plant & Devine, 1998). The latter scales measure the degree to which individuals are motivated by internal (self-motivated) or external (social pressure) influences to show non-prejudiced behaviour. Finally, this experiment used the IAT to measure implicit racial bias. If the decision-making bias on this version of the IGT is a consequence of race-based influences, then there may be a relationship between IGT performance and established measures of racial bias.

Method

Participants

56 White-European participants (41 females), aged 19-47yrs ($M = 20.3$, $SD = 4.36$) and with no history of neurological or psychiatric disorder, were obtained via a student participation panel at the University of Wales, Bangor. The participants were

randomly allocated to one of two experimental conditions; incongruent ($n = 28$), congruent ($n = 28$). The participants were given credit for course fulfilment.

Procedure

The methodology of facial stimuli selection and the Iowa Gambling Task variants themselves were identical to Experiment 2. However, in this experiment, no SCRs were recorded during the facial stimuli selection phase. A paired-samples t-test of participant's subjective face ratings showed no significant difference between attractiveness (t (55) = -.450, p = .655) and distinctiveness ratings (t (55) = -1.264, p = .212) for the faces selected from each racial category. However, there was a significant difference between the ratings for trustworthiness (t (55) = -2.662, p = .010), with black faces rated more untrustworthy than white faces.

Measure of implicit prejudice. After completing the IGT phase, participants performed the IAT, presented as a 'word categorisation' task. The IAT involved seven trial blocks (see Table 1). The first two blocks allowed the participants the opportunity to learn the mappings between attribute (Block 1; good *vs.* bad) and race category (Block 2; Black name *vs.* White name) and response keys (left = 'e' and right = 'i'). Block 5 is a further practice block which involves reversal of the initial target race category (48 trials). There were four experimental blocks, two of which measure the associations between Black + pleasant/White + unpleasant, and two which measure association between White + pleasant/Black + unpleasant (24 blocks in Test1, 48 in Test2). An inter-trial interval of 500ms was used. IAT *D* values for each participant were calculated according to the improved scoring algorithm outlined in Greenwald, Nosek, and Banaji (2003).

Table 1

Sequence of Trial Blocks in the Black-White IAT

Block	No. of Trials	Function	Items assigned to left key response	Items assigned to right key response
1	24	Practice	Black name	White name
2	24	Practice	Pleasant words	Unpleasant words
3	24	Test1	Black name + Pleasant words	White name + Unpleasant words
4	48	Test2	Black name + Pleasant words	White name + Unpleasant words
5	48	Practice	White name	Black name
6	24	Test1	White name + Pleasant words	Black name + Unpleasant words
7	48	Test2	White name + Pleasant words	Black name + Unpleasant words

Note. For half the participants, the positions of blocks 1, 3, and 4 are switched with blocks 5, 6, and 7, respectively. The IAT *D* values were calculated using the improved scoring algorithm (Greenwald, Nosek, & Banaji, 2003).

Attribute stimuli and some race category names were taken from Greenwald, McGhee, and Schwarz (1998). However, some race category names were altered to be more indicative of the UK population[5] (see Appendix 2c for a full list of stimuli items). The IAT was performed on a Toshiba Tecra A2 laptop installed with Microsoft Windows XP Professional.

[5] A small pilot study was undertaken to determine popular and familiar Black names in the UK. Although names of the Black population may be less familiar than names of the white UK population, studies do show that the IAT is robust to such minor stimuli effects when the stimuli are good exemplars of the target category (Dasgupta et al., 2000; Greenwald & Nosek, 2001; Ottaway, Hayden, & Oakes, 2001).

Independent t-tests showed there were no significant differences for participant IAT *D* scores between the Incongruent ($M = .839$, $SD = .381$) and Congruent ($M = .834$, $SD = .450$) conditions ($t\ (54) = -.041$, $p > .05$).

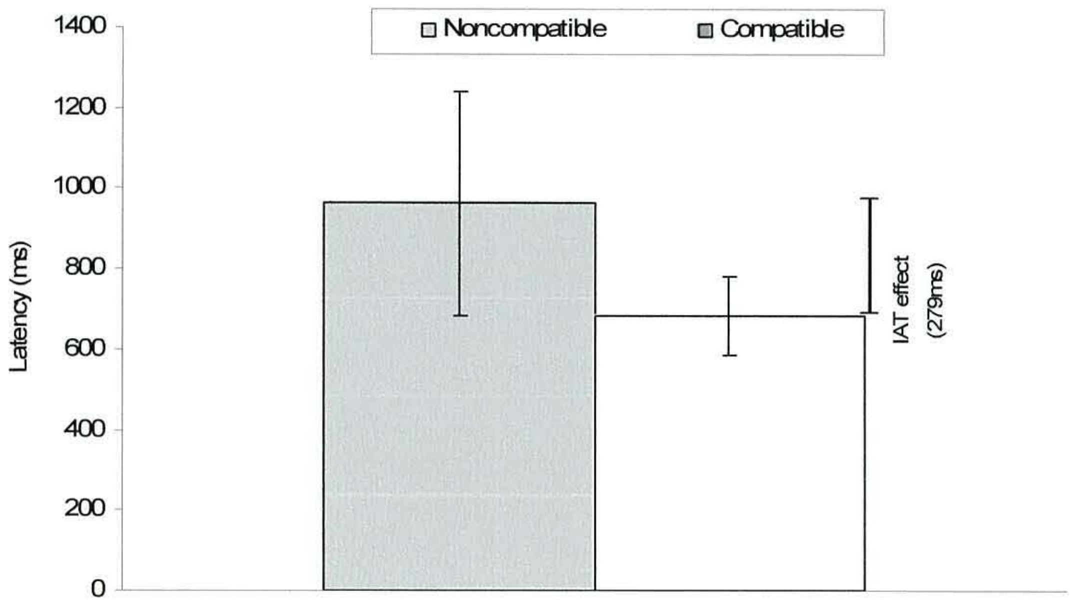


Figure 16. Comparison of mean latency results for the compatible (*White + pleasant* and *Black + unpleasant*) and incompatible (*White + unpleasant* and *Black + pleasant*) blocks of the IAT. The difference between the two conditions is the 'IAT effect', which was large and significant in Experiment 3. Error bars are the standard deviations.

Overall IAT latency data showed a significant IAT effect of 279ms (see Figure 16), a paired t-test showed a significant difference between compatible and noncompatible blocks ($t\ (55) = 9.086$, $p < .001$).

Measures of explicit prejudice. In the final phase, participants completed an 'opinion questionnaire' that included three separate questionnaires: (i) a six item Modern Racism Scale[6] (MRS; McConahay, 1986), which required responses along a five point Likert scale; (ii) the eight item Symbolic Racism Scale (SRS; Henry & Sears, 2002), which required responses on a four point Likert scale; and (iii) the internal (IMS) and external (EMS) motivation to respond without prejudice scales from Plant & Devine (1998), scored on a nine point Likert scale. For the participants in this study, Cronbach α was (i) .357 for the MRS (M = -.66, SD = .706); (ii) .556 for the SRS (M = .32, SD = .114); and (iii) .835 for the IMS (M = 7.13, SD = .325) and .710 for the EMS (M = 4.57, SD = 1.480)[7]. Independent t-tests showed there were no significant differences in questionnaire scores between the Congruent and Incongruent conditions ($p > .05$). Information about the participant's cultural identity (i.e., ethnic identity) was also collected.

Design

The experiment consisted of a mixed between- and within-subjects design and utilised an independent t-test between Congruency condition (between-subject, 2 congruent *vs.* incongruent) and a dependent factor of overall task score, and repeated-measures ANOVA with factors of task variant (between-subjects; Congruent *vs.* Incongruent) and Block (within-subjects; 5 levels). A similar analysis

[6] The original version of the Modern Racism Scale (McConahay, 1986) uses seven items, however, item 2 – "Blacks have more influence upon school desegregation plans than they ought to have" – was considered irrelevant to racial discrimination in the UK and Europe, and was therefore removed.
[7] As four participants failed to fully complete the opinion questionnaire, missing data was substituted with the overall mean value for each of the relevant items.

was performed for the subjective experience data, with data reduced using the same formula (i.e. [(C+D)-(A+B)]). Overall performance on the IGT was correlated with the measures of implicit and explicit racial prejudice.

Results

Investigation 1: Behavioural IGT data

Overall analysis. Mean overall scores for each of the two experimental conditions were calculated indicating that the Congruent condition (M = 18.7, SD = 14.38) possessed the most advantageous overall performance and the Incongruent the least (M = 2.32, SD = 12.50; see Figure 17). An independent t-test indicated that these differences in overall selection strategy were significant (t (54) = 4.543, p < .001, d = 1.21) with substantially more disadvantageous cards selected in the Incongruent condition.

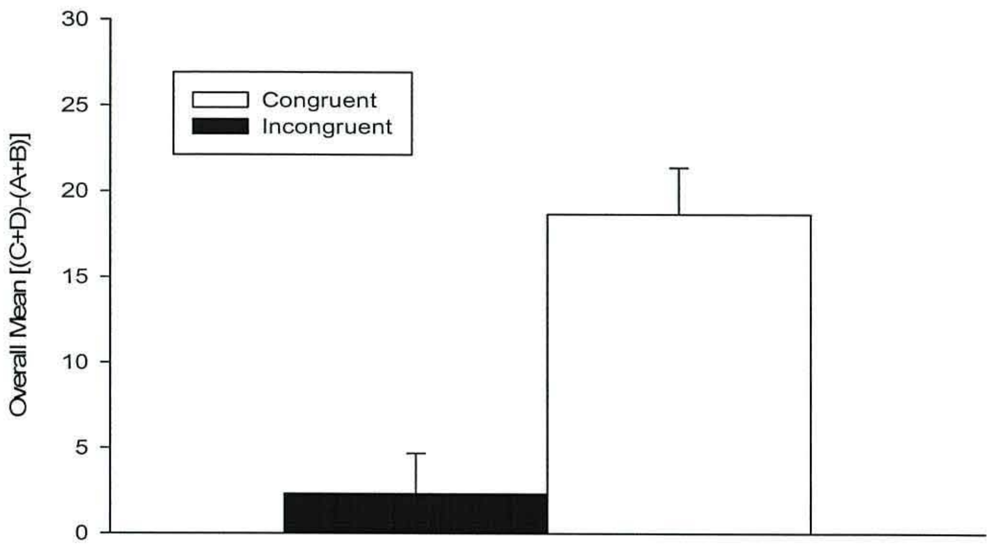


Figure 17. Mean overall task scores for the two race Congruency conditions (Error bars indicated 1 *SEM*). Significantly more selections were made from the disadvantageous decks in the Incongruent condition.

Analysis by block. The learning profile data showed that participants learned in both conditions, but that performance in the Incongruent condition was hindered compared to that attained in the Congruent condition (see Figure 18). A mixed ANOVA with factors of Congruency (between-subjects; congruent *vs.* incongruent) and Block (within-subjects; 5 levels) found a significant main effect of Block, (F (4, 216) = 14.174, $p < .001$, $\eta^2 = .20$), no interaction between Block*Congruency, (F (4, 216) = .830, $p > .05$), but a significant difference between Congruency conditions (F (1, 54) = 20.759, $p < .001$, $\eta^2 = .28$). Post-hoc independent t-tests showed significant differences between the Incongruent and Congruent conditions in block 2 ($p = .015$, *d* = .67), block 3 (*p* = .034, *d* = .58), block 4 (*p* = .003, *d* = .83) and block 5 (*p* = .003, *d* = .83).

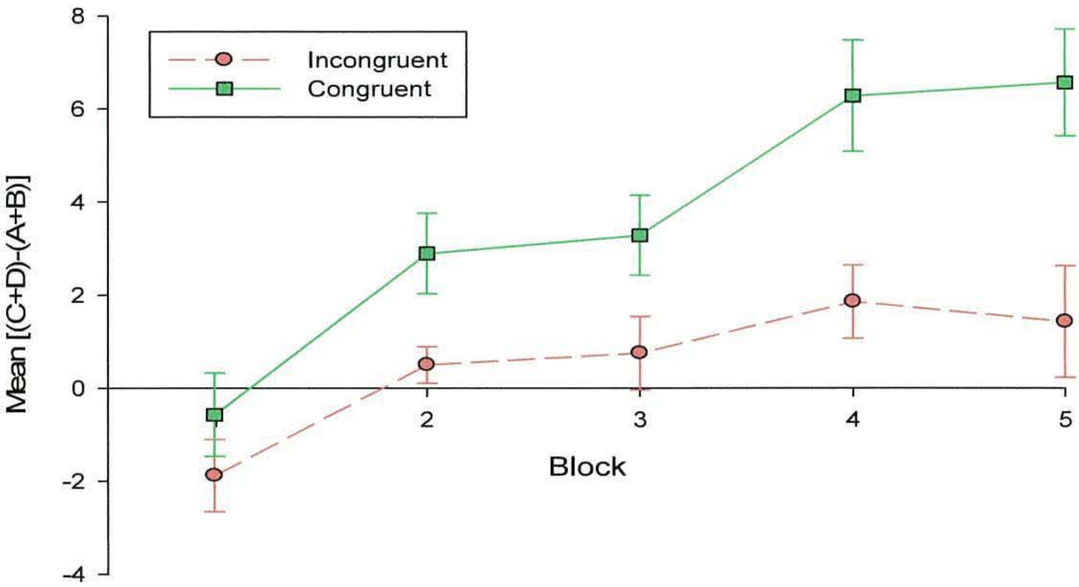


Figure 18. The mean card selection profiles for the Incongruent (*n* = 28*)* and Congruent (*n* = 28) conditions in the racial labelling version of the IGT (Error bars indicate 1 *SEM*). Learning was hindered in the Incongruent condition when compared to the Congruent condition.

Investigation 2: Subjective Experience Data

Overall Analysis. Mean subjective experience ratings for each of the two experimental conditions were calculated indicating that the Congruent condition (*M* = 20.8, *SD* = 15.46) possessed the highest overall subjective ratings and the Incongruent the lowest (*M* = 9.5, *SD* = 16.67; see Figure 19). An independent t-test indicated that these differences in overall selection strategy were significant (*t* (54) =

2.627, $p < .05$, $d = .70$) with substantially lower ratings of the good decks in the Incongruent condition.

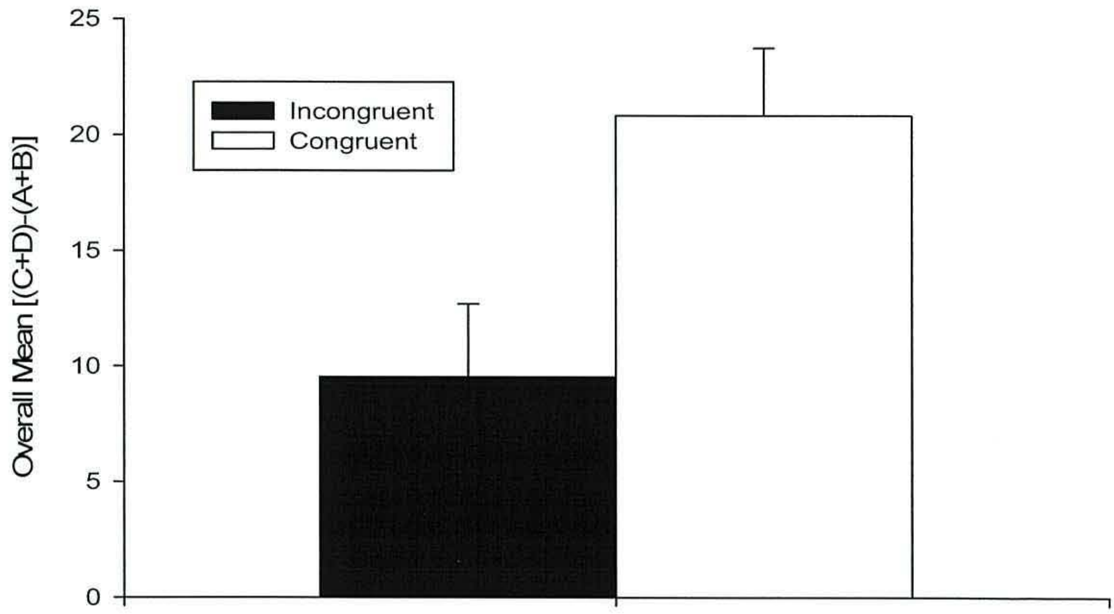


Figure 19. Mean overall subjective experience ratings for the two race congruency conditions (Error bars indicated 1 *SEM*). The good decks were rated more favourable across the task in the Congruent condition compared to the Incongruent condition.

Analysis by block. The results showed that from block 1 to block 3, the financially advantageous decks were rated progressively more favourable, with ratings becoming more variable in the latter 2 blocks. However, subjective ratings in the Incongruent condition were lower in all blocks compared to that attained in the Congruent condition (see Figure 20).

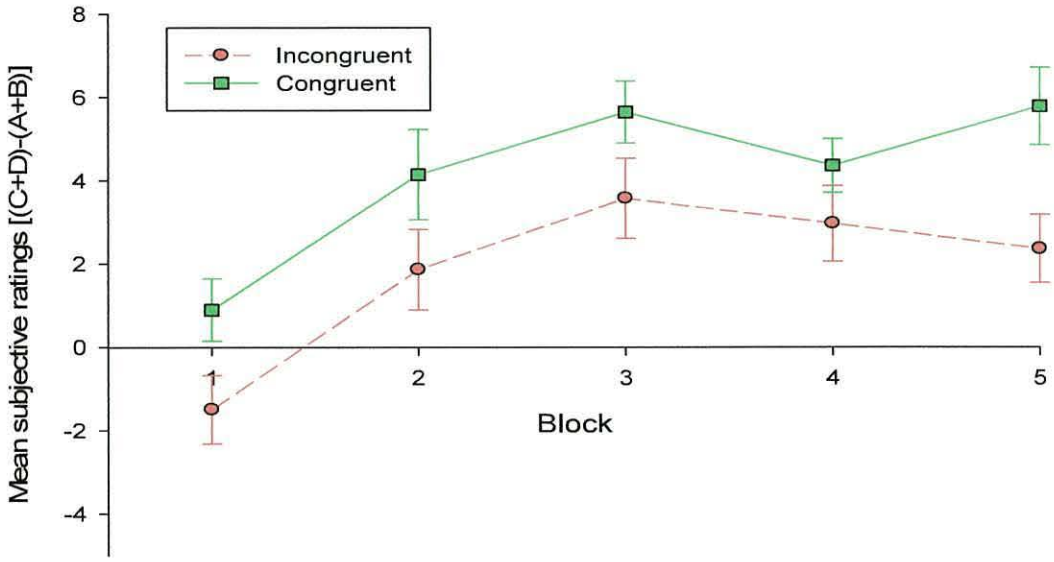


Figure 20. The mean subjective rating profiles for the Incongruent (n = 28) and Congruent (n = 28) conditions in the racial labelling version of the IGT (Error bars indicate 1 *SEM*). Participants rated good decks less favourably across all blocks in the Incongruent condition compared to the Congruent condition.

A mixed ANOVA with factors of Congruency (between-subjects; Congruent *vs.* Incongruent) and block (within-subjects; 5 levels), found a significant main effect of Block, (F (3.413, 184.294) = 15.547, $p < .001$, $\eta^2 = .22$), but no interaction between Block*Congruency, (F (3.413, 184.294) = .667, $p > .05$). However, a significant difference between Congruency conditions (F (1, 54) = 7.176, $p = .010$, $\eta^2 = .12$) was found. Post-hoc independent t-tests showed that there was a significant difference between the subjective ratings in the Incongruent and Congruent conditions in block 1, ($p = .036$, $d = .58$), and block 5 ($p = .008$, $d = .74$).

Investigation 3: explicit and implicit measures of prejudice

Explicit measures. To examine the relationship between the explicit self-report measures of prejudice and the Race-bias IGT, the total scores from the Modern Racism Scale (MRS; M = -4.0, SD = 2.52), Symbolic Racism Scale (SRS; M = 2.6, SD = 1.00), and the External (EMS; M = 22.9, SD = 7.02) and Internal (IMS; M = 35.6, SD = 7.68) motivation to respond without prejudice scales were correlated to overall performance and subjective experience data in the two congruency conditions of the Race-bias IGT.

Table 2

Correlations (N = 28) between Race-bias Iowa Gambling Task overall selection [(C+D)-(A+B)] and overall subjective experience response [(C+D)-(A+B)] data, and measures of implicit (IAT) and explicit (MRS, SRS, IMS, and EMS) prejudice

IGT Congruency	MRS	SRS	IMS	EMS	IAT
Congruent - selections	-.091	.065	.235	-.075	.074
Congruent - subjective	-.105	-.101	-.058	.101	.077
Incongruent - selections	-.096	-.036	-.066	.003	**.404***
Incongruent - subjective	-.059	-.277	.168	.085	**.590****

Note. MRS = Modern Racism Scale (McConahay, 1986); SRS = Symbolic Racism Scale (Henry & Sears, 2002); EMS = External Motivation to respond without prejudice Scale (Plant & Devine, 1998); IMS = Internal Motivation to respond without prejudice Scale; IAT = Implicit Association Test (Greenwald, McGhee, & Schwarz, 1998). $^{*}p < .05$ level; $^{**}p < .01$ level

There were no significant correlations between self-report measures of prejudice and performance on the Race-bias IGT in the Congruent or Incongruent condition for either measure (see Table 2), however, significant correlations were found between the various measures of explicit prejudice (see Table 3).

Table 3

Correlations (N =56) between Explicit Measures of Racial Prejudice the Implicit Association Test (D values)

	MRS	SRS	EMS	IMS	IAT
MRS	-	**.590****	.025	**-.591****	.033
SRS	**.590****	-	.025	**-.547****	-.081
EMS	.025	.079	-	.010	.205
IMS	**-.591****	**-.547****	.010	-	-.139
IAT	.033	-.081	.205	-.139	-

Note. MRS = Modern Racism Scale (McConahay, 1986); SRS = Symbolic Racism Scale (Henry & Sears, 2002); EMS = External Motivation to respond without prejudice Scale (Plant & Devine, 1998); IMS = Internal Motivation to respond without prejudice Scale; IAT = Implicit Association Test (Greenwald, McGhee, & Schwarz, 1998). $^{**}p < .01$ level

Implicit Association Test. To examine the relationship between participant's implicit race bias and IGT performance outcomes, correlations were calculated in the Congruent and Incongruent conditions and IAT *D* values. For overall card selection, there were no significant correlations in the Congruent condition, however, there was a moderate significant positive correlation in the Incongruent condition ($p < .05$; see Figure 21).

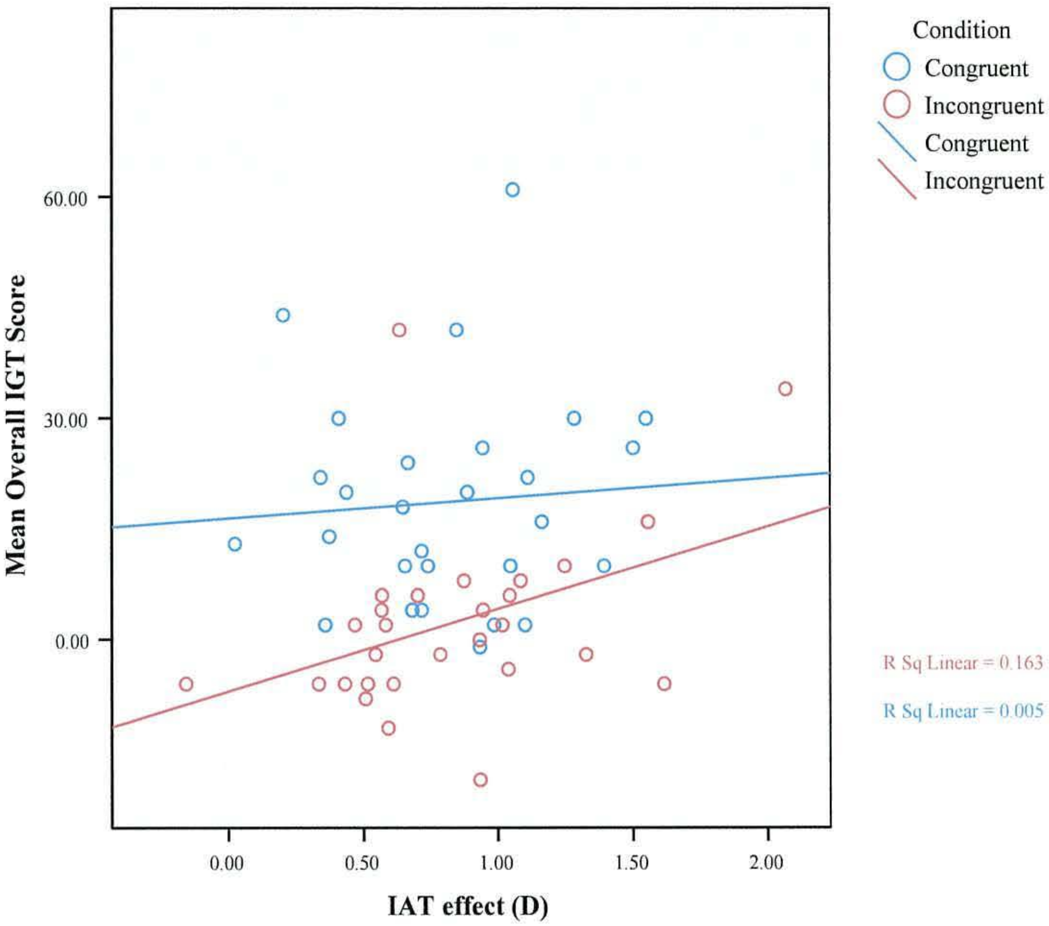


Figure 21. Correlations ($N = 28$) between IGT overall selection scores [(C+D)-(A+B)] and IAT D values in the Congruent and Incongruent conditions. In the Incongruent condition, there was a significant positive correlation indicating that with increasing implicit race bias, more selections were made from the good decks (Black face) in the Race-bias Iowa Gambling Task.

This was also reflected in participant's subjective experience data, where, again, a fairly strong significant positive correlation was found in the Incongruent condition ($p < .01$; see Figure 22), but no correlation was present in the Congruent condition.

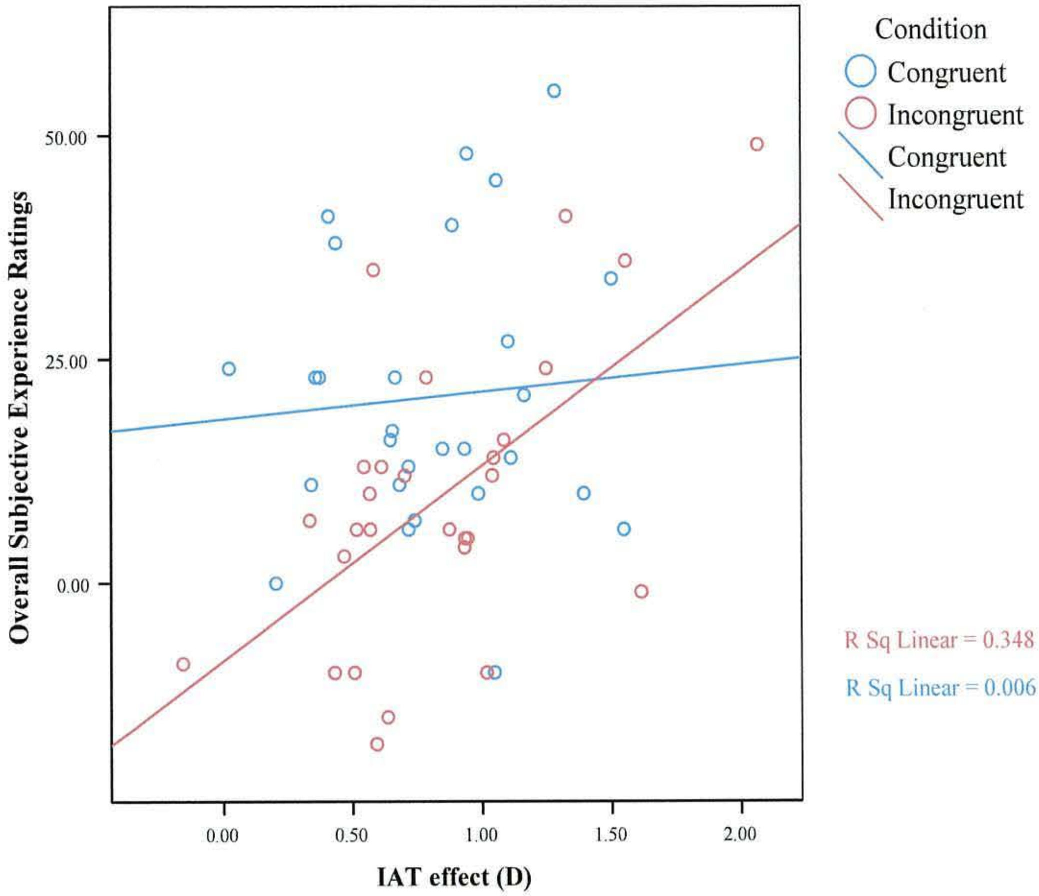


Figure 22. Correlations ($N = 28$) between IGT overall subjective experience ratings [(C+D)-(A+B)] and IAT D values in the Congruent and Incongruent conditions. In the Incongruent condition, there was a significant positive correlation indicating that with increasing implicit race bias participants increasingly rated the good decks (Black face) more favourable in the Race-bias Iowa Gambling Task.

Discussion

Experiment 3 examined the relationship between the race-derived affective bias on complex decision-making and well-established measures of implicit and explicit racial prejudice. Similar to both Experiments 1 and 2, participants showed learning in both conditions, beginning at levels close to chance, with a growing preference for selections from the advantageous decks, consistent with many previous original IGT findings (e.g., Bechara et al. 1994; Bowman & Turnbull, 2003).

Race bias and the IGT

The central finding of this chapter is the remarkable extent to which affective decision-making is altered by race-based labelling. The replication of Experiment 2 suggests the decision-making bias found in the incongruent condition is a robust effect. Thus, as in Experiment 2, the addition of incongruent race-based labels to individual decks significantly biased decision-making on the task, such that participants were more likely to choose cards from decks labelled with a White face, although this leads to striking financial losses. Consistent with Experiments 1 and 2, the magnitude of the affective bias in the incongruent condition was sustained throughout the entire task, indicating a persistent biasing of decision-making.

From the perspective of the subjective experience data, findings were also consistent with Experiment 2. Thus, both congruency conditions demonstrated increasing ratings of 'goodness' for the financially advantageous decks in each condition, but also a significant difference between subjective ratings in the two congruency conditions, with lower ratings in the incongruent labelling condition than the congruent labelling condition. As in Experiment 2, this suggests that participant's affective evaluations of the task objects were altered in a comparable way to their actual choice behaviour.

Relationship between IGT race labelling bias and measures of racial prejudice

Experiment 3 specifically focused on how the decision-making bias found in the race variant of the IGT was related to well-established measures of racial prejudice. One useful finding in this regard was that many self-report measures were inter-correlated. Thus the Symbolic Racism Scales (SRS; Henry & Sears, 2002), Modern Racism Scale (MRS; McConahey, 1986), and the Internal Motivation to Respond without prejudice Scale (IMS; Plant & Devine, 1998) were found to show high correlations, although there was little relationship between External Motivation to Respond without prejudice Scale (EMS; Plant & Devine, 1998) and the other self-report measures. However, self-report measures are often poor predictors of implicit race bias on the IAT (Greenwald, McGhee, & Schwarz, 1998). This is consistent with the proposal that explicit and implicit measures of attitudes can often show minimal relationships (e.g., Blair, 2001; Dovidio, Kawakami, & Beach, 2001; Hofmann et al., 2005; Karpinski & Hilton, 2001; Nosek, 2005), with correlations ranging from -.05 to .70 for various attitudes in one meta-analysis (Nosek, 2005).

The lack of relationship between explicit and implicit measures of attitude is particularly true when participants are motivated to control their explicit behaviour (e.g., Fazio & Olsen, 2003). This might also account for the absence of any relationship between performance on this race-based variant of the IGT and the self-report measures of race bias used in this experiment.

As noted, the major aim of Experiment 3 was to relate responses on well-established measures of prejudice to performance on this race variant of the IGT. In the *congruent* condition, this relationship did not appear to be present - there were no significant correlations found between measures of prejudice and IGT outcomes, for both behavioural and subjective ratings.

However, in the incongruent condition there were significant positive correlations between overall measures of IGT performance. These demonstrated, rather counter-intuitively, that individuals high in implicit race bias were more successful on this version of the IGT, selecting more cards from the good (Black face) decks, and also rating the good decks more positively across the task. This is an intriguing finding, and could be explained in a number of ways.

Implicit attitude change

Firstly, it is possible that performing the IGT before the measures of prejudice has altered the way people perform the IAT. Thus, could the learned incentive values experienced during the IGT influence implicit bias on the IAT? Such an effect would be expected to lead to different outcomes in the congruent and incongruent conditions. For example, in the incongruent condition the outgroup stimuli were associated with long-term good outcomes, and *vice versa*. Therefore, a carry-over effect from the IGT should have led to a reduction in the IAT effect compared to the congruent condition. However, analysis of the IAT data demonstrated that the results were unaffected by prior performance on the IGT, showing no significant difference between implicit race bias for participants within each congruency condition. Indeed, the data from the incongruent condition indicates that individuals who actually performed well on the IGT were *more* likely to show a higher level of implicit bias. That is, they chose more cards from outgroup decks, and also subjectively rated them more positively than participants demonstrating low levels of implicit bias. Thus, an explanation based on IGT influencing implicit bias on the IAT seems implausible.

It appears more likely, therefore, that implicit racial attitudes were relatively unchanged by performing the IGT first, even though participants underwent multiple trials in the incongruent condition where the outgroup stimuli were associated with a financially (and emotionally) rewarding contingency. Moreover, the behavioural and subjective experience data indicated a persistent decision-making bias in the incongruent condition. That is, the decision-making bias was present throughout the task, whereas, if attitude change was present one might expect to find that the magnitude of affective bias would alter over time.

The consistency of this decision-making bias over the task may reflect findings from the social cognition literature showing the relative inflexibility of race-based affective bias (e.g., Amodio, Devine, & Harmon-Jones, 2003). The involvement of the amygdala in the processing of race-related information has been reported in previous studies (e.g., Hart et al., 2000; Cunningham et al., 2004; Lieberman et al., 2005; Wheeler & Fiske, 2005), which includes the report of a positive correlation between implicit prejudice and amygdala activity (Phelps et al., 2000). Thus, if race-related bias is amygdala-sourced[8], the relative indelibility of associations derived from this brain region (LeDoux, 1996, 2000; Rolls, 1999, 2000) may underlie the apparent inflexibility of affective race bias (e.g., Amodio, Devine, & Harmon-Jones 2003).

Conscious self-presentation effect

A second explanation for the positive relationship between implicit race bias and performance in the incongruent condition of the race-labelled IGT regards the possibility of conscious and purposeful self-presentation. It has long been known that prejudiced individuals attempt to mask their negative attitudes to outgroups (e.g., Allport, 1954/1979). For instance, Allport's classic work observed that:

> Especially when inner conflict is present, people put brakes upon their prejudices. They do not act them out – or act them out only up to a certain point. Something stops the logical progression somewhere…To be sure, the inner check operates differently in different

[8] However, evidence from a case study does show that bilateral amygdala lesions had little effect on implicit race bias (Phelps, Cannistrasi, & Cunningham, 2003), suggesting that other regions of the brain also contribute to the neurobiological processes underpinning racial bias.

> circumstances…Brakes may be applied anywhere, according to the strength of the counterforces (inner and outer). Allport (1954/1979, p. 332-333).

Is it possible that participants high in prejudice 'put brakes upon their prejudice' and consciously, in an explicitly directed fashion, selected cards to in a way which would mask their prejudice? The nature of the IGT allows a participant time to consciously contemplate their decisions. Therefore, those with high implicit race bias would have an opportunity to behave in a way in which they could reduce concerns about negative evaluation from the researcher, essentially explicitly 'faking' their behaviour. Indeed, both subjective experience and behavioural data in the incongruent condition potentially showed more positive evaluation of the outgroup decks with higher implicit race bias.

'Faking' participants with high levels of race bias would be expected to bias choices from the outgroup decks in both the congruent and incongruent conditions. In the incongruent condition this would show as more selections from good decks (better performance). Conversely, in the congruent condition the selections would be expected to be biased more towards the bad decks (i.e., poorer performance). When the data in Experiment 3 was explored further, it became clear that this claim was not supported[9]. Thus, low and high race bias participants made comparable

[9] Splitting participants into highest and lowest IAT D scores (n = 10, 4 groups) for the behavioural data allowed more insight into the behaviour of the participants. In the congruent condition individuals high (M = 20.9, SD = 17.56) and low (M = 19.7, SD = 11.59) in race bias performed at similar levels, in the incongruent condition participants high in race bias (M = 6.8, SD = 11.67)

selections in the congruent condition. This suggests that conscious and directed adjustment of decision behaviour appears an unlikely explanation for the relationship between race bias on the IAT and performance on the race variant of the IGT, especially when also noting the lack of correlation in the congruent condition.

Furthermore, an explanation that relies on directed adjustment of behaviour (i.e., faking) in high race bias participants also fails to adequately explain a further finding of Experiment 3. In the incongruent condition, participants with low levels of implicit bias showed poor IGT performance and also low subjective ratings - these participants were found to perform *worst* of all.

Framing effects

In all three experiments thus far, the major effect of the affective labelling variants of the IGT is found in the *incongruent* condition. Performance in the congruent condition in Experiment 3 appears to be entirely comparable to performance in classic IGT experiments (e.g., Bowman & Turnbull, 2003), and previous experiments in this thesis. Therefore, a suitable explanation for the findings of Experiment 3 should be able to account for: (i) why participants under incongruent conditions perform at levels *below* those found in the congruent condition, (ii) why

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performed at a higher level than those with low race bias (M = -2.0, SD = 5.08). This suggests that those with low race bias were most affected by the 'incongruency' effect, and that individuals with high race bias would only have been consciously directing decision-making behaviour in one condition, which seems implausible. Therefore, the improved performance with increasing race bias appears to be a consequence of a more indirect factor.

higher levels of implicit bias lead to more *effective* performance in the incongruent condition of this race variant IGT.

One plausible explanation might be related to 'framing effects' (e.g., Kuhberger, 1998; Tversky & Kahneman, 1981). For instance, in the well-known Tversky & Kahneman (1981) 'disease outbreak' example two scenarios only differed in the way the issue was framed - in the first, as *saving* lives (positive frame); in the second, as *loss* of lives (negative frame). However, negative framing was shown to result in riskier decisions, whereas positive framing resulted in risk aversion. This influence of framing effects on risky decisions has been demonstrated in many studies (see Kuhberger, 1998, for a review). Similarly, the problem space in our modified Gambling Task is open to framing interpretations. The incongruent condition could be considered a form of 'negative' framing because of the inherent conflict between the affective labelling and the incentive values of the task objects. In contrast, the congruent condition can be viewed as a form of 'positive' framing due to the consistency between affective labels and the rewarding properties of the task objects.

However, why does implicit race bias lead to more *effective* performance in the incongruent condition? This appears at first glance to be a paradoxical finding, as it is this group of individuals (i.e., individuals high in implicit race bias) who might be expected to be *more* influenced by the incongruent framing of decisions in this condition, That is, people with higher race bias should possess more negative pre-existing affective bias and therefore should feel greater conflict between affective labels and long-term deck affective values. However, individuals both high and low in racial bias appear to possess knowledge of racial stereotypes, which might be readily activated automatically (Devine, 1989; Kawakami, Dion, & Dovidio, 1998; although see Lepore & Brown, 1997; Wittenbrink, Judd, & Park, 1997) and could underpin framing biases in all participants. Thus, the explanation of this somewhat counterintuitive finding might lie in the *regulation* of automatic race-based attitudes, and the overlap in brain regions involved in the regulation of emotion and complex decision making. This is evident from a substantial literature on the neurobiology of both processes.

Regulating implicit prejudice and the toleration of race-based framing

Firstly, as regards the regulation of racial prejudice, recent research shows how people appear to regulate their automatic negative biases through frontal lobe based mechanisms (Cunningham et al., 2004; Lieberman et al., 2005; Richeson et al., 2003; Richeson & Shelton, 2003). Thus, Richeson et al. (2003) have demonstrated a relationship between activity in the right DLPFC when exposed to Black faces, and interference on a subsequent Stroop test. This was interpreted as indicative of the 'resource depletion' model of inter-racial contact, whereby negative implicit attitudes are inhibited by executive resources (Richeson & Shelton, 2003). Indeed, Richeson & Shelton (2003) showed a positive correlation between implicit bias as measured by the IAT and resource depletion following interracial contact, suggesting that higher levels of implicit bias attract enhanced frontal lobe activity. A second set of neural structures may map onto other mechanisms by which pre-existing biases are managed. Thus, Richeson et al. (2003) also showed activation of the anterior cingulate cortex (ACC) during the processing of race-related information and Amodio et al. (2006) suggested that conflict-monitoring (via the ACC) modulates race-based responses. Consistent with this, Cunningham et al. (2004) report that, although implicit processing of race-related information evokes responses from the amygdala, when the same stimuli are presented above the level of awareness, areas of the frontal lobe (ventrolateral, dorsolateral, and ACC) regulate the reflexive amygdala activity. Therefore, humans appear to engage a range of executive control and emotion-regulation systems when encountering settings prone to prejudice.

Notably, the same regions of the brain are strongly implicated in complex decision making. Thus, damage to the DLPFC has been shown to lead to poor performance on the IGT (e.g., Fellows & Farah, 2005a; Manes et al., 2002), most likely by disruption of the working memory processes required for maintaining and manipulating task-relevant information (Goldman-Rakic, 1992; Krawczyck, 2002). Furthermore, neuroimaging studies demonstrate the involvement of the DLPFC in complex decision making (e.g., Bolla et al., 2004; Ernst et al., 2002), and the ACC in decision making under uncertainty (e.g., Critchley, Mathias, & Dolan, 2001; Ernst et al., 2002; Ernst et al., 2004; Rogers et al., 2004) aiding the control and selection of appropriate behavioural responses between conflicting alternatives (e.g., Critchley, Mathias, & Dolan, 2001; Ernst et al., 2004; Rogers et al., 2004). Moreover, the rostral region of the ACC has been suggested to have a specific role in the resolution of conflict between emotional stimuli (Egner, Etkin, Gale, & Hirsch, 2008; Etkin et al., 2006). On a related point, the ventrolateral PFC is proposed to mediate affective shifting/reversal learning (Kringelbach, 2004; Kringelbach & Rolls, 2003; Hornak et al., 2004), possibly by inhibiting responses which were previously rewarding (e.g., Elliot, Dolan, & Frith, 2000; O'Doherty et al., 2003). In sum, there appears to be considerable overlap between the neural regions that modulate racial bias and those that underpin flexible complex decision making.

This neuroanatomical overlap may underlie the counterintuitive finding that individuals with higher race bias are better able to tolerate the conflicting affective signals in the incongruent condition in Experiment 2. From this line of reasoning, the regulation of high implicit race bias by a network of frontal brain regions, a network also implicated in flexible problem solving, might help overcome the disruption of decision making due to the incongruent framing in the race variant of the IGT.

Supporting this argument, a somewhat similar enhancement of decision making has been shown recently in another IGT experiment. Thus, Overman et al. (2006) reported that contemplating moral dilemmas served to eliminate the sex differences commonly found on the IGT (e.g., Bolla et al., 2004; Overman, 2004). Bolla et al. (2004) showed that performance differences between the sexes may be a related to differential prefrontal cortex activity, with males showing greater right hemisphere lateral OFC (BA 47) and dorsolateral PFC activity than females. Thus, this activity might underpin better performance for males in the IGT. Indeed, the lateral areas of the orbitofrontal cortex do appear to be involved in regulating the infusion of emotion-based information into the decision making process (Beer, Knight, and D'Esposito, 2006).

In the Overman et al. (2006) investigation, participants were required to perform the IGT whilst deliberating on personal moral dilemmas. Previous neuroimaging studies show increases in various frontal regions of the brain, including dorsolateral, orbitomedial, and ventrolateral PFC, along with the ACC (Greene et al., 2001; Moll, Eslinger, & de Oliveira-Souza, 2001; see Moll et al., 2005, for a review) during the contemplation of personal moral problems. Thus, elimination of sex-related differences in the IGT suggests that increased activity of frontal regions of the brain from moral-related processing enhanced IGT decision making specifically in females. A similar process could account for the findings in this experiment. For example, in the incongruent condition, a related explanation would suggest all participants were influenced by the incongruent framing of the problem space. However, activity in the frontal cortex derived from the regulation of strong implicit race biases (i.e., DLPFC, VLPFC, and/or ACC) would allow some participants to better tolerate this framing effect.

Chapter 4: Racial bias and complex decision-making

Summary

In sum, the findings of Experiment 2 and 3 clearly show that participants in the race-based incongruent condition exhibited a persistent biasing of decision-making behaviour, compared to participants in the congruent condition. One reasonable explanation of this consistent bias is that framing effects in the incongruent condition cause participants to become riskier decision-makers and choose less advantageously across the task (c.f., Tversky & Kahneman, 1981). Experiment 3 clarified the relationship between race bias and performance on this race variant of the IGT by demonstrating a positive correlation between implicit race bias and IGT performance in the incongruent condition. Thus, higher implicit bias was related to more adaptive decision-making, suggesting that participants with higher race bias can better tolerate the incongruent framing compared to those with low race bias. This may be due to enhanced neural activity within regions of the frontal lobe regulating race-related responding (Amodio et al., 2006; Cunningham et al., 2004; Lieberman et al., 2005; Richeson et al., 2003), but which also overlap considerably with the neural correlates of adaptive decision-making, such as dorsolateral, ventrolateral, and ACC (e.g., Ernst et al., 2002; Ernst et al., 2004; Hornak et al., 2004). Thus, the greater the individual's implicit bias, the more frontal lobe regulation required to inhibit these automatic attitudes (c.f. Richeson & Shelton, 2003). The presence of such a process might possibly underpin more advantageous decision-making on the IGT (c.f. Overman et al., 2006).

Earlier in the chapter, other possible reasons for the effect found in these experiments were discussed. An outstanding issue is that of non-race facial attributes. Two highly relevant attributes are facial trustworthiness and attractiveness, both of which have been shown to be mediated by regions of the brain implicated in emotion (e.g., Adolphs, Tranel, & Damasio, 1998; Engell, Haxby & Todorov, 2007; Winston et al., 2002; Winston et al., 2007).

Distrust of outgroups is known to be one consequence of social categorisation (Brewer, 1981; Kramer & Jost, 2003), and Black individuals can elicit lower ratings of trustworthiness than White individuals (Switkin & Gynther, 1974). This suggests that within the race variant, trustworthiness as a confounding variable is a minor issue, due to its close relationship to social categorisation of outgroups. However, the effects of trustworthiness and attractiveness as another social source of affective bias in complex decision-making are worth pursuing. Chapter 5 will investigate such effects on the affective labelling variant of the IGT.

Chapter 5

Pre-existing affective bias from non-race facial attributes

Although the well-known saying compels us to not 'judge a book by its cover', faces are an important source of social information for gaining an impression of other people (e.g., Zebrowitz, 1997). As well as transmitting information about mood and emotional states (e.g., Ekman, & Oster, 1979; Ekman, 1982), faces are also used to judge personality characteristics (e.g., Hassin & Trope, 2000; Zebrowitz, 1997).

Using faces as a source of information for personality traits (i.e., *physiognomy*[10]) has a long history (e.g., Browne, 1645; Lavater, 1797). Although physiognomy attracted criticism (e.g., Gall, 1835; Hegel, 1931/1967) and has been generally viewed as pseudoscientific (Brandt, 1980), it still possessed a degree of scientific credibility during the 20th century (e.g., Brandt, 1980). Lombroso's (1899/1911) evolution-based version of physiognomy, for example, provided a basis for identifying criminals, and even scientific racism (e.g., Collins, 1999; Pick, 1989). However, with the development of scientific mental testing, physiognomy gradually lost scientific credibility (e.g., Rose, 1985), but still lingered in psychological discourse (Collins, 1999).

[10] Lavater's physiognomy included the whole body, whereas other writers believed it to be restricted to the head and face. Phrenology can be readily considered a variant of physiognomy (see Collins, 1999, for a review of the history of physiognomy).

In lay psychology, beliefs in the validity of physiognomy are shown to be widespread, with 75% of a general population (Hassin & Trope, 2000) and 90% of a student sample (Liggett, 1974) proposing that faces provide some degree of information about personality traits. Famously, the captain of HMS Beagle, Robert Fitzroy, believed that Charles Darwin's large nose was indicative of a sluggish personality when assessing him for a position on the famous voyage around the South American continent (Fancher, 1990). Indeed, using physiognomic information to judge the suitability of job candidates was still seen as a valid approach in the 20th century (Brandt, 1980; Collins, 1999; Zebrowitz, 1997). Thus, regardless of the *scientific* validity of physiognomy, the value of reading faces for social information has widespread *public* acceptance.

The 'kernel-of-truth' in face-based judgments

Although the extreme form of physiognomy should rightly be regarded as pseudoscience (Brandt, 1980), a corpus of research shows that ratings of personality traits from faces are found to be highly reliable (e.g., Albright et al., 1997; Berry, 1990; Zebrowitz, 1997). Thus, individual ratings of some personality traits are in close agreement (e.g., Berry, 1990), even across cultures (e.g., Albright et al., 1997), suggesting a degree of universality in extracting physiognomic information from faces.

However, the evidence for the validity of such physiognomic information has been viewed as less robust (e.g., Alley, 1988; Cohen, 1973), until recently (e.g., Berry, 1990; Zebrowitz, 1997; Zebrowitz & Collins, 1997). For instance, Berry (1990) showed that individual ratings of social dominance, interpersonal warmth, and honesty from facial photographs possess a fair degree of accuracy with ratings provided by impressions formed from longer term social interaction. It has been proposed that such ratings are related to a more fundamental aspect of facial appearance, such as 'babyfaceness' (i.e., facial neoteny) and attractiveness (e.g., Hassin & Trope, 2000; Zebrowitz, 1997). Thus, studies have shown that facial attractiveness is perceived to be associated with more positive personality characteristics (e.g., Dion, Berscheid, Walster, 1972; Zebrowitz, Hall, Murphy, & Rhodes, 2002). In contrast, adults with neotenous faces tend to be viewed as possessing poor social and intellectual capacities (Montpare & Zebrowitz, 1998; Zebrowitz & Lee, 1999), but higher levels of honesty (along with attractive faces; e.g., Zebrowitz, Voinescu, & Collins, 1996).

The infusion of physiognomic information into judgments and decisions

It appears, then, that people do use faces as a source of information about personality and character (e.g., Zebrowitz, 1997), and that these judgments might have a degree of predictive validity (Berry, 1990; Zebrowitz & Collins, 1997). It is therefore not surprising that, particularly in situations of ambiguity and uncertainty, this social information can infuse into decision-making and judgments (e.g., Dion, 1972;

Hassin & Trope, 2000), much like racial attitudes (e.g., Hodson, Dovidio, & Gaertner, 2002; see Chapter 4). For example, Hassin & Trope (2000; Study 1) demonstrated that by varying the levels of 'power' (i.e., confidence, charisma, & dominance) conveyed by adult faces the interpretation of ambiguous behaviour could be readily altered. Unambiguous behaviour, however, was unaffected by the infusion of physiognomic information.

This source of social judgment bias might also have important real-world effects (e.g., Dipboye, Arvey, & Terpstra, 1977; Hamermesh & Biddle, 1994; Todorov, Mandisodza, Goren, & Hall, 2005; Zebrowitz, 1997; Zebrowitz & McDonald, 1991). For instance, Todorov et al. (2005) reported that politicians rated more competent from brief facial glances were much more likely to be successful in elections. This effect may be underpinned by facial neoteny (Zebrowitz & Montpare, 2005). Although baby-faced individuals might have a poor chance of succeeding in politics they might, in contrast, be less likely to attract high sentences in a court of law (Zebrowitz & McDonald, 1991).

Consequently, physiognomic information is likely an important influence in a wide range of social decision-making. Indeed, as shown by Todorov et al. (2005), a brief glance is sufficient to extract such information. Moreover, Willis and Todorov (2006) report that 100ms exposure is sufficient to make reliable judgments of a range of personality traits (attractiveness, likeability, trustworthiness, competence, and aggressiveness). It appears, therefore, that humans extract social information from faces in a rapid and automatic fashion (Olsen & Marshuetz, 2005; Willis & Todorov, 2006).

Emotion and physiognomic information

The chapter thus far has illustrated the importance of physiognomic information on social decision-making (Hamermesh & Biddle, 1994; Todorov, Mandisodza, Goren, & Hall, 2005; Zebrowitz, 1997). Indeed, the extraction of such information may be an effortless automatic process (Locher, Unger, Sociedade, & Wahl, 1993; Olsen & Marshuetz, 2005; Willis & Todorov, 2006), suggesting that reading faces for socially relevant information has a special status in the brain (e.g., Olsen & Marshuetz, 2005). The processing of faces *per se* might have a specialised neural system (e.g., Kanwisher, McDermott, & Chun, 1997), but recently the neural correlates underpinning some forms of physiognomic information has attracted attention, highlighting a significant input from brain regions strongly implicated in emotion (e.g., Engell, Haxby, & Todorov, 2007; Winston et al., 2007).

The two studies in this chapter assess the influence of two socially important traits that are readily drawn from facial information (i.e., trustworthiness and attractiveness) on affective decision-making using the Iowa Gambling Task. First, Experiment 4 assesses the effect of facial attractiveness and so, accordingly, discussion will now focus specifically on facial attractiveness, and its influences on social judgment. Later, Experiment 5 examines the influence of facial trustworthiness.

Facial attractiveness as an affective bias in decision-making

Like many traits extracted from faces (e.g., Hassin & Trope, 2000; Todorov et al. 2005), attractiveness has been found to have an important impact on social judgments (Ambady & Rosenthal, 1993; Dion, 1972; Dion, Berscheid, & Walster, 1972; Dipboye Arvey & Terpstra, 1977; Frieze, Iso, & Russell, 1991; Hamermesh & Biddle, 1994; Langlois, Ritter, Casey, & Sawin, 1995). For instance, Hamermesh and Biddle (1994) showed that attractive people are more successful in employment. That is, they tend to earn higher salaries (e.g., Frieze, Ison, & Russell, 1991), which may be a consequence of attractive people being viewed as more intelligent and socially adept (Dion, Berschedid, & Walster, 1972).

Likewise, Dion (1972) showed that both mild and severe bad behaviour was reported as less negative for an attractive child, compared to an unattractive child. In a similar vein, Langlois, Ritter, Casey and Swan (1995) demonstrated that parents of attractive babies are more affectionate and playful with their children than those of babies rated as unattractive. From the other perspective, babies prefer to look at attractive adult faces rather than unattractive faces (Langlois, Ritter, Roggman, & Vaughn, 1991), and show more positive interaction with attractive strangers

(Langlois, Roggman, & Rieser-Danner, 1990). These findings suggest that a preference for attractive faces might well be innate (Thornhill & Gangestad, 1999).

Thus, it appears that processing the attractiveness of faces has special significance for humans. Consistent with this, attractiveness has been demonstrated to be rapidly and automatically appraised on exposure to faces (Locher, Unger, Sociedade, & Wahl, 1993; Olsen & Marshuetz, 2005; Willis & Todorov, 2006). For example, Olsen & Marshuetz (2005) found that the presentation of attractive faces at an exposure of only 13ms was sufficient to bias processing on an affective priming task. This biasing of cognition might be a result of the activation of reward-related neural systems that accompanies exposure to attractive face stimuli (Aharon et al., 2001; O'Doherty et al, 2003; Olsen & Marshuetz, 2005; Winston et al., 2007).

O'Doherty et al. (2003) found that facial attractiveness was associated with neural responses in the orbitofrontal cortex (OFC), an area of the brain strongly implicated in reward processing (e.g., Rolls, 2000). Medial regions of the OFC were more activated for attractive faces, whereas, the lateral OFC was associated with unattractive faces (along with the lateral PFC). Likewise, Winston et al. (2007) demonstrated responses in the medial OFC and PFC when exposed to attractive faces, although no comparable responses in the lateral areas of the frontal cortex for unattractive faces were found. Moreover, Winston et al. reported amygdala activity for both unattractive and attractive faces.

Thus, attractiveness appears to be an emotionally salient aspect of faces (e.g., Winston et al., 2007) and an important form of social information (Zebrowitz, 1997). Moreover, as outlined earlier, attractiveness is readily able to infuse into judgments and decisions (e.g., Dion, 1972), especially under situations of ambiguity (Hassin & Trope, 2000).

Experiment 4 assessed whether facial attractiveness was sufficient as a pre-existing affective bias to produce a disruption of complex decision-making on the labelling variant of the Iowa Gambling Task. This involved manipulating the congruency of facial attractiveness, where male faces (rated by female participants as attractive and unattractive) were associated with Gambling Task decks such that they were either congruent or incongruent to their incentive properties.

Experiment 4: The effect of labelling IGT decks with attractive and unattractive faces

Method

Participants

33 female participants, aged 18-44yrs ($M = 20.2$, $SD = 4.41$) and with no history of neurological or psychiatric disorder, were obtained via a student participation panel at the University of Wales, Bangor. The participants were randomly allocated to one of two experimental conditions; incongruent ($n = 17$), congruent ($n = 16$). The

participants were either given credit for course fulfilment or nominal financial compensation.

Procedure

Selecting facial stimuli. One set of 15 face slides was produced, containing male Caucasian faces. They were selected from the MacBrain NimStim face database (Tottenham et al., 2002) and the A-face database (McKimmie & Chalmers, 2002; see Appendix 3a). All faces were frontal views of with neutral emotional expressions.

The slides were subjectively rated by each participant on three Likert scales for attractiveness, trustworthiness, and distinctiveness. Four slides were selected based on these ratings for use in the later Gambling Task, this included two attractive and two unattractive face slides with comparable mid-scale subjective ratings for other traits. A paired-samples t-test of participant's subjective face ratings showed no significant difference between trustworthiness ($t(32) = 1.997, p > .05$) and distinctiveness ratings ($t(32 = -1.173, p > .05$), but a significant difference between attractiveness ($t(32) = -18.211, p < .001$) ratings for the faces selected for each congruency condition.

The Iowa Gambling Task variants. The majority of materials utilized were identical to previous experiments; however, the stimuli associated with the

Gambling Task decks were male faces of only European descent from the preceding selection phase[11].

There were two experimental conditions which manipulate how the stimuli are associated with each deck. In the *Incongruent* condition the advantageous decks were associated with unpleasant stimuli (e.g. Decks C & D – unattractive faces), and disadvantageous decks associated with pleasant stimuli (e.g. Decks A & B-attractive faces). The *Congruent* condition used the reverse association (see figure 23).

In the two conditions the stimuli were placed directly on top of the decks, with the participant required to name the decks in a socially salient manner (e.g. for deck A, named as 'Mr A') and forced to touch the card to remove the gambling card beneath the pictures. The slide was then replaced to its original position. As in previous experiments, the contingency pattern of the original task was retained in both conditions.

[11] In a similar way to Experiment 1, no subjective ratings over the task were collected in this experiment. This was a consequence of the timing of collecting this set of data during research, that is, the data was collected before the subjective rating method was fully validated (Bowman, Evans, & Turnbull, 2005).

Deck	Net Gain (10 trials)	Frequency Punishment
A	-£250	50%
B	-£250	10%
C	+£250	50%
D	+£250	10%

Figure 23. Representation of the Affective Labelling Iowa Gambling Task facial attractiveness variant with overall financial incentives for 10 card blocks. Decks were labelled with either congruent (attractive faces - good decks, unattractive faces - bad decks) or incongruent (as illustrated; unattractive face - good decks, attractive face-bad decks) face stimuli. Participants were required to name each deck in a socially relevant manner (e.g. Mr A).

Design

The experiment consisted of a mixed between- and within-subjects design and utilised an independent t-test between of congruency condition (between-subject, 2 levels) and a dependent factor of overall task score, and repeated-measures ANOVA with factors of task variant (between-subjects; 2 levels) and block (within-subjects; 5 levels). The independent variable will be the congruency of the IGT, the dependent variable the mean block score of advantageous cards minus disadvantageous cards for each block of 20 cards (i.e. [(C+D)-(A+B)]).

Results

Overall Analysis

Participant's overall performance was calculated using the equation [(C+D)-(A+B)], providing an index of their overall choices. Thus, a high overall score indicated an advantageous selection strategy, with more good deck cards chosen. Mean overall scores for each of the two experimental conditions were calculated indicating that the congruent condition (M = 12.0, SD = 17.96) possessed the most advantageous overall performance and the incongruent the least (M = 6.0, SD = 16.52; see Figure 24).

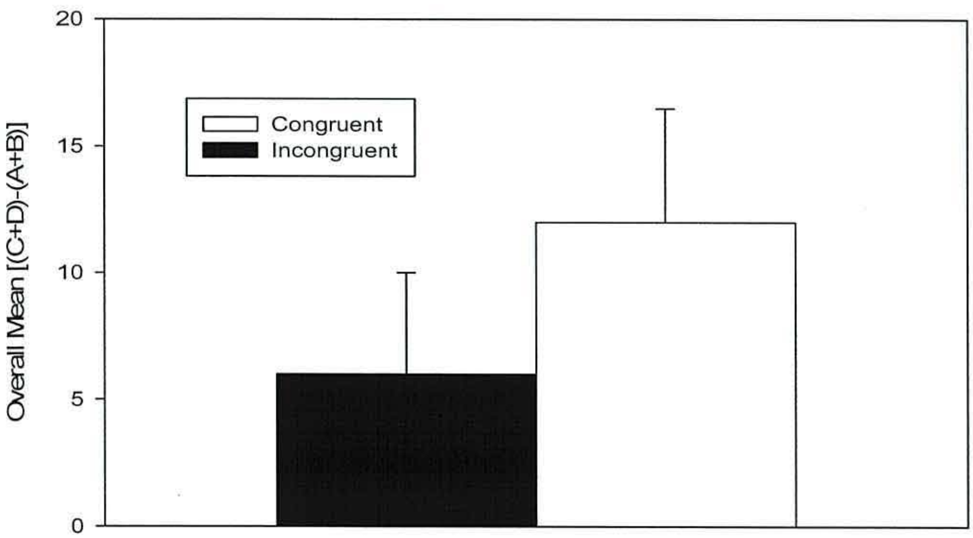

Figure 24. Mean overall task scores for the two congruency conditions (Error bars indicated 1 *SEM*). More selections were made from the disadvantageous decks in the incongruent condition (unattractive faces-good decks, attractive faces - bad decks), although the effect was not significant.

However, an independent t-test indicated that these differences in overall selection strategy were not significant (t (31) = .999, p = .325).

Analysis by block

As in the original Gambling Task (Bechara et al., 1994), the 100 card selections were split into five equivalent blocks of 20 cards. An overall block score was calculated from the equation [(C+D)-(A+B)], illustrating how advantageous their deck preferences were during the five blocks and providing a profile of their emotion-based learning. The results showed that participants learned in both conditions, but that performance in the incongruent condition was hindered compared to that attained in the congruent condition (see Figure 25).

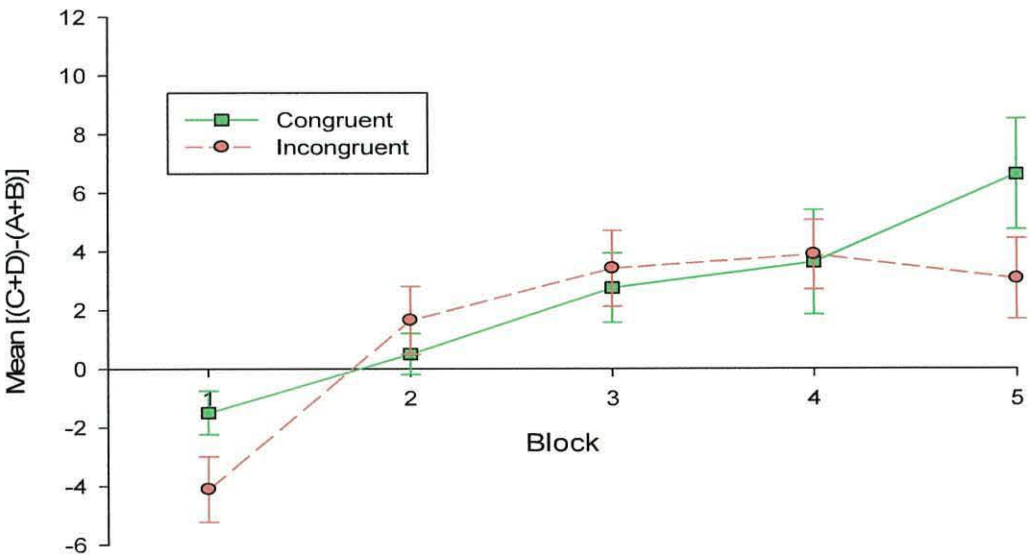

Figure 25. The mean card selection profiles for the Incongruent (n = 17) and Congruent (n = 16) conditions in the attractiveness labelling version of the IGT (Error bars indicate 1 *SEM*). Learning profiles were not significantly different between congruency conditions.

A mixed ANOVA with factors of congruency (between-subjects; 2 levels) and block (within-subjects; 5 levels) found a significant main effect of Block, ($F(2.492, 77.256) = 13.606, p < .001$), no interaction between Block*Condition, ($F(2.492, 77.256) = 1.598, p = .203$) and no significant difference between congruency conditions ($F(1, 31) = .999, p = .325$).

Discussion

Experiment 4 examined the effects of facial attractiveness of a source of integral affective bias on the affective labelling variant of the IGT. Participants showed learning in both conditions, beginning at levels close to chance, with a growing preference for selections from the advantageous decks, consistent with many previous findings (e.g., Bechara et al. 1994; Bowman & Turnbull, 2003), and previous experiments in this thesis.

The addition of incongruent emotional labels to individual decks did not significantly reduce the magnitude of learning on the task. However, the overall data showed a trend towards a bias from incongruent facial attractiveness, such that the mean data indicated that participants were more likely to choose cards from decks with an attractive face label, even when this was financially disadvantageous. Block 1 appeared to show the strongest biasing effect, with a post-hoc independent t-test indicating a borderline significant difference between the congruency conditions

($t(31) = 2.023$, $p = .052$)[12]. In many ways this is not surprising, as it is known that facial attractiveness has its greatest influence on decisions under situations of ambiguity (Hassin & Trope, 2000), and block 1 is the period of the IGT which can be considered to exhibit the greatest degree of decision-related ambiguity.

The failure of facial attractiveness to result in a comparable significant incongruency effect to the previous experiments in this thesis could be explained in a number of ways. For example, it is likely that attractiveness is a less salient affective bias compared to highly emotionally salient pictures (Experiment 1) and race-based faces (Experiments 2 & 3). The presence of a borderline bias in block 1 appears to suggest that the affective bias sourced from facial attractiveness failed to persist in a robust fashion across the task. That is, the affective bias was readily overcome as the task became less ambiguous. It is likely that using more extreme levels of unattractiveness (e.g., facial disfigurements) may produce more substantial effects.

A second possibility is that gender-related effects underlie the absence of a significant decision bias. The neurobiological salience of facial attractiveness is (unsurprisingly) linked to mating and sexual-selection (Thornhill & Gangestad, 2000; Gangestad & Buss, 1993), and therefore we might expect to find gender differences in the effects of presenting mating-related opposite-sex stimuli. For example, males are proposed to become more 'present-orientated' in mating situations than females (e.g., Wilson & Daly, 2004; Daly & Wilson, 2005).

[12] All other blocks showed no significant differences at $p = .05$, although block 5 showed a trend towards significance ($p = .109$).

Thus, Wilson and Daly (2004) demonstrated that the decision-making of males was significantly affected by attractive opposite-sex faces in a monetary task of future discounting (i.e., a measure of the way in which future rewards are devalued with temporal delay; Kirby & Marakovic, 1996). In sum, males became more 'myopic' when exposed to attractive opposite-sex faces, but not when exposed to unattractive faces. In contrast, females showed minimal changes in the discounting of future rewards when exposed to attractive male faces. Therefore, we might expect to find more significant modulation of complex affective decision-making in a population of male participants. From this perspective, the results found in this experiment might have been expected, as the experiment involved exposing female participants to male faces. Indeed, an obvious extension of this particular experiment would involve the comparison between the genders of the impact of opposite-sex facial attractiveness using this variant of the IGT.

In sum, Experiment 4 failed to show a significant disruption of complex decision-making in the affective labelling variant of the IGT. However, the findings are of some interest in that facial attractiveness was unlikely to be a highly significant variable in the previous race-based experiments, particularly as this variable was well-matched in those experiments. Experiment 5 extended the investigation of the effects of physiognomic traits on complex decision-making, by assessing facial trustworthiness as an alternative source of face-based affective bias in the IGT.

Experiment 5: The effect of labelling IGT decks with trustworthy and untrustworthy faces.

As noted earlier, people make strong and reliable inferences from facial structure (e.g., Zebrowitz, 1997), extracting trait information that can readily infuse into judgments and decisions (e.g., Hassin & Trope, 2000). Moreover, some physiognomic judgments can be efficiently and reliably made from rapid exposure to faces (Olsen & Marshuetz, 2005; Willis & Todorov, 2006). One specific form of social information shown to be extracted in such a way is trustworthiness (Willis & Todorov, 2006). Indeed, it has been suggested that the ability to efficiently detect untrustworthiness might have been selected for during the evolution of human social cognition (i.e., cheater detection; Cosmides & Tooby, 1992, 2005).

For example, Willis and Todorov (2006) report that judgments of facial trustworthiness at 100ms exposure are highly correlated to those at 500ms and 1000ms, suggesting that the extraction of trustworthiness from faces is rapid and efficient, perhaps even automatic. Studies assessing the neural correlates of the evaluation of facial trustworthiness indicate that trustworthiness judgments might be underpinned by regions of the brain implicated in emotion, such as the amygdala (Adolphs, Tranel, & Damasio, 1998; Engell, Haxby, & Todorov, 2007; Winston et al., 2002).

Adolphs, Tranel and Damasio (1998), for instance, found that patients with bilateral damage to the amygdala rated unfamiliar faces as more trustworthy and approachable than control participants, suggesting that the amygdala is essential for appraising the trustworthiness of other people. Winston et al. (2002) and Engell, Haxby, and Todorov (2007) showed an inverse correlation between amygdala activity and subjective ratings of trustworthiness, whether this trait was assessed explicitly or implicitly. Thus, the amygdala has been shown to rapidly and automatically process facial trustworthiness, placing such information in an ideal position to infuse into complex decision-making.

However, it appears that few studies have directly assessed the effects of facial trustworthiness derived from novel faces on complex decision-making. Delgado, Frank, & Phelps (2005) can be considered to have studied a related question by investigating the effect of moral character of a fictional trading partner on decisions in the money-based 'trust game'. Thus, novel faces were associated with moral-related social information (i.e., good, bad, or neutral) that subsequently influenced ratings of trustworthiness. Participants were then required to make decisions to share or keep money in a task similar to the prisoner's dilemma. The findings showed that participants were more co-operative with fictional trading partners rated as trustworthy, compared to the untrustworthy partners (i.e., suspect morality). In sum, participants made riskier decisions when paired with a trading partner viewed as more trustworthy and of higher moral character. This effect was also accompanied by alterations in the neural activity of reward-related neural systems.

Experiment 5 assessed whether novel faces rated high and low in trustworthiness were a sufficient source of affective bias on the labelling variant of the Iowa Gambling Task. This was achieved by associating trustworthy and untrustworthy faces in conditions that were congruent and incongruent with the incentive value of the task decks. Rather than manipulating moral character to induce a pre-existing affective bias, in this experiment, affective bias was restricted directly to basic physiognomic information.

Method

Participants

28 participants (24 female), aged 18-34yrs ($M = 20.0$, $SD = 2.89$) and with no history of neurological or psychiatric disorder, were obtained via a student participation panel at the University of Wales, Bangor. The participants were randomly allocated to one of two experimental conditions; incongruent ($n = 14$), congruent ($n = 14$). The participants were given credit for course fulfilment.

Procedure

Selecting facial stimuli. One set of 15 face slides was produced, containing male Caucasian faces. They were selected from the MacBrain NimStim face database (Tottenham et al., 2002) and the A-face database (McKimmie & Chalmers, 2002). All faces were frontal views with neutral emotional expressions.

The slides were subjectively rated by each participant on three Likert scales for attractiveness, trustworthiness, and distinctiveness. Four slides were selected based on these ratings for use in the later Gambling Task, this included two trustworthy and two untrustworthy face slides with comparable mid-scale subjective ratings for other traits. A paired-samples t-test of participant's subjective face ratings showed significant difference between trustworthiness ratings ($t(27) = 17.492, p < .001$), but none for attractiveness ($t(27) = 1.064, p > .05$) or distinctiveness ($t(27) = 1.267, p > .05$) ratings for the faces selected for the IGT phase.

The Iowa Gambling Task Variants. The majority of materials utilized were identical to previous experiments; however, the stimuli associated with the Gambling Task decks were faces of only European descent from the preceding selection phase. Furthermore, subjective experience data was collected during the IGT. Decks were rated after each 20 card block on a Likert-style questionnaire using a subjective affect scale of 'goodness/badness' from 0 (very bad) to 10 (very good; Bowman, Evans, & Turnbull, 2005) .

There were two experimental conditions which manipulate how the stimuli are associated with each deck. In the *Incongruent* condition the advantageous decks were associated with unpleasant stimuli (e.g. Decks C & D – untrustworthy faces), and disadvantageous decks associated with pleasant stimuli (e.g. Decks A & B-trustworthy faces). The *Congruent* condition used the reverse association (i.e. trustworthy faces with advantageous decks and *vice versa*).

In the two conditions the stimuli were placed directly on top of the decks, with the participant required to name the decks in a socially salient manner (e.g. for deck A, named as 'Mr A') and forced to touch the card to remove the gambling card beneath the pictures. The slide was then replaced to its original position. As in previous experiments, the contingency pattern of the original task was retained in both conditions.

Design

The experiment consisted of a mixed between- and within-subjects design and utilised an independent t-test between of congruency condition (between-subject, 2 levels) and a dependent factor of overall task score, and repeated-measures ANOVA with factors of task variant (between-subjects; 2 levels) and block (within-subjects; 5 levels). The independent variable will be the congruency of the IGT, the dependent variable the mean block score of advantageous cards minus disadvantageous cards for each block of 20 cards (i.e. [(C+D)-(A+B)]). A similar analysis was performed for the subjective experience data, with data reduced using the same formula (i.e. [(C+D)-(A+B)]).

Results

Investigation 1: Behavioural IGT data

Overall Analysis. Participant's overall performance was calculated using the equation [(C+D)-(A+B)], providing an index of their overall choices. Thus, a high overall score indicated an advantageous selection strategy, with more good deck cards chosen. Mean overall scores for each of the two experimental conditions were calculated indicating that the congruent condition (M = 18.1, SD = 17.42) possessed the most advantageous overall performance and the incongruent the least (M = 16.7, SD = 13.02; see Figure 26).

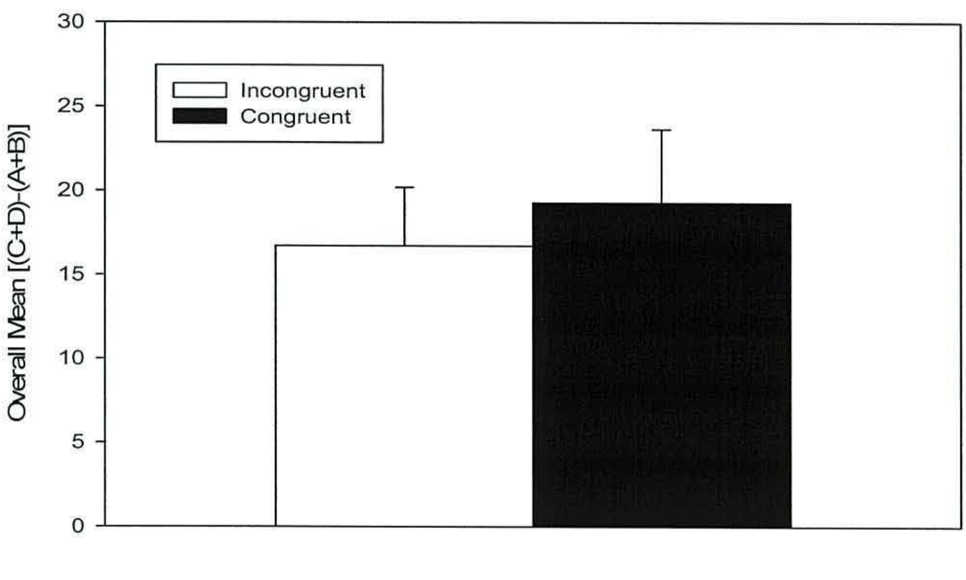

Figure 26. Mean overall task scores for the two congruency conditions (Error bars indicated 1 *SEM*). More selections were made from the disadvantageous decks in the incongruent condition (untrustworthy faces-good decks, trustworthy faces - bad decks), although the effect was negligible.

However, an independent t-test indicated that these differences in overall selection strategy were not significant (t (26) = .246, p = .808).

Analysis by block. As in the original Gambling Task (Bechara et al., 1994), the 100 card selections were split into five equivalent blocks of 20 cards. An overall block score was calculated from the equation [(C+D)-(A+B)], illustrating how advantageous their deck preferences were during the five blocks and providing a profile of their emotion-based learning. The results showed that participants learned in both conditions, but that performance in the incongruent condition was hindered compared to that attained in the congruent condition (see Figure 27).

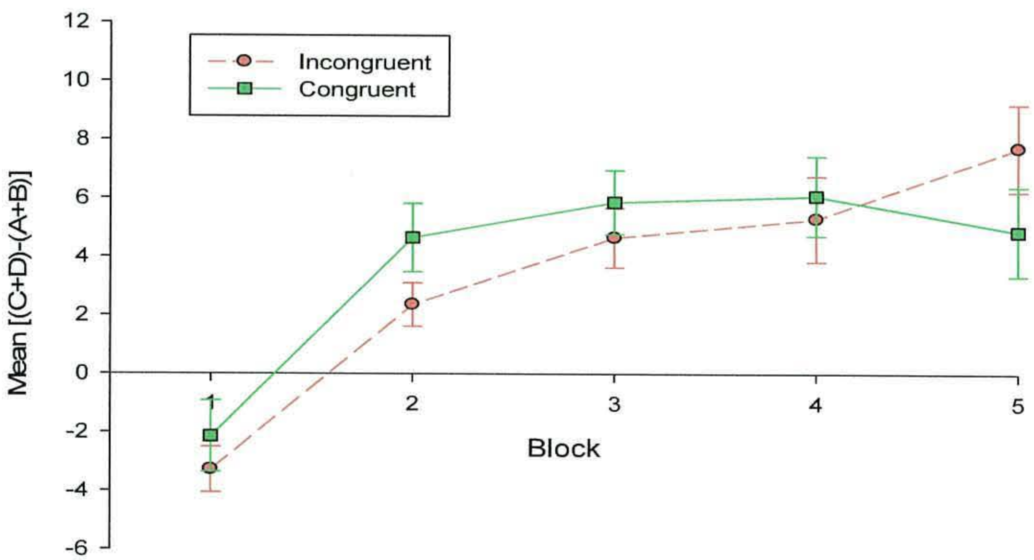

Figure 27. The mean card selection profiles for the Incongruent (n = 14) and Congruent (n = 14) conditions in the facial trustworthiness labelling version of the IGT (Error bars indicate 1 *SEM*). Learning profiles were similar in both congruency conditions.

A mixed ANOVA with factors of congruency (between-subjects; 2 levels) and block (within-subjects; 5 levels) found a significant main effect of Block, (F (2.745, 71.363) = 22.049, p < .001), no interaction between Block*Condition, (F (2.745, 71.363) = .553, p > .05) and no significant difference between congruency conditions (F (1, 26) = .088, p > .05).

Investigation 2: Subjective Experience Data

From the subjective experience data, an overall block score was calculated from the equation [(C+D)-(A+B)], as in Bowman et al. (2005). This shows an index of the participant's subjective deck preferences during each of the five blocks and providing an alternative profile of their emotion-based learning. The results showed that from block 1 onwards participants the financially advantageous decks were rated more favourable, but that subjective ratings in the incongruent condition were lower in all blocks compared to that attained in the congruent condition (see Figure 28).

A mixed ANOVA with factors of congruency (between-subjects; 2 levels) and block (within-subjects; 5 levels) found a significant main effect of Block, (F (2.918, 75.863) = 13.216, p < .001), no interaction between Block*Condition, (F (2.918, 75.863) = .219, p > .05), but a significant difference between congruency conditions (F (1, 26) = 6.414, p = .018). Post-hoc independent t-tests showed that there was a significant difference between the subjective ratings in the Incongruent and

Congruent conditions in block 1 ($p = .003$) and a borderline difference in block 3 ($p = .076$).

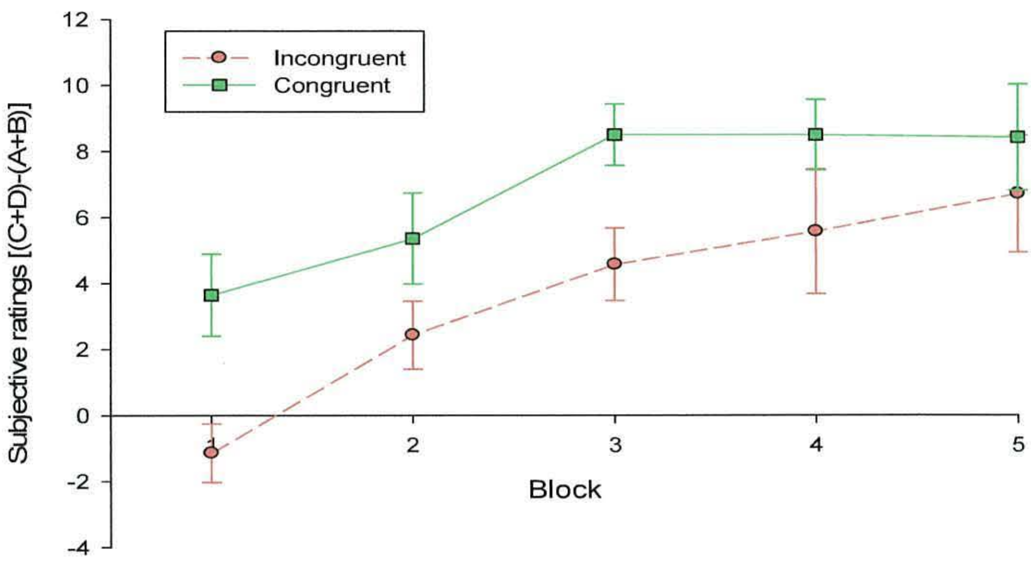

Figure 28. The mean subjective rating profiles for the Incongruent ($n = 14$) and Congruent ($n = 14$) conditions in the facial trustworthiness labelling version of the IGT (Error bars indicate 1 *SEM*). Participants rated good decks less favourably across all blocks in the Incongruent condition when compared to the Congruent condition.

Discussion

Experiment 5 examined the effects of facial trustworthiness of a source of integral affective bias on the affective labelling variant of the IGT. Participants showed learning in both conditions, beginning at levels close to chance, with a emergent preference for selections from the advantageous decks, which is consistent with numerous IGT studies (e.g., Bechara et al. 1994; Bowman & Turnbull, 2003), and previous experiments in this thesis.

The addition of incongruent emotional labels related to facial trustworthiness to individual decks did not significantly alter the extent of learning on the task. However, the overall data showed a minor trend towards a bias from incongruent facial trustworthiness. In a similar way to Experiment 4, it appears that block 1 showed the largest biasing effect ($p = .111$), suggesting that the affective bias sourced from facial trustworthiness was readily overcome as decision-based ambiguity reduced with task progression.

The failure of facial trustworthiness to result in a significant incongruency effect to the previous experiments may simply be a consequence of the affective bias being too weak to infuse into the behavioural task in a robust and persistent fashion. However, the subjective ratings did demonstrate an interesting asymmetry from the behavioural findings. Thus, participants subjective experience data showed significant differences between the congruency conditions, with more positive ratings found in the congruent condition compared to the incongruent condition. This was especially true in block 1 ($p = .003$), although a borderline effect was also found in block 3 ($p = .076$). It appears, therefore, that subjective ratings in the incongruent condition were influenced by the labelling of the decks to a greater extent than actual decision-making behaviour.

Assuming this particular finding is not an experimental artefact, this asymmetry may be due to the differences between the nature of decision-making behaviour and subjective assessment of the task decks. Thus, decision-making behaviour in the Iowa Gambling Task depends on an exploratory search for information, particularly during the early phase of the task. That is, participants will select cards from across the four decks to gain experience about the incentives each provides even when they are aware of the best strategy (c.f., Maia & McClelland, 2004). Whereas, the subjective ratings require participants to make affect-based judgments on the information gathered during a particular block of the task, and an appraisal of the decks themselves. Therefore, it is possible that single affect-based judgments (i.e., decks ratings) will be more sensitive to infusion from the affective labelling of the task objects than decision behaviour (i.e., card selection) that depends on a more exploratory approach.

Indeed, previous studies (Evans, Bowman, & Turnbull, 2005; Maia & McClelland, 2004) have demonstrated that participants can report greater subjective awareness of the nature of the IGT than is expressed in their behavioural performance. Thus, emotional feelings do not necessarily lead to associated behavioural actions. In fact, the failure to effectively regulate emotion underlies some forms of psychopathology (e.g., Gross & Munoz, 1995; Davidson, 2000). Emotion regulation appears to involve areas of the frontal lobe, such as the lateral and medial regions of the orbitofrontal cortex (e.g., Ohira et al., 2006; Oschner, Ray, et al., 2004; see Quirk & Beer, 2006, for a review). As noted in Chapter 4, emotion regulation might also underpin suppression of racial bias (e.g., Amodio et al., 2006; Cunningham et al., 2004; Richeson et al., 2003).

Thus, Experiment 5 failed to show a significant biasing of decision-making behaviour on the IGT from labelling the task decks with faces varying in the trait of trustworthiness. However, it perhaps appears that subjective assessment of the task decks demonstrated a fair degree of infusion from this source of affective bias. In this type of experiment it might be possible to produce a greater biasing effect by using the technique from Delgado, Frank, and Phelps (2005). In their approach, faces were associated with information relating to the social and moral character of novel individuals, which are subsequently used as a source of affective bias on this labelling variant of the IGT.

Summary

Experiments 4 and 5 assessed some basic boundaries for social sources of affective bias on the labelling variant of the IGT, showing that labelling task decks with faces varying in trustworthiness and attractiveness was insufficient to lead to robust and persistent decision-making biases on the IGT. Indeed, in both experiments the strongest trend towards a significant decision bias between the incongruent and congruent conditions was found in block 1. This phase of the task can be considered to possess the highest degree of decision-related ambiguity, as participants have minimal information as to the incentive quality of the decks, and is therefore most open to any biases sourced from the affective labels. This is consistent with the findings of Hassin and Trope (2000), who demonstrated that physiognomic information only influenced decisions under situations of ambiguity. Experiment 5 also showed that subjective ratings might have been more sensitive than actual decision-making behaviour to the bias sourced from the affective labelling of the task decks, particularly during the high ambiguity phase of the IGT.

Although Experiments 4 and 5 failed to show a substantial influence from two forms of socially-derived affective bias, these findings do help provide further insight into the race experiments in Chapter 4. Thus, it appears that these forms of social information would not have been a significant influence in the race variants of the IGT, particularly as an attempt was made to control for these physiognomic attributes. This further bolsters the claim that the effects found in Experiments 2 and 3 were due to the manipulation of racial bias, rather than the non-race physiognomic attributes of attractiveness and trustworthiness.

Chapter 6

Incongruent affective framing in the IGT: Insights from patients with lesions of the frontal cortex

It has long been suggested that adaptive social behaviour requires an individual to balance the tensions between internal emotional impulses and socially acceptable behaviours (Freud, 1923/1961). Emotions can be evoked rapidly and automatically (e.g., LeDoux, 1996; Zajonc, 1980), however, in many circumstances they are required to be regulated (e.g., Gross, 1998a; Parrot, 1993; Thompson, 1991). For example, when a relative gives a birthday present that is far below expectations, we will tend to inhibit our disappointment and express satisfaction and gratitude. Thus, there are well-established social norms as to when and where particular emotions and impulses are externally expressed. Indeed, failures of emotion-regulation might underlie many forms of psychopathology (e.g., Gross & Muñoz, 1995).

Neuroimaging studies of emotion regulation

Two common methods to examine the regulation of emotional state are the suppression and reappraisal paradigms (see Gross, 2002, for a review). The suppression technique involves participants consciously inhibiting emotion elicited by exposure to emotion-evoking stimuli or events, whereas the reappraisal paradigm requires participants to assess such emotional events in a non-emotional manner (Gross, 2002).

Brain imaging studies using the suppression and reappraisal paradigms consistently implicate regions of the orbitofrontal cortex/inferior frontal gyrus (Levesque et al., 2004; Ohira et al., 2006; Oschner, Ray, et al.; Phan et al., 2005; Urry et al., 2006) and dorsal anterior cingulate (Levesque et al., 2004; Oschner, Ray, et al., 2004; Phan et al., 2005; Urry et al., 2006) in emotion regulation. For example, Phan et al. (2005) demonstrated that the suppression of negative emotion activated many areas of the frontal cortex, including the ventrolateral PFC and dorsal anterior cingulate. Likewise, Oschner, Ray, et al. (2004) found that cognitive reappraisal of negative pictures involved the ventrolateral PFC and the dorsal ACC. Some studies also show activation of the orbitomedial PFC during emotion regulation (Levesque et al., 2004; Ohira et al., 2006; Urry et al., 2006).

One well-established finding associated with suppression techniques of emotion regulation is the increase in physiological emotional responses. Thus, participants show reduced emotional expression, but increases in objective physiological measures of emotion. For example, whilst suppressing emotions, increases in skin conductance and blood pressure are commonly found (e.g., Gross, 1998b; Gross & Levenson, 1997; Harris, 2001). Ohira et al. (2006) investigated the neural correlates of this physiological response and found a correlation between SCR during emotional suppression and activity in the orbitomedial PFC. Therefore, the orbitomedial PFC appears to underpin physiological responses during emotion-regulation.

In sum, brain imaging studies strongly indicate the involvement of a network of prefrontal cortex areas in the regulation of emotion. These areas might well act to modulate amygdala activity (e.g., Levesque et al., 2004; Urry et al., 2006), allowing the control of inappropriate emotional responses.

Emotion dysregulation associated with damage to the orbitofrontal cortex

The behavioural changes associated with damage to areas of the orbitofrontal cortex commonly include disruption of social and emotional functioning in both monkeys (e.g., Dias, Robbins, & Roberts, 1996; Izquierdo, Suda, & Murray, 2005; Brush, Mishkin, & Rosvold, 1961) and humans (Eslinger & Damasio, 1985; Shamay-Tsoory et al., 2005; Stone, Baron-Cohen, & Knight, 1998). These patients are generally found to exhibit socially inappropriate behaviour (e.g., Damasio, 1994; Stuss & Benson, 1984), which led Saver and Damasio (1991) to term their dysfunction 'acquired sociopathy'.

For example, OFC lesions have been demonstrated to lead to deficits in inferring the mental states of other people (e.g., Shamay-Tsoory et al., 2005; Stone, Baron-Cohen, & Knight, 1998) and using emotions to guide adaptive behaviour (e.g., Bechara, Damasio, & Damasio, 2000). Moreover, Beer et al. (2003) have shown how this group of patients fail to adaptively use self-conscious emotions such as embarrassment to regulate their social behaviour.

One recent explanation of the resultant social deficits of patients with lesions to the OFC suggests that this area of the brain allows the monitoring, control, and filtering of emotional information (Rule, Shimamura, & Knight, 2002; Shimamura, 2000). Thus, the OFC is proposed to monitor the emotionally salient aspects of a situation provided from other regions of the brain via reciprocal connections, and actively inhibits and filters irrelevant emotional inputs. From this perspective, damage to the OFC can readily be considered to lead to a form of emotional disinhibition.

Support for the emotion-based 'dynamic filtering' hypothesis of OFC function was provided by Rule, Shimamura, and Knight (2002). In this study, patients with lesions to the OFC demonstrated enhanced orienting responses to emotional stimuli (i.e., P300 ERPs). Moreover, the patients also failed to show a similar level of habituation to emotion-evoking stimuli to both control participants and patients with damage to the DLPFC. This suggests that rather than lesions to the OFC leading to blunted emotional responses (Damasio, 1998; Rolls, 2000), they can lead to exaggerated and disinhibited emotional responses. Thus, lesions of the OFC might well result an inability to control and inhibit irrelevant sources of emotion, leading to dysfunctional social behaviour.

The control of emotion-based information in decision-making

Chapter 3 outlined how emotion can readily infuse into the decision-making process, with both incidental moods and other irrelevant sources of affect readily disrupting social judgment (e.g., Forgas, 1990; Schwarz & Clore, 1983). It is likely that this process involves the OFC (Kringelbach & Rolls, 2004; Rule et al., 2002) and, indeed, one recent study suggests this might be the case. Beer, Knight, and D'Esposito (2006) examined the neural basis of the control and infusion of emotion-based information into decision-making. Their experiments involved exposing participants to stimuli of either neutral or negative valence prior to making risky betting decisions. The primed emotion readily infused into the decision-making process whether participants were told the stimuli were relevant or irrelevant to the required judgements, with participants risking less money in the negative emotion condition compared to the neutral condition. That is, the infusion of negative emotion resulted in risk-aversion.

fMRI analyses showed that the lateral orbitofrontal cortex in the left hemisphere was most activated whether the stimuli were relevant or irrelevant. In the irrelevant emotion condition, activity in the lateral OFC was associated with the ability to successfully inhibit the incidental source of affective information (i.e., less disruption of decisions). Similarly, in the relevant emotion condition, lateral OFC activity was associated with the infusion of the source of affective information (i.e., more disruption of decisions).

This appears to suggest that this area of the brain is involved in regulating the infusion of emotion-based information into risk-based decisions. Indeed, the lateral areas of the OFC have been consistently implicated in the inhibition of irrelevant and inappropriate associations/responses (e.g., Iverson & Mishkin, 1970; Kringelbach, 2004; Quirk & Beer, 2006; Rubia, Smith, Brammer, & Taylor, 2003; see Elliot, Dolan, & Frith, 2000, & Aron, Poldrack, & Robbins, 2004, for a review).

Experiment 6 examined the effect of lesions of the frontal lobe on decision-making in the affective labelling variant of the Iowa Gambling Task. 3 patients (one predominately right lateralised; one predominately left lateralised; one bilateral) who had previously shown no impairment on the IGT were assessed on a task similar to that in Experiment 1. Thus, IGT decks were associated with emotionally salient labels (i.e., IAPS stimuli; CSEA, 2001) in an incongruent relationship, and performance of this small patient group compared to that of a student comparison group.

Experiment 6: The impact of frontal lobe lesions on incongruent affective framing

Method

Participants

Three patients suffering damage to the medial regions of the prefrontal cortex were examined; each patient's lesion was assessed by computerised axial tomography (CT), magnetic resonance imaging (MRI), or by surgical history.

One patient (EO) suffered bilateral orbitofrontal and left temporal pole contusions along with an occipital skull fracture on the left that extended into the foramen magnum. Subsequently, EO underwent a right frontal lobectomy. EO was 45 years old at the time of testing; he was still employed in his pre-surgical occupation as a farm-hand. Persistent impairments included poor initiative and confabulation (a fixed delusion of being a helicopter pilot). There were no persistent physical problems. EO was taking no medication at testing.

The second patient, DT, suffered a subarachnoid haemorrhage, with a subsequent clipping of the anterior communicating artery due to an aneurysm. However, complications led to hydrocephalus and the placing of a ventricular peritoneal shunt. At the time of testing, DT was 59 years old; she had never been in employment. She suffered persistent impairments such as memory problems, and had physical problems with walking and also incontinence. DT was only being treated with asthma medication at testing. Lesions appear to be predominately in the left hemisphere, starting in the orbitofrontal cortex, but mainly involving more medial regions of the PFC, including the dorsal and ventral anterior cingulate, extending into the frontal eye fields and the anterior region of the supplementary motor cortex (see Figure 29).

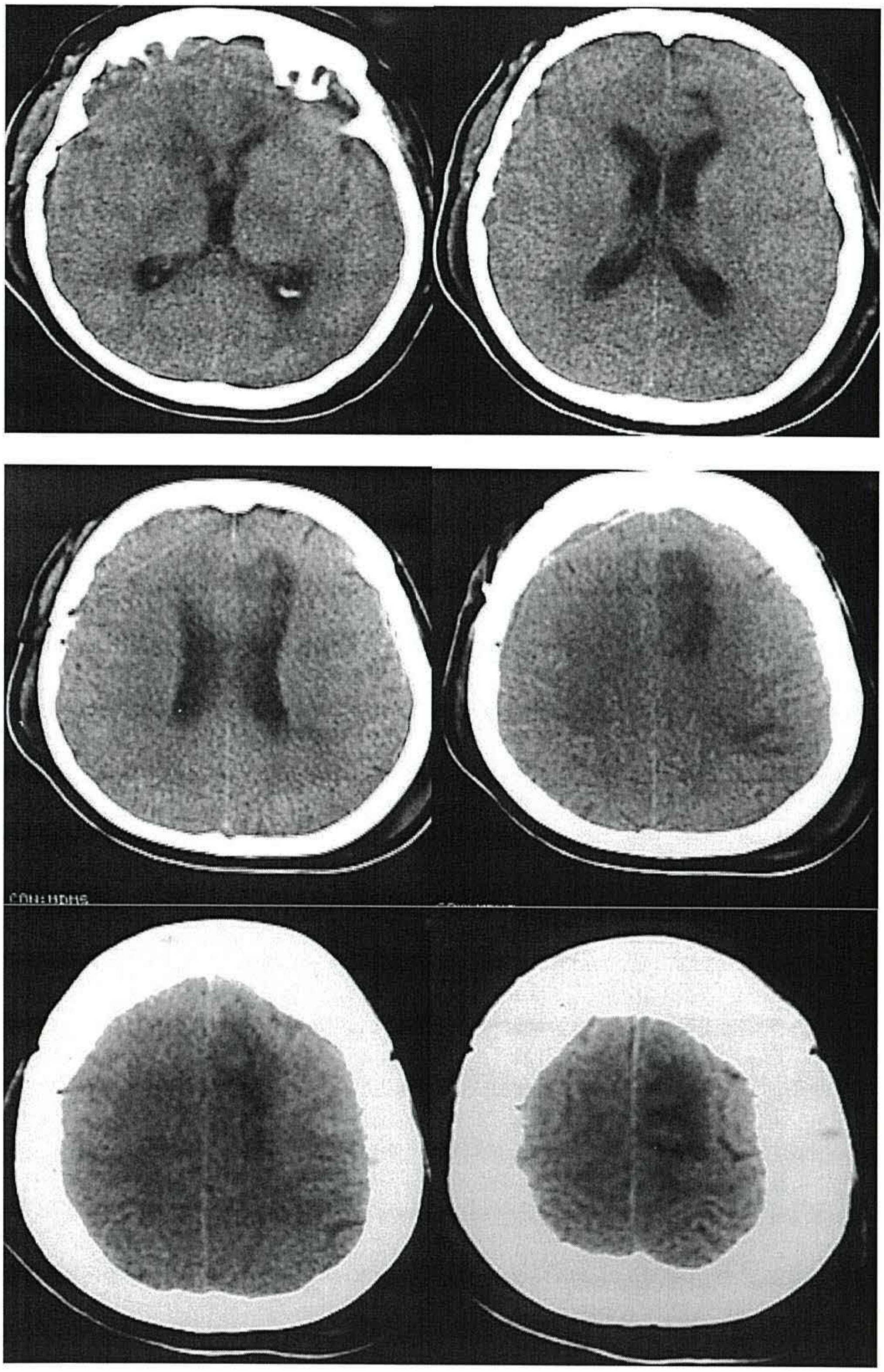

Figure 29. CT scans for patient DT, who suffered a subarachnoid haemorrhage; an ACA aneurysm was subsequently clipped. Lesions appear to be predominately in the left hemisphere.

GT, the third patient, had a left falx meningioma for 20 years, declining treatment. Eventually surgery was performed and the meningioma removed. At the time of testing she was 68 years old; GT had left school at 16yrs and studied at secretarial college. Before surgery she had been an accomplished artist. Persistent mental impairments include language and memory problems, such as findings words and remembering names, GT also suffers physical problems (e.g., balance, fatigue, incontinence) and psychomotor retardation. GT was being treated with carbamazepine, phenytoin, and levatricetan at the time of testing.

Lesions were bilateral in the medial frontal regions, and include much of the ventral and dorsal anterior cingulate (extending to the posterior cingulate cortex on the left). In the left hemisphere, lesions encroach on the dorsolateral prefrontal cortex. Likewise, on the right hemisphere the lesion extends into the dorsolateral regions of the PFC. On the left hemisphere, the lesion encroaches on the supplementary motor cortex and the frontal eye fields (see Figure 30).

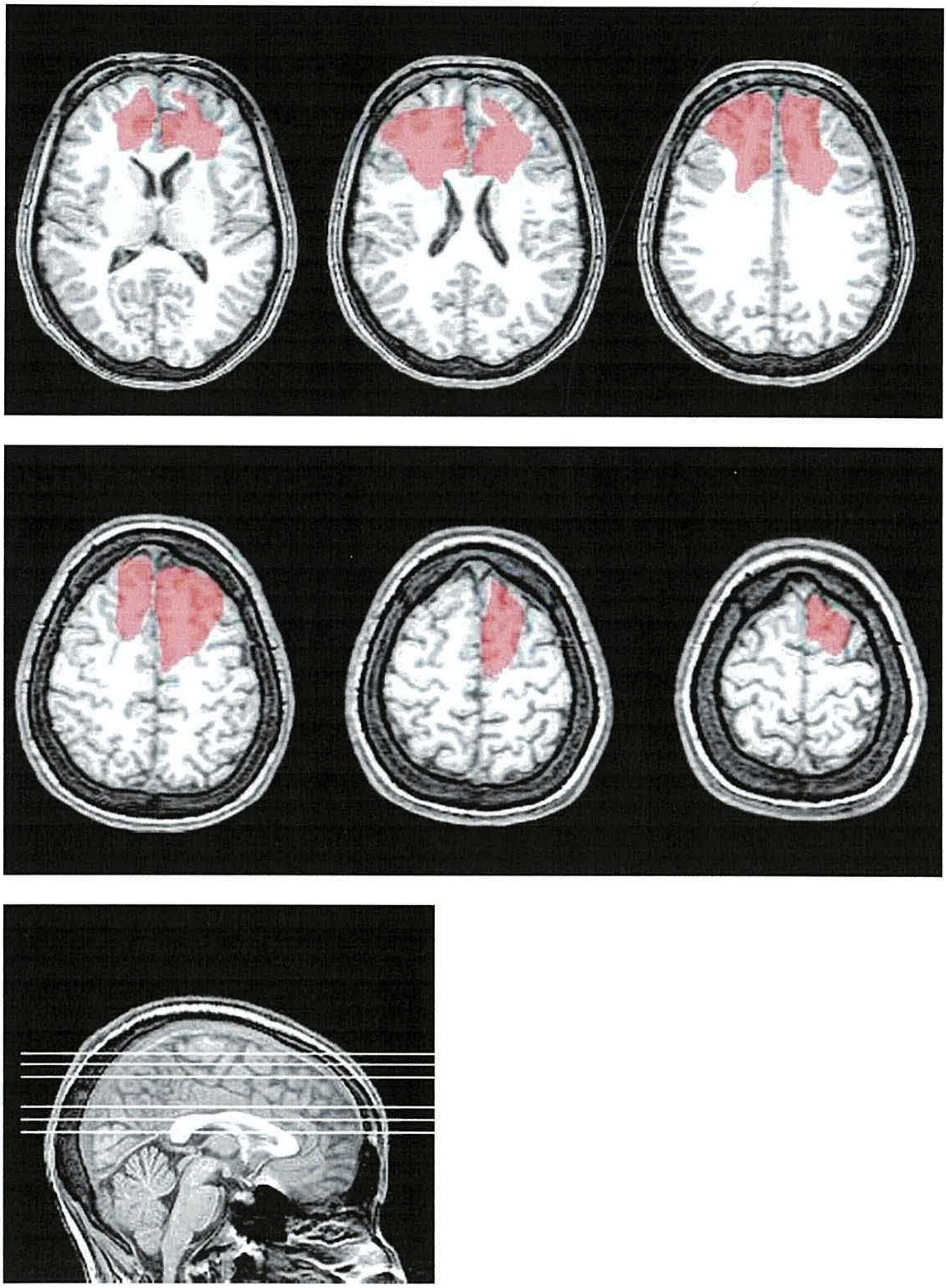

Figure 30. MRI scan of patient GT. This patient suffered a large 7 inch left hemisphere falx meningioma. GT's lesions in the frontal lobe are bilateral. Red colour area indicates extent of lesion.

In addition to the patients, 22 healthy control participants (11 female), aged 19-35yrs ($M = 24.6$, $SD = 4.44$) were examined. All were obtained from the student population of the University of Wales, Bangor, and received either course credit or a small financial payment (£5).

Iowa Gambling Task Variant

The majority of materials used were identical to the original Iowa Gambling Task (Bechara et al, 1994); however, the facsimile money was in British denominations of £5, £10, £20, and £50, whereas $5, $20, $50, and $100 were originally used (Bowman & Turnbull, 2003).

These variants of the Gambling Task involved associating four affective stimuli from the International Affective Picture System (IAPS; Lang, Cuthbert, & Bradley, 2001) with the card decks. Two of the pictures were affectively negative (Slide No. 1050- Snake & Slide No. 1201- Spider) and two affectively positive (Slide No. 1463- Kittens & Slide No. 1811- Monkeys; CSEA, 2001).

Normative ratings from several hundred participants suggest that these two slide types differed to a degree in subjective arousal, but the negative and positive stimuli were at the opposite extremes of valence (see Table 4; CSEA, 2001; Lang, Bradley, & Cuthbert, 2001).

Table 4

Normative ratings for the experimental affective stimuli utilised for the Gambling Task variant (Lang, Bradley, & Cuthbert, 2001)

Slide Number/Name	Valence	Arousal
1463 Kittens	7.45	4.79
1811 Monkeys	7.62	5.12
1050 Snake	3.46	6.87
1201 Spider	3.55	6.36

The stimuli were placed directly on top of the decks, with the participant required to name the decks according to their associated stimuli (e.g. "A kitten card") and forced to touch the card to remove the gambling card beneath the pictures. The slide was then replaced to its original position. In this affective variant of the IGT the decks are associated, labelled and named with the affective stimuli from the IAPS picture set. The affective association was incongruent with the overall financial contingency of the decks. Thus, advantageous decks were associated with negative unpleasant stimuli (Deck C- Snake; Deck D- Spider), and disadvantageous decks associated with positive pleasant stimuli (Deck A- Monkey; Deck B- Kittens). The contingency pattern of the original task was retained.

Neuropsychological Assessment

The neuropsychological test battery included standardised tests of verbal and non-verbal intelligence, memory, and tests of executive function (see Table 5). Patients had also been previously assessed on the original Iowa Gambling Task; all were found to successfully show emotion-based learning (see Figure 31).

Table 5

Neuropsychological profile of the three patients with lesions of the frontal lobe

Test	DT	GT	EO
MCST	23 errors	31 errors	6 cats completed
Hayling C score	3	1	1
Brixton correct	39	28	26
BADS	3	0	0
General Memory	47	33	37
Working Memory	14	19	23
Verbal IQ	96	79	85
Performance IQ	102	102	88
Full Scale IQ	99	88	84

Note. MCST = Modified Wisconsin Card Sorting Test; BADS = Behavioural Assessment of Dysexecutive Syndrome Rule Shift. References for the tests mentioned above can be obtained elsewhere (e.g., Lezak, Howieson, & Loring, 2004). No MCST error data was available for patient EO.

Data analysis

For the IGT variant data, raw scores of each patient are presented separately and assessed as to whether their performance was within 95% of the healthy participant control group mean data (i.e. 1.64 S.D.s).

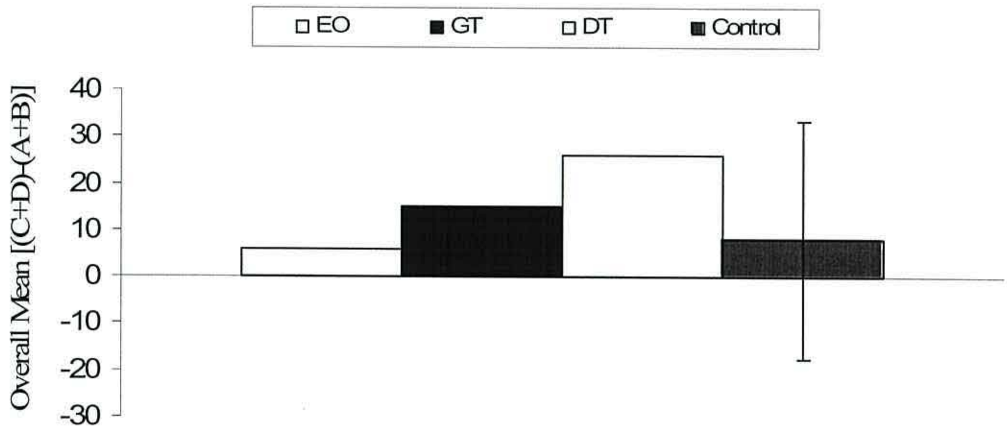

Figure 31. Overall performance of the 3 neurological patients and a control group[13] on the original Iowa Gambling Task. All patients performed at levels that can be considered normal, showing some degree of emotion-based learning. Error bars show 1.64 S.D.s of the mean control group data.

Results

Overall Analysis

As in Bechara et al. (1994), participant's overall performance was calculated using the equation [(C+D)-(A+B)], which provides an index of their overall choices. Thus, a high overall score indicated an advantageous selection strategy, with more good deck cards chosen. Mean overall score for the comparison group was 3.45 (*SD* =

[13] Control group data was taken from the manual IGT condition of Bowman, Evans & Turnbull (2005).

17.04). On the single case level, performance of EO (10) and GT (-12) was within 1.64 S.D.s of the comparison group (-24.5 to 31.4). However, DT was far outside this boundary (-72). Although GT showed exploratory behaviour in block 1 (block score of -2), in the latter four blocks she selecting predominately from decks with a positive emotion label (A and B). Figure 32 shows the performance of the three patients and the mean Gambling Task variant performance of the comparison group.

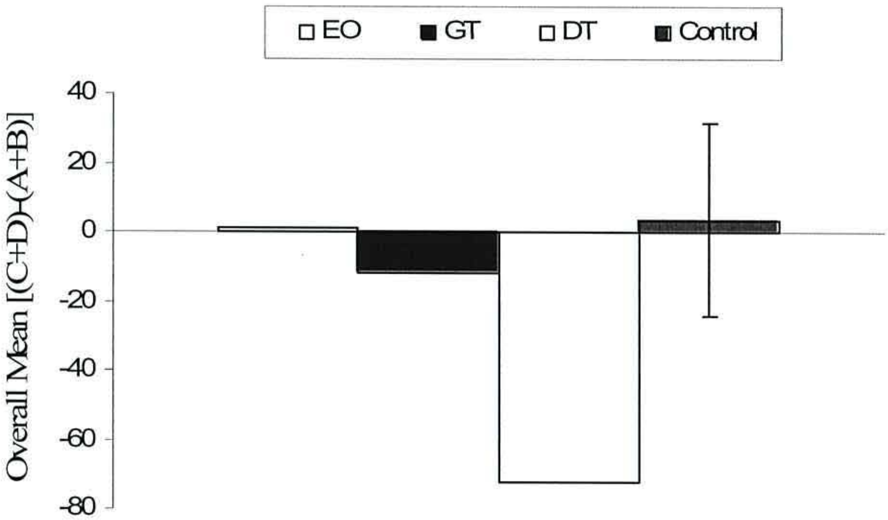

Figure 32. Performance on the Gambling Task variant showing total net scores over the five experimental blocks. The results of the three patients are shown in contrast to the performance of the student control group. Error bars show 1.64 S.D.s. of mean group data.

Analysis by block data. As in the original Gambling Task (Bechara et al., 1994), the 100 card selections were split into five equivalent blocks of 20 cards. An overall block score was calculated from the equation [(C+D)-(A+B)], illustrating how advantageous their deck preferences were during the five blocks and providing a profile of the lesion patients emotion-based learning (see Figure 33).

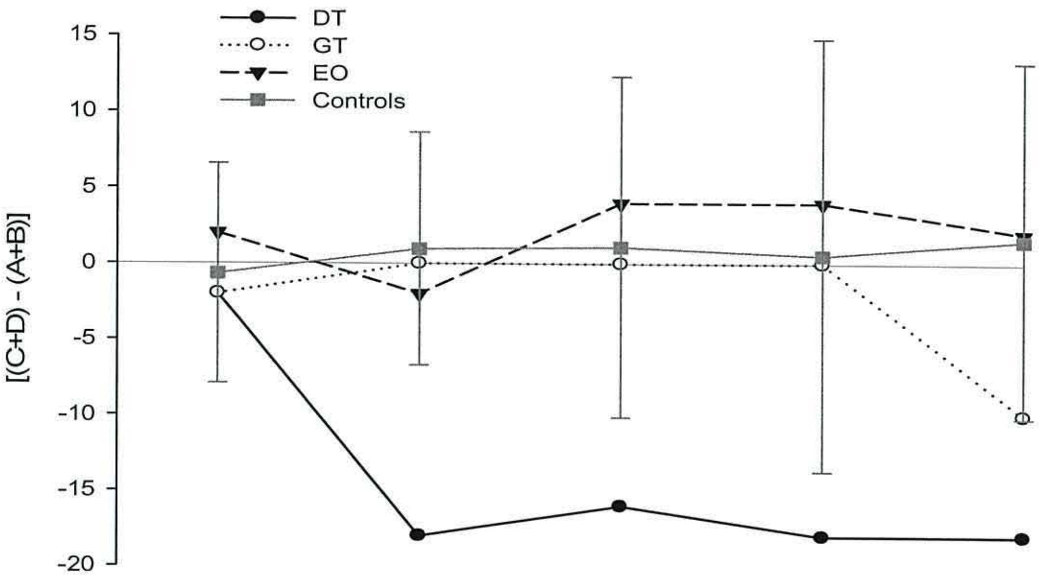

Figure 33. Performance of the three lesion patients on the Incongruent IGT variant showing scores over the five experimental blocks. The patient data is contrasted with performance of a student control group. Error bars show 2 S.D.s of mean control group block data.

Although GT showed exploratory behaviour in block 1 (block score of -2), in the latter four blocks she selecting predominately from decks with a positive emotion label (A and B).

Discussion

Experiment 6 involved a preliminary study of the performance of three patients with frontal lobe lesions on the incongruent affective labelling variant of the IGT. The overall performance of the comparison group was similar to that of the incongruent condition of Experiment 1, with overall scores below that found in the original version of the IGT. That is, the performance of the comparison group was normal for the incongruent affective labelling variant of the IGT.

For the neurological group, EO and GT were found to perform normally (within 1.64 S.D.s of the control group), suggesting these two patients were unimpaired on this task. However, in striking contrast, DT performed at a level far below this boundary, indicating a significant impairment on this task. Indeed, her performance was over 4 S.D.s below that of the control group. DT began the task in a comparable way to the other patients and controls by exploring the incentive properties of the four decks in block 1. However, in the next four blocks she almost exclusively selected cards from the decks with a positive emotional label, even though this resulted in extreme and persistent financial penalties.

This finding suggests that DT was especially sensitive to the conflicting emotional information provided within this task when compared to controls. Experiment 1 and the control group in this experiment demonstrated that the presence of incongruent affective labels negatively affected IGT performance in normal participants compared to the original version of this task. DT showed a similar effect, but greatly magnified. Indeed, it appears that the emotional labels were her primary guide on the task.

Neuropsychological assessment appeared to be unable to account for the differences in performance, therefore we might speculate as to the impact of lesion site on performance on this task, as the patients did differ in the site of their frontal lesions. Thus, EO possessed a significant lesion of the frontal lobe in the right hemisphere; GT's lesion was bilateral; whereas, DT's lesion appeared to be predominately left hemisphere.

As noted earlier, Beer, Knight, and D'Esposito (2006) implicated the lateral orbitofrontal cortex in the left hemisphere in controlling the infusion of emotional information into decision-making. Thus, this area of the brain might underlie the filtering and inhibition of emotional information that is irrelevant to current goals (Rule, Shimamura, Knight, 2002; Shimamura, 2000). The lateral regions of the orbitofrontal cortex are consistently proposed to be involved in emotion-based inhibition (Elliot, Dolan, & Frith, 2000; Iversen & Mishkin, 1970; Kringelbach, 2004; Rubia et al., 2003) and regulation (e.g., Levesque et al., 2004; Oschner, Ray, et al., 2004; Phan et al., 2005). Indeed, an animal lesion study demonstrated that frontal lobe lesions can alter the ability to suppress pre-existing or spontaneous object preferences (and aversions) when faced with a setting which required such behaviour (Brush, Mishkin, & Rosvold, 1961).

Therefore, one speculative explanation for the impaired performance of DT would suggest that her lesion site encroached significantly upon the lateral regions of the orbitofrontal cortex in the left hemisphere, whereas GT's lesion might have relatively spared this area. If this was the case, this might underlie the striking infusion of irrelevant emotion into DT's decision-making on the affective labelling variant of the IGT. Indeed, if DT was unable to overcome a pre-existing preference for a particular object (in this case, a picture of kittens), this could account for her failure to regulate a pre-existing preference, even when faced with striking losses (cf. Brush, Mishkin, & Rosvold, 1961). This issue should be clarified with a larger and more detailed study involving voxel-based analysis, along with a more appropriate matched control group, but at this point it is somewhat unresolved.

General Discussion

Overview

This thesis described six experiments which have studied the effects of pre-existing emotional biases on complex affective decision-making, using a novel variant of the original Iowa Gambling Task. Manipulation of the nature of the biasing object (e.g., race, facial attractiveness etc) on this task has provided an insight into the disrupting effects of affective bias in emotion-based learning, including how the regulation of racial bias might influence decision-making. Moreover, the small scale neurological study identifies some interesting questions regarding the effects of frontal lobe lesions on the regulation of emotion irrelevant to goal-directed behaviour, and possibly racial bias.

Each experimental chapter has considered the particular points raised by each study. Therefore, this general discussion will predominately focus on the main issues raised *across* the studies in an attempt to integrate the findings as a whole and indicate possible directions for future research.

Affective labelling in the Iowa Gambling Task

First, it is worth noting that the addition of labels *per se* to Iowa Gambling Task (IGT) decks had little effect on decision-making performance in Experiment 1. Thus, the control condition in this experiment involved digitally morphed emotional stimuli which removed any salient emotional content. Performance was consistent with previous IGT experiments (e.g., Bechara et al., 1994; Bowman & Turnbull, 2003), and also with the congruent condition in that particular experiment. Therefore, it seems safe to assume that the act of associating pictures with the task alone was of minimal importance to decision-making performance, and that any effects seen in the later experiments were a consequence of the emotional content of the stimuli.

Although participants were explicitly informed that these labels were irrelevant to performance, many of the investigations in this thesis show that labelling the Gambling Task decks with incongruent emotionally salient labels resulted in a persistent biasing of decision-making. This is consistent with previous studies illustrating the ease with which irrelevant emotion can infuse the decision-making process (e.g., Beer, Knight, D'Esposito, 2006; Forgas, 1990, 1992).

Congruency. As a whole, congruent association (i.e., positive emotion-good decks; negative emotion-bad decks) in all experiments had little effect on decision-making in these affective labelling tasks. Indeed, performances were closely comparable to both the control condition in Experiment 1, and previous IGT studies (e.g., Bechara et al., 1994; Bowman & Turnbull, 2003). Further analysis (see Appendix 4) demonstrated that the congruent variant had negligible influence on deck selections across the experiment as a whole (Supplementary data 1) and minimal influence on deck selections during the early phase of the task (block 1;

Supplementary data 2). This is inconsistent with the single previous related IGT study (Hinson et al., 2006) which showed that congruent association enhanced decision-making performance by inducing participants to select significantly more cards from the advantageous decks. This may be a consequence of important differences between the two experimental approaches. Thus, whereas the experiments in this thesis were based on the original four-deck IGT (2 positive; 2 negative), the Hinson et al. (2006) experiments used altered incentives in a three-deck variant (positive, negative, & neutral). Indeed, the prominent lower frequency of punishment (cf. bad and neutral) intrinsic to the good deck in the Hinson et al. variant would likely bolster emotion-based learning, particularly when guided by a helpful emotional label. Overall, in a series of comparable experiments using the classic IGT contingency congruent emotional labels failed to enhance decision-making.

However, incongruent association (positive emotion-bad decks; negative emotion-good decks) demonstrated a striking and persistent decision-making bias in most experiments (Experiments 1, 2, 3, and 6). The addition of highly emotionally salient pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001; CSEA, 2001) showed a remarkable disruption of decision-making specifically in the incongruent condition (Experiment 1). Here, participants were more likely to choose from decks labelled with a positive emotional label, even though this resulted in high financial penalties compared to the congruent condition. Likewise, in the two experiments (Experiments 2 and 3) using the race-based variant of this task, White-European participants were biased towards the decks labelled with ingroup faces, although this was financially disadvantageous. Again, the biasing effect was striking and persistent, with participants only minimally favouring cards from the good decks in the latter blocks of the task. Further analyses (see Appendix 4) confirmed these general observations. For example, during the early part of the task (block 1; Supplementary data 2) participants were much more likely to select cards from the high reward decks A and B than in the congruent (or control in E1) condition. Total deck selections across the task (Supplementary data 1) demonstrated that participants generally failed to favour or only minimally favoured the good decks. Thus, the bias induced by the goal-irrelevant incongruent stimuli was persistent and hindered the normal shift towards the good decks. Indeed, the pre-existing incongruent bias influenced both decisions under ambiguity (early task) and risk (later task).

In contrast, the two studies (Experiments 4 & 5) which involved the manipulation of facial attractiveness and trustworthiness showed no significant differences in decision-making behaviour between the congruent and congruent conditions. Although there was a borderline biasing of selection in block 1 in both these studies, it appears to have been readily overcome with time and experience. This is most likely a result of the more subtle affective nature of these classes of physiognomic feature, a point discussed in more detail below.

In sum, the addition of emotional labels to IGT decks showed that only an *incongruent* association produced any significant biasing of decision-making behaviour, even though the formal features of the task remained identical in both congruency conditions. This might be viewed as a form of 'framing' effect (Kuhberger, 1998; Tversky & Kahneman, 1981), whereby decision-making behaviour can be readily altered depending on how a logically equivalent problem is presented to a participant. In fact, previous studies examining the nature of the framing effect clearly show that negative framing results in riskier decision-making (e.g., Kahneman & Tverksy, 1979, Experiment 11; Tversky & Kahneman, 1981). This is comparable to that shown in many of the experiments in this thesis (Experiments 1, 2, and 3), with participants selecting a greater number of cards from high risk decks in the incongruent condition compared to the congruent.

In the literature on framing effects, positive framing is generally shown to result in risk-aversion (Kuhberger, 1998; Tversky & Khaneman, 1981). However, in the IAPS-based affective labelling variant, positive framing was shown to be relatively comparable to the no-frame condition (i.e., neutral control). This may simply be a result of the lack of conflict between the incentive qualities of the Gambling Task decks and the associated affective labels in this particular condition. Thus, conflicting emotional signals appear to be disruptive on this variant of the Gambling Task, specifically when the integral, but task-irrelevant, stimuli possess salient emotional properties.

Emotional nature of the labelling stimuli

Clearly, the experiments show that some stimuli (e.g., race) were more able to infuse into the decision-making process than others (e.g., facial attractiveness). This raises the general question of how different classes of stimuli result in disparate effects? Although all the stimuli used in the experiments in this thesis were selected on the basis of their emotional nature, findings from the experiments might possibly indicate that it was the emotional salience of the stimuli *categories* which underpinned the persistent effect on complex affective decision-making.

Physiological arousal. In the pre-testing selection phase, two experiments assessed whether category of stimuli (e.g., black face *vs.* white faces) within each class differed with regards to their arousing nature using Skin Conductance Responses (SCRs). Thus, in the IAPS-based study (Experiment 1), the selection phase showed that unpleasant stimuli were found to elicit greater SCRs compared to the pleasant stimuli, even though the stimuli were matched for normative subjective assessments of arousal (CSEA, 2001; Lang, Bradley, & Cuthbert, 2001). Previous studies using the IAPS stimuli set also demonstrate that unpleasant pictures reliably produce greater SCRs than pleasant pictures (Lane et al., 1997; Lang, Greenwald, Bradley, & Hamm, 1993).

In contrast, faces of each race category did not differ in their arousing properties in Experiment 2. Indeed, the facial stimuli used in these experiments produced minimal SCRs. This was perhaps not surprising, as the faces used in these experiments possessed neutral emotional expressions. The finding of no differences in indexes of autonomic responses to faces of ingroup and outgroup stimuli is entirely consistent with another recent study (Brown, Bradley, & Lang, 2006).

However, in both the race- and IAPS-based experiments the stimuli were capable of producing persistent biases in decision-making behaviour under conditions of incongruency. Thus, the effect on decision-making appears to not have been reliant on stimuli categories evoking dissociated autonomic arousal responses.

As noted in Chapter 2, the development of an asymmetry in anticipatory SCRs before selecting from the task decks has been proposed to underlie advantageous decision-making on the Gambling Task (e.g., Bechara et al., 1997; Bechara et al., 2002). Therefore, from this perspective, the presence of labelling stimuli which possess pre-existing differences in emotional arousal would theoretically be expected to disrupt the development of 'somatic markers', and as a consequence decision-making (cf. Hinson et al, 2006). Although this could have been the case in the IAPS-based experiment, the race-based studies show that this might not be a *necessary* requirement to alter decision-making behaviour in these variants of the IGT.

Emotional salience. Neuroimaging studies implicate regions of the brain involved in emotion and reward for the processing of all the classes of stimuli used in the experiments in this thesis. Thus, previous studies demonstrate that processing outgroup faces (Cunningham et al., 2004; Hart et al., 2000; Lieberman et al., 2005; Phelps et al., 2000; Wheeler & Fiske, 2005), facial trustworthiness (Engell, Haxby, & Todorov, 2007; Winston et al., 2002), facial attractiveness (O'Doherty et al., 2003; Winston et al., 2007), and unpleasant-pleasant IAPS stimuli (e.g., Lane et al., 1997) reliably activate regions of the brain associated with emotion and reward, such as the amygdala and orbitofrontal cortex.

However, this was not a sufficient requirement for the presence of a decision-making bias in this variant of the Gambling Task, as the variables of facial attractiveness and trustworthiness were unable to produce a persistent biasing of decision-making. In both of these experiments, the strongest trend towards a significant bias was present in block 1 of the task, suggesting that any influence of pre-existing affective bias was overcome with increasing goal-relevant information from the decks. As noted earlier, this is likely a consequence of the less overt emotional salience of the stimuli in these two experiments. That is, they have less salient, robust and easily differentiated emotional characteristics. Indeed, studies of physiognomic information show that its greatest effect is under situations of ambiguity (Hassin & Trope, 2000). This is certainly a characteristic of the Gambling Task in its early blocks, during which facial trustworthiness and attractiveness were found most able to alter decision-making. However, latter parts of the task can be better defined as involving decisions under risk, as the outcome probabilities are more clearly defined.

In sum, the stimuli which produced significant and persistent decision-making biases possessed easily determined characteristics which were both easily categorised (e.g., Black *vs.* White; Pleasant *vs.* Unpleasant) and, further, possessed emotional salience. That is, their affective nature was more obvious during the task, and could therefore readily infuse the decision-making process in a persistent fashion. In contrast, the emotional nature of some forms of physiognomic information can be considered subtle and, as a consequence, readily overcome with time and experience.

Emotion-regulation and the toleration of incongruent framing

Although the IAPS- (Experiment 1) and race-based (Experiment 2 & 3) Gambling Task variants showed a similar form of decision-making bias in the incongruent condition, there was also an interesting dissociation between the ability of participants to overcome the biasing effect found in these two experiments.

Thus, in IAPS-based Experiment 1 participants who exhibited high levels of trait anxiety were found to be most influenced by the inconsistent framing of the incongruent condition. In the original version of the Gambling Task, anxiety or neuroticism is generally found to be associated with better performance (e.g., Carter & Smith-Pasqualini, 2004), which was also present in the control condition of Experiment 1. This relationship is inferred as being a consequence of these high trait anxious participants being more risk-averse (e.g., Carter & Smith-Pasqualini, 2004). However, in the race-based variant, Experiment 3 demonstrated that greater levels of implicit race bias were associated with a *better* ability to overcome the incongruent framing of the task.

This finding is somewhat paradoxical, as in both cases the participants would have similar affective associations with the stimuli used as deck labels. That is, to a participant with high trait anxiety the incongruent condition involves an inconsistent relationship between a negative affective label (e.g., a spider) and a deck that provides an overall positive rewarding outcome, and *vice versa*. Similarly, to an individual with a high level of race bias on the IAT, the same relationship applies - positively rewarding decks are associated with what will be perceived as negative affective labels (i.e., Black faces), and *vice versa*. We might have expected a similar performance from both these groups of participants.

However, that was not the case. Participants high in race bias were better able to overcome incongruent framing, whilst those participants high in trait anxiety were somewhat less able to tolerate this inconsistent affective relationship. Why would this be the case?

This discrepancy might be the result of the intrinsic abilities and motivations of these two participant groups to regulate the emotional experiences evoked by the integrated affective labels in each experiment. Thus, the explicit expression of racial bias is now generally deemed unacceptable in modern multicultural societies (Devine, 1989; Kleugal & Smith, 1986) and, therefore, we might expect individuals who do hold such attitudes to be motivated and better able to control and regulate their emotion-based biases in everyday behaviour. Indeed, studies clearly show a reduction in racial prejudice over the 20th century when measured by self-report measures (e.g., Greeley & Sheatsley, 1971; Schuman, Steeh, & Bobbo, 1985), whilst the presence of more covert racial bias is readily found when more indirect measures are used (e.g., Devine, 1989; Fazio, Jackson, Dunton, & Williams, 1995). Moreover, neuroimaging studies implicate a network of frontal brain regions in the regulation and inhibition of racial bias (Cunningham et al., 2004; Lieberman et al., 2005; Richeson et al., 2003; see later). In sum, individuals with high levels of race bias are likely motivated to control the explicit manifestation of their racial bias in most circumstances, enabling them to conform to current social norms. This regulation of racial bias may be a purposeful or an automatic process (c.f., Gross, 1998).

In contrast, participants with high trait anxiety may be less able and motivated to control their reactions to even innocuous negative stimuli in the environment. Indeed, individuals with high levels of trait anxiety are found to focus excessively on irrelevant unpleasant stimuli (Gray, 1985; Mogg & Bradley, 1998). There will be minimal social pressure that would proscribe responding to, for example, spiders and snakes negatively, or even holding negative attitudes about such objects. Indeed, Thayer and Lane (2000) suggest that anxiety disorders may be the result of a failure to inhibit maladaptive responses in particular situations. Therefore, in addition to emotion being adaptive in decision-making (e.g., Damasio, 1994), a lack of ability, or simple motivation, to regulate irrelevant emotional experiences in the decision process can be detrimental.

Implications for inter-group behaviour

As noted earlier, in both race-based experiments (Experiments 2 and 3) the incongruent association of ingroup and outgroup faces (i.e., Black faces-good decks; White faces-bad decks) resulted in striking and persistent decision-making biases. The fact that this outcome was replicated suggests good reliability of this important finding. Indeed, this race-based incongruent association had an effect on Gambling Task decision-making to a magnitude close to that found for the association of the highly emotionally salient IAPS stimuli (Experiment 1).

For the IAPS-based study (Experiment 1), the disrupting effect of affective bias was shown to be related to higher trait anxiety. Surprisingly, however, Experiment 3 demonstrated a relationship between higher implicit racial bias and better performance on this variant of the task. The most plausible explanation for this somewhat unexpected finding appears to be that people with high levels of racial bias readily utilise top-down reflective mechanisms to inhibit the more reflexive response to outgroup stimuli (c.f., Cunningham et al., 2004; Lieberman et al., 2005; Phelps et al., 2000; Richeson et al., 2003). These mechanisms could enhance a participant's ability to overcome the conflicting and shifting affective qualities of the Gambling Task decks under conditions of incongruent framing.

Previous studies demonstrate that implicit race bias can negatively influence fairly rapid and instinctive decisions (e.g., Correll et al., 2002; Correll et al., 2007), however, it appears from the findings in this thesis that active regulation of affective race bias might have enhanced more controlled decision-making under settings of complexity, ambiguity, and conflicting affective signals.

Prior studies do show that information processing and group decision-making can be enhanced by increasing the salience of race in some circumstances (Sargent & Bradfield, 2004; Sommers, 2006), possibly as a consequence of motivation to regulate racial prejudice (Sommers, 2006). Moreover, other studies suggest that regulation of automatic racial bias can have positive effects in some racial interactions (e.g., Shelton, Richeson, Salvatore, & Trawalter, 2005; Vorauer & Turpie, 2004). For example, Shelton et al. (2004) showed that Black participants preferred to interact with White participants who were highest in implicit racial bias, finding these individuals more engaging and favourable than those with low levels of race bias. Shelton et al. suggest this is a consequence of high levels of regulation to appear non-prejudiced from participants with negative race bias, which is expressed as more appealing explicit social interactions. However, using such regulatory mechanisms may have cognitive costs (Richeson & Shelton, 2003; Richeson & Trawalter, 2005), but resource depletion appears to not have resulted in any detrimental effect on decision-making in these experiments – perhaps due to the affective nature of the task.

Thus, this finding consolidates the disconcerting inference from research studying the regulation of race bias (e.g., Shelton, Richeson, Salvatore, & Trawalter, 2005; Vorauer & Turpie, 2004). Individuals from particular social groups likely find it difficult to identify those out-group members who do and do not harbour implicit prejudice (Shelton, Richeson, Salvatore, & Trawalter, 2005). For example, a White individual who possesses low levels of race bias may appear to be less positive in a social interaction with a Black person simply because they do not feel the need to actively engage in self-regulation of behaviour. As a consequence, Black people might avoid interacting with such non-biased people in future, and favour interactions with outgroup members who actually possess *high* implicit race bias.

Limitations of the present research

As with all research, there are limitations found in the studies in this thesis. For example, like a vast majority of psychological research, most studies in this thesis assessed performance in a student population. This could be a relevant issue in a number of ways.

Firstly, we might expect university students to possess a higher level of education and intelligence than a more generalised population. Previous studies (e.g., Bechara et al., 2000a, 2000b; Monterosso et al., 2001; Rodriguez-Sanchez et al., 2005; Evans, Kemish, Turnbull, 2004) have assessed the influence of education and intelligence on Gambling Task performance demonstrating somewhat equivocal findings. Thus, some studies suggest that intelligence was not an important mediator of performance on this task (e.g., Bechara et al., 2000a, 2000b; Bechara et al., 2001; Bechara & Martin, 2004), whilst others show that intelligence (Monterosso et al., 2001; Rodriguez et al., 2005) and education (Rodriguez et al., 2005) are positively correlated with performance. In contrast, another study suggests that higher levels of education lead to worse performance on the IGT (Evans, Kemish, & Turnbull, 2004). Thus, it is unclear as to whether the higher levels of education of the student samples used in much of this research would underpin any restriction of the ability to generalise the findings in these studies to the wider population.

The small preliminary lesion study (Experiment 6) does provide some insight into how these findings might be generalised. Thus, two patients with lesions of the frontal lobe performed within 1.64 S.D.s of the student sample within that particular experiment. These two participants were both older than the student population and also acquired less formal education. Therefore, from this quite restricted sample, we might tentatively infer that the decision-making biases found in the incongruent condition in these studies will be readily found in the general population.

A more important limiting factor of the population used in this thesis relates to the expression and regulation of racial bias. Both race-based experiments were based on student populations. We might *assume* such populations (i.e. younger cohorts) hold more liberal and egalitarian attitudes to racial outgroups (c.f. Shelton, Richeson, Salvatore, & Trawalter, 2005) than the general population, particularly as social norms have moved towards egalitarian attitudes (Blanchard et al., 1994). Thus, explicit attitudes have clearly been shown to change over time (Greeley & Sheatsley, 1971; Schuman, Steeh, & Bobbo, 1985), however implicit racial bias seems more persistent (Devine, 1989; Fazio, Jackson, Dunton, & Williams, 1995).

As noted earlier, implicit racial bias appears to be regulated by the action of more reflective top-down frontal lobe mechanisms, which likely enables individuals to conform to the prevailing social norms (Cunningham et al., 2004; Lieberman et al., 2005; Richeson et al., 2003). Therefore, it is quite possible that such mechanisms are influenced by age and social influences. For example, 'modern' prejudice may be related to the ability to inhibit negative attitudes, whereas pre-modern prejudice likely involved little need for inhibitory control of racial bias. Indeed, von Hippel, Silver, and Lynch (2000) found that elderly people exhibited higher racial prejudice and greater reliance on racial stereotypes, when compared to a younger sample. These age differences were reported to be mediated by inhibitory abilities (von Hippel, Silver, & Lynch, 2000). However, inhibitory ability does deteriorate with age (Chao & Knight, 1997; Zacks, Radvansky, & Hasher, 1996), thus it is difficult to separate age from socialisation effects.

In sum, it is possible that the results from the race-based studies may not completely reflect that of the wider population, due to the possibility of more egalitarian attitudes found in younger and better educated populations. However, this would be likely to suggest that we might find a *greater* level of racial bias, and possibly *more* disruptive effect on decision-making for older or more general populations. Where such population effects may have a more important influence is on individual abilities to regulate prejudice, which may be reflected in the relationship between implicit race bias and the incongruent framing effect in the race-based variant of the IGT. Thus, in older populations less effective inhibition of race bias (von Hippel, Silver, & Lynch, 2000) would be expected to lead to a different relationship between decision-making bias on this task and implicit race bias, compared to that found in the younger sample in the race-based experiments. Although this might be worth pursuing in future, this has little impact on the findings in this thesis being extended to a large proportion of the population.

A further more general criticism of Gambling Task studies is the finding that around 20-30% of the normal population are found to show poor decision-making on this task (e.g., Bechara et al., 2001; Bechara & Damasio, 2002). This is probably of little consequence for the majority of the studies in this thesis. As most studies (Experiments 1, 2, 3, 4, & 5) compare two or more normal samples in conditions manipulating task features, rather than attempting to discover impairments on the IGT within particular clinical or sub-clinical populations. However, this might be an important issue for the lesion study (Experiment 6).

For the small sample lesion study, the variable performance of a normal population might, as noted above, be more relevant. However, the single patient that was found to be impaired on the IAPS-based variant of the IGT was over 4 S.D.s outside that of the performance of the student control group, suggesting the impairment was striking. Of course, this highlights another limitation of this particular experiment. Although this was mainly a preliminary study aiming to lay the basis for further research, the use of a non-matched control group is less than ideal. To make a more robust inference from such a study, along with examining a larger sample of patients with frontal lobe lesions, the non-lesion control group should be matched for a variety of characteristics (age, education etc).

Future work

The filtering and infusion of emotion into decision-making. One obvious strand of future work will be to consolidate and extend the work begun in the preliminary lesion study in Experiment 6. Thus, this study appears to suggest that some patients with lesions of the frontal lobe might be particularly unable to filter irrelevant emotional information out of the decision-making process. Consistent with this, Beer, Knight, and D'Esposito (2006) indicated using neuroimaging that lateral regions of the orbitofrontal cortex may control the infusion of emotion into risky decision-making. Indeed, one hypothesis of orbitofrontal cortex function relates to its involvement in the filtering of emotional information (Rule, Shimamura, & Knight, 2002). Taken together, these findings readily suggest the need for more detailed investigation of patients with lesions of the frontal lobe on tasks that assess the infusion of emotion-based information into both simple and complex decision-making. Therefore, Experiment 6 should be extended to assess a larger sample of the appropriate patients using more detailed voxel-based morphometry. Such studies will provide an important insight into the integration of emotion into social cognition, social decision-making, and other related processes

Implicit affective bias. One interesting line of inquiry suggested from the findings of this thesis would be to assess the impact of *implicit* pre-existing affective bias on complex decision-making in the IGT. Thus, experiments in this thesis using explicit integral emotional labels demonstrate the ease with which this source of emotion can bias decision-making on the Gambling Task. However, the influence of more implicit sources of affective bias would be an important extension of this work.

For example, presenting implicit congruent/incongruent emotional primes (e.g., IAPS or faces) following selections, but *before* decision feedback, may also result in similar decision-making biases to those found in this thesis. Alternatively, primes could be presented during the deck assessment phase, that is, before selections. Such approaches may well circumvent any potential prefrontal-mediated regulation in the race-based variant of the IGT.

Thus, as shown by Cunningham et al. (2004), presenting race-based stimuli below the level of awareness predominately results in higher amygdala activity for Black faces. However, longer exposure times (i.e. conscious processing) show the activation of a network of frontal lobe regions, which likely mediate regulation of this race-based affective bias. Therefore, we might expect to find that presenting implicit incongruent race-based stimuli would bias decision-making, but, moreover, may also demonstrate a negative (or absent) correlation between implicit race bias and the magnitude of bias on the incongruent condition of such a task (i.e., higher implicit race bias, poorer IGT performance). Thus, a task using an implicit source of race bias might show the *reverse* finding to that found in the second race experiment in Chapter 2 (Experiment 3).

The neurobiological basis of race bias and regulation. As often noted, the findings from social neuroscience demonstrate the involvement of the prefrontal cortex in the regulation of prejudice-related processes (e.g., Cunningham et al., 2004; Lieberman et al., 2005; Richeson et al., 2003). However, most have been based on neuroimaging work, and the guiding principle of cognitive neuroscience is the building of multiple lines of converging evidence. The relative absence of a lesion study literature on racial prejudice seems an obvious limitation. The particular importance of building congruence between functional imaging and lesion study findings is becoming increasingly well-recognised (Price & Friston, 2002; Rorden & Karnath, 2004; Shallice, 2003).

Studying neurological patients with damage to frontal brain areas seems especially important, because so many classes of frontal lesion produce substantial changes in psychological processes that are likely to underpin to racial bias, such as social inhibition (e.g. Dimitrov, Phipps, Zahn, & Grafman, 1999; Saver & Damasio, 1991), reversal learning (e.g. Fellows & Farah, 2003; Rolls et al., 1994), and flexibility of set-shifting (e.g. Stuss et al., 2000; Dias, Robbins, & Roberts, 1996). Indeed, the preliminary lesion study in this thesis (Experiment 6) suggested that some patients with lesions of the frontal lobe may have impairments in the ability to filter irrelevant emotion from complex decisions. Moreover, Milne and Grafman (2001) have shown that individuals with lesions of the ventromedial prefrontal cortex showed a reduction in implicit gender-related stereotyping, assessed via IAT performance (although see Chapter 1). In contrast, von Hippel, Silver, & Lynch (2000) demonstrated that inhibitory ability was related to the use of stereotyping, with elderly participants showing more stereotyping than younger participants. It is well-established that inhibitory abilities decline with age (Chao & Knight, 1997; Zacks, Radvansky, & Hasher, 1996), which is likely related to declining frontal lobe function (Chao & Knight, 1997; West, 1996).

Remarkably, however, there appears to have been no work on the question of whether frontal brain lesions alter the expression of racial attitudes; whether these changes are selective to the implicit versus explicit aspects of prejudice; and which classes of executive ability are most directly correlated with these changes. An investigation of these issues would produce a far more systematic account of the psychological basis of racial bias than is currently available, and would serve as an essential compliment to the work in functional imaging, which cannot investigate the psychological and behavioural basis of prejudice in such a direct way (Price & Friston, 2002; Rorden & Karnath, 2004; Shallice, 2003).

Real-world complex social decision-making. Although the variant of the IGT used in this thesis aim to provide a better model of real-world social decision-making than has been previously available, the ecological validity could be further improved. Thus, the variants in this thesis present the decks with labels invoking socially salient pre-existing affective biases. If the aim is to provide a real-world social cognition, this can be considered an improvement over utilising neutral unlabelled card decks. However, the contingency used within the original task, and also the variants in this thesis, rely on money-based incentives. Whilst this has been reliably demonstrated to underpin emotion-based learning, altering the incentives to be more *socially* salient would further improve the ecological validity of such IGT variants.

One previous study has examined the possibility of making the task contingency of the IGT more socially salient by converting the experienced task incentives from direct financial reward and punishment to the *indirect* consequences of the actions of others (Turnbull, Berry, & Bowman, 2003). The results of this 'fire-fighter' variant showed that participants failed to learn in a comparable way to the original Gambling Task, suggesting that participants were unable to reliably experience and extract the indirect emotional consequences. Thus, using indirect emotional consequences appears to not be an effective approach to model complex real-world social decision-making.

However, it is possible that a more *direct* socially salient contingency might allow a more robust emotional experience for participants, and so underpin learning in a comparable way to the IGT. Thus, for example, a variant of the IGT could be framed as a 'friend' evaluation task, with participants required to select from a series of face-labelled decks which provide feedback about social behaviours of candidate friends that are generally deemed positive, negative, or neutral (e.g., dishonesty, altruism etc). Participants could show their friend preference by periodic subjective ratings of the four candidates, which would also serve as an indicator of learning. Essentially, making the task outcomes socially salient and directly related to the participant might be a more effective approach to further improving the ecological validity of the IGT, and to develop a task that is a better model of real-world social cognition. Another potential more ecologically valid approach would be to include facial emotion as reward feedback in a Gambling Task variant. If such tasks enabled emotion-based learning (i.e., differentiation between good and bad with experience), the task labels would be readily manipulated to assess the effect of varying relevant social characteristics on task behaviour (e.g., race) and also probe decision-making deficits in patients with frontal lesions under more pertinent socially relevant situations (cf. economical decisions).

Conclusion

This thesis has examined the role of pre-existing affective biases in social decision-making, using a laboratory paradigm which aims to model real-world interactions. That is, the studies assessed how the mechanisms underpinning prejudice influenced emotion-based decisions in a setting which is complex, ambiguous, and possesses shifting affective associations. The major new findings of this thesis might be summarised as:

1. The association of emotional labels that are *consistent* with the net incentive properties of Gambling Task decks has no significant impact on decision-making (Experiments 1-5).

2. The addition of emotional labels that are *incongruent* with the net incentive properties of the task decks can lead to significant and persistent biases. These labelling effects seem most powerful when the labels are emotionally salient and readily categorised (Experiments 1, 2, & 3).

3. The biasing of decision-making by pre-existing emotionally salient objects does not appear to depend on the two classes of stimuli evoking contrasting levels of autonomic arousal (i.e., skin conductance responses; Experiments 1 & 2).

4. Only Experiment 1 suggested an interaction between congruency and learning across the task. Therefore, emotion-based learning *per se* appears to be relatively robust to the association of incongruent emotional labels (Experiments 1-5).

5. Affective bias from incongruent association can readily infuse into participant's subjective experiences. For example, experiments using racial stimuli produced reliable biases in subjective ratings of the affective properties of the task decks (Experiments 2 & 3).

6. The addition of White and Black faces in an incongruent association disrupts performance on the IGT, with higher levels of implicit racial bias associated with *more* advantageous performance. Thus, somewhat paradoxically, people with high levels of implicit race bias were less affected by the conflict between task labels and task rewards (Experiments 2 & 3).

7. Measures of implicit race-based attitudes taken after the IGT showed no difference between the incongruent and congruent conditions. Thus, implicit racial prejudice appeared to be resistant to the complex contingencies presented in the IGT (Experiment 3).

8. The magnitude of decision-making biases found in many of these experiments is perhaps a consequence of the presence of a frontal lobe emotion-regulating process. This could underpin an enhanced ability to overcome, or tolerate, conflicting emotional signals during decision-making.

These findings have implications that are salient for an understanding of real-world social cognition, complex decision-making, and the interface between cognition and emotion. They also provide a foundation for further research into the influence of emotion on social decision-making and potential tasks which can more effectively model real-world social cognition under controlled conditions.

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Appendices

Appendix 1a: Psychiatric/Neurological History Questionnaire

Conducted by:

Date:……………………………………………………………………………………
Initials:………………………………………………………………………………..
Gender:……………………………………………………………………………….
Age:…………………………………………………………………………………..
Educational Level:……………………………………………………………………

Psychiatric History

Have you ever suffered major depression or any psychiatric disorder?
E.g. Schizophrenia. If yes please supply further details.

Yes/No

Have you ever been referred to a psychiatrist for treatment?

Yes/No

Neurological History

Have you ever suffered any neurological damage?
E.g. stroke or multiple sclerosis? If yes please supply further details.

Yes/No

Have you ever suffered serious head injury causing you to lose consciousness? E.g. car accident. If yes for how long were you unconscious?

Yes/No

Appendix 1b: IAPS Slide numbers and normative ratings for Experiment 1 (CSEA, 2001; Lang, Bradley, & Cuthbert, 2001)

Slide No.	Name	Valence	Arousal
1463	kittens	7.45	4.79
2345	kids	7.05	5.28
4641	Romance	7.20	5.28
8200	waterskier	7.54	6.35
5480	firework	7.53	5.48
4626	wedding	7.60	5.78
8080	sailing	7.73	6.25
8470	gymnast	7.94	6.14
5260	waterfall	7.34	5.71
7270	ice cream	7.53	5.76
8170	sailboat	7.63	6.12
8034	skier	7.06	6.30
4660	kiss	7.40	6.58
8496	waterslide	7.58	5.79
8540	athletes	7.56	5.74
8500	gold	6.96	5.60
1811	monkeys	7.62	5.12
5623	windsurfer	7.19	5.67
8501	money	7.91	6.44
2389	teens	6.61	5.63
9584	dental exam	3.34	4.96
1050	snake	3.46	6.87
6555	knife	2.95	5.78
2120	angry face	3.34	5.18
6571	gun	2.85	5.59
1201	spider	3.55	6.36
6838	sacredgirl	2.45	5.80
9592	needle	3.34	5.23
6212	soldier	2.19	6.01
9050	planecrash	2.43	6.36

Appendix 1c: Example Page from IAPS Subjective Ratings Booklet

PARTCIPANT NUMBER: **SLIDE NUMBER:**

THIS SECTION OF THE EXPERIMENT REQUIRES YOU TO RATE EACH OF THE 30 PICTURES THAT YOU WILL SEE ON THE THREE SCALES PROVIDED, AS TO HOW THE SLIDE MAKES *YOU* FEEL, **THE SCALES RANGE FROM 0 TO 6**, THE THREE EMOTION SCALES ARE:

PLEASANTNESS, FEAR, SADNESS

FOR EXAMPLE, HOW WOULD YOU RATE THIS SLIDE?

EXAMPLE 1

PLEASANTNESS

UNPLEASANT			NEITHER PLEASANT NOR UNPLEASANT			PLEASANT
0	1	2	3	4	5	6

FEAR

VERY RELAXED			NEITHER RELAXED NOR SCARED			VERY SCARED
0	1	2	3	4	5	6

SADNESS

VERY HAPPY			NEITHER HAPPY NOR SAD			VERY SAD
0	1	2	3	4	5	6

Appendix 1d: Affective Labelling Task Instructions

- Your goal is to win as much money as possible!
- You have a loan of £2000. Treat the money as though it was real!
- You can select a card from the top of any deck you like.
- For every card you choose, I will pay you some money.
- On some cards, you will have to pay me some money.
- You will find out how much you win or lose as we go along.
- The colour of the cards and the image above each deck are irrelevant.
- It is impossible for you to work out when you will win or lose money. Some decks are worse than others, but no matter how much you find yourself losing, you can still win if you stay away from the worst decks.
- You don't know when the game will end. Just keep playing until I tell you to stop.

Appendix 1e: Affective Labelling Gambling Task Scorecard

Number………………………………Date……………………………………..

……………-D +50	……………-C +50	……………-B +100	……………-A +100	Response Option
				1
				2
	-50Q		-150	3
				4
	-50Q		-300	5
				6
	-50Q		-200	7
				8
	-50Q	-1250	-250	9
-250	-50Q		-350	10
				1
	-25		-350	2
	-75			3
		-1250	-250	4
			-200	5
				6
	-25		-300	7
	-75		-150	8
				9
-250	-50Q			10
		-1250		1
			-300	2
				3
	-50Q		-350	4
	-25			5
	-50Q		-200	6
			-250	7
			-150	8
-250	-75			9
	-50Q			10
			-350	1
		-1250	-200	2
			-250	3
	-25			4
-250	-25			5
				6
	-75		-150	7
			-300	8
	-50Q			9
	-75			10

Appendix 2a: Face stimuli for Experiments 2 and 3

A-face database (McKimmie & Chalmers, 2002)	*NimStim (Tottenham et al., 2002).*
3-20021030124510-s1-2.jpg	22M_NE_C.BMP
3-20021030124809-s1-3.jpg	29M_NE_C.BMP
3-20021030130731-s1-9.jpg	36M_NE_C.BMP
3-20021030133337-s1-10.jpg	37M_NE_C.BMP
3-20021030133758-s1-11.jpg	38M_NE_C.BMP (Black)
3-20021030134834-s1-14.jpg	39M_NE_C.BMP (Black)
3-20021101112234-s2-23.jpg	40M_NE_C.BMP (Black)
3-20021121164232-48.jpg	41M_NE_C.BMP (Black)
3-20030205102523-73-113.jpg	42M_NE_C.BMP (Black)
3-20030205165931-83-123.jpg	43M_NE_C.BMP (Black)
3-20030206100448-85-125.jpg	

Appendix 2b: Example page for subjective ratings of faces

PARTICIPANT NUMBER : **SLIDE NUMBER:**

THIS SECTION OF THE EXPERIMENT REQUIRES YOU TO RATE EACH OF THE FOLLOWING PICTURES THAT YOU WILL SEE ON THE THREE SCALES PROVIDED, AS TO HOW THE SLIDE MAKES YOU FEEL, THE SCALES RANGE FROM 0 TO 6, THE THREE EMOTION SCALES ARE:

DISTINCTIVENESS, ATTRACTIVENESS, AND TRUSTWORTHINESS

FOR EXAMPLE – HOW WOULD YOU RATE THIS SLIDE:

EXAMPLE 1

DISTINCTIVENESS

VERY UNDINSTINCTIVE			AVERAGE			VERY DISTINCTIVE
0	1	2	3	4	5	6

ATTRACTIVENESS

VERY UNATTRACTIVE			AVERAGE			VERY ATTRACTIVE
0	1	2	3	4	5	6

TRUSTWORTHINESS

VERY UNTRUSTWORTHY			AVERAGE			VERY TRUSTWORTHY
0	1	2	3	4	5	6

Appendix 2c: Implicit Association Test stimuli

Name stimuli for the Black-White IAT

Black names	White names
Leroy	Peter
Theo	Robert
Jermaine	Ryan
Dwight	Simon
Jamel	Harry
Malik	Timothy

Attribute stimuli for Black-White IAT

Positive attributes	Negative attributes
Happy	Hatred
Honest	Evil
Peace	Poison
Friend	Filth
Cheer	Pollute
Laughter	Abuse

Appendix 2d: IGT subjective experience ratings sheet

Participant Number:____________

After 20 cards:
I would like you to give each deck of cards a score, based on how good or bad you feel they are so far. I want you to give each deck a score out of ten. That is, 10 if you think the deck is very good; 0 if you think the deck is very bad. Don't be afraid to use the whole scoring range.

Deck A:

0	1	2	3	4	5	6	7	8	9	10

Deck B:

0	1	2	3	4	5	6	7	8	9	10

Deck C:

0	1	2	3	4	5	6	7	8	9	10

Deck D:

0	1	2	3	4	5	6	7	8	9	10

Appendix 3a: Face stimuli for Experiments 4 and 5

A-face database
(McKimmie & Chalmers, 2002)

3-20021030124510-s1-2.jpg

3-20021030124809-s1-3.jpg

3-20021030130731-s1-9.jpg

3-20021030133337-s1-10.jpg

3-20021030133758-s1-11.jpg

3-20021030134834-s1-14.jpg

3-20021101112234-s2-23.jpg

3-20021121164232-48.jpg

3-20030205102523-73-113.jpg

3-20030205165931-83-123.jpg

3-20030206100448-85-125.jpg

NimStim
(Tottenham et al., 2002).

22M_NE_C.BMP

29M_NE_C.BMP

36M_NE_C.BMP

37M_NE_C.BMP

Appendix 4: Supplementary Analyses

Supplementary data 1: overall IGT deck preferences and their relationship with rating SCRs.

To assess overall Deck preferences, the total choices for each of the four decks over the 100 selections were calculated in three experiments (E1, E2, and E3). In both Experiments 1 and 2, SCRs collected from the participants during the stimuli rating phase were correlated with overall deck preferences. Additionally, the overall deck data for Experiment 3 is presented for comparison.

Experiment 1: Emotional bias on a task of affective decision-making

Analysis by Deck. To assess overall Deck preferences, the total choices for each of the four decks over the 100 selections were calculated (see Figure 34). The data indicated that participants preferred the good decks (C & D) over the bad decks in both the Control and Congruent conditions. However, in the Incongruent condition participants selected similar numbers of cards from each of the four options, and therefore showed no notable deck preference.

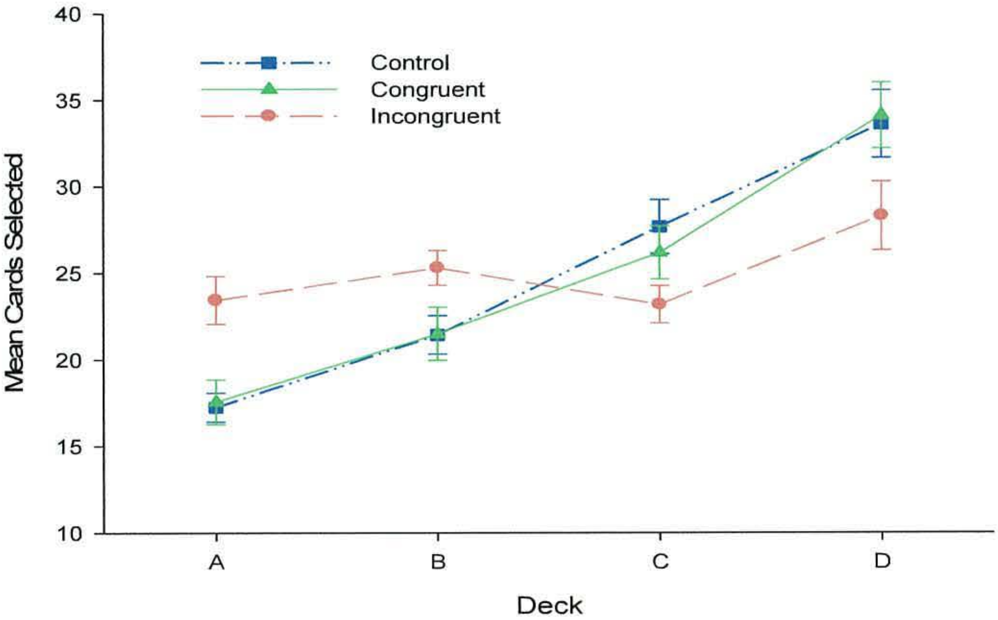

Figure 34. Mean total number of cards selected from each deck during emotional labeling IGT variant. The selection in the Incongruent condition showed less dissociation between good and bad than Congruent and Control. Error bars show SE of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; 3 levels) and dependent variable of Deck (4 levels) found a main effect of congruency, (Pillai's Trace = .438, F (8, 86) = 3.010, p = .005), and a significant between-subject difference for Decks A (F (2, 45) = 8.620, p = .001) and B (F (2, 45) = 3.226, p = .049), and borderline significance for Decks C (F (2, 45) = 2.646, p = .082) and D (F (2, 45) = 2.732, p = .076). Tukey's HSD Post-Hoc analyses demonstrated significant difference between Incongruent *vs.* Congruent (p < .003) and Incongruent *vs.* Control for Deck A (p = .002), and a borderline significant difference for Incongruent *vs.* Congruent for Decks B (p = .079) and C (p = .072); and for Incongruent *vs.* Control for Decks B (p = .085) and D (p = .099).

Relationship between stimuli SCR and Deck preferences.

Table 6. *Correlations (N =14) between Skin conductance responses and Overall selections from each deck in the Control condition*

Deck	SCR Unpleasant	SCR Pleasant
A	-.084	.096
B	-.141	-.120
C	.226	.128
D	-.080	-.092

Note. All correlations were *ps* > .438.

Table 7. *Correlations (N =12) between Skin conductance responses and Overall selections from each deck in the Congruent condition*

Deck	SCR Unpleasant	SCR Pleasant
A	.287	.198
B	-.167	-.154
C	-.151	-.097
D	.107	.152

Note. All correlations were *ps* > .365.

Table 8. *Correlations (N =14) between Skin conductance responses and Overall selections from each deck in the Incongruent condition*

Deck	SCR Unpleasant	SCR Pleasant
A	.506	.376
B	.178	.194
C	-.167	-.023
D	-.400	-.254

Note. Deck A unpleasant (p = .065), Deck D unpleasant (p = .156).

Experiment 2: The effect of racially salient labelling on IGT decision-making

Analysis by Deck. Overall Deck preferences were assessed by calculating the total choices for each of the four decks over the 100 selections (see Figure 35). The data indicated that participants preferred the good decks (C & D) over the bad decks in the Congruent condition. However, in the Incongruent condition participants appeared to avoid deck A, but selected similar numbers of cards from the other three options.

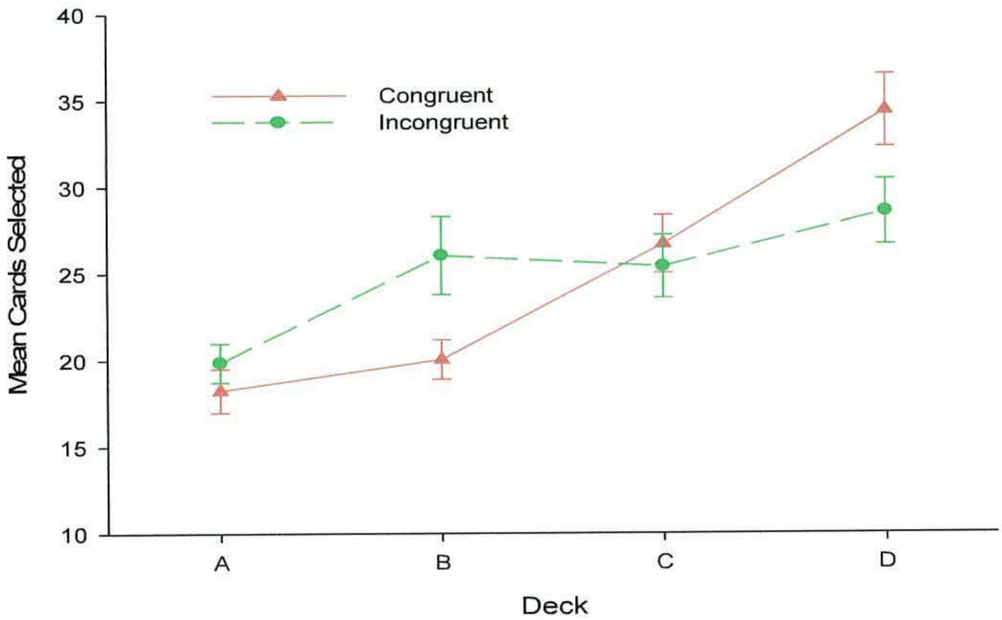

Figure 35. Mean total number of cards selected from each deck during the race labeling IGT variant. The selection in the Incongruent condition showed less dissociation between good and bad than Congruent and Control. Error bars show SE of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; Incongruent vs. Congruent) and dependent variable of Deck (4 levels) found a borderline main effect of congruency, (Pillai's Trace = .227, F (4, 35) = 2.572, p = .055), and a significant between-subject difference for Decks B (F (1, 38) = 5.653, p = .023) and D (F (1, 38) = 4.312, p = .045), and no significant effects for Decks A (F (1, 38) = .894, p = .350) and C (F (1, 38) = .277, p = .602).

Relationship between SCR and Deck preferences.

Table 9. *Correlations (N =18) between Skin conductance responses and Overall selections from each deck in the Congruent condition*

Deck	SCR Black Faces	SCR White Faces
A	.168	.069
B	.100	.039
C	-.006	.216
D	-.127	-.225

Note. All correlations were $p > .369$.

Table 10. *Correlations (N =19) between Skin conductance responses and Overall selections from each deck in the Incongruent condition*

Deck	SCR Black Faces	SCR White Faces
A	.017	-.077
B	-.189	-.140
C	.381	.317
D	-.176	-.111

Note. Deck C White ($p = .186$), Deck C Black ($p = .108$).

Analysis by Deck. To assess overall Deck preferences, the total choices for each of the four decks over the 100 selections were calculated (see Figure 36). The data indicated that participants preferred the good decks (C & D) over the bad decks in both the Control and Congruent conditions. However, in the Incongruent condition participants were somewhat deterred from deck A, but selected similar numbers of cards from the other three options.

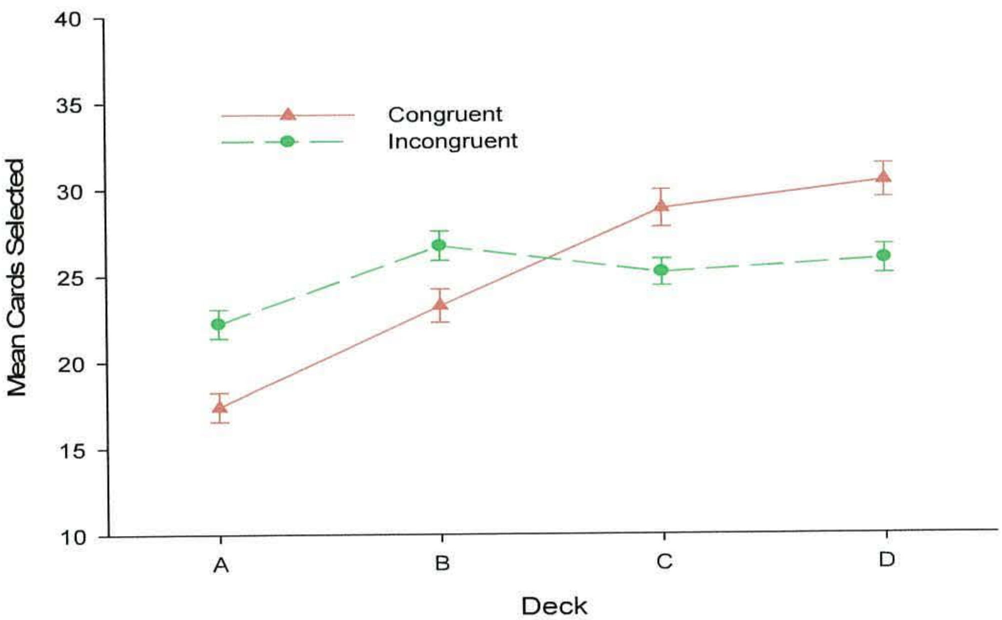

Figure 36. Mean total number of cards selected from each deck during the second race labeled variant experiment. The selection in the Incongruent condition showed less dissociation between good and bad than Congruent and Control. Error bars show SE of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; Incongruent vs. Congruent) and dependent variable of Deck (4 levels) found a significant main effect of congruency, (Pillai's Trace = .291, F (4, 51) = 5.234, p = .001), and a significant between-subject difference for Decks A (F (1, 54) = 16.652, p < .001), B (F (1, 54) = 7.218, p = .010), C (F (1, 54) = 7.872, p = .007), and D (F (1, 54) = 12.467, p = .001).

Discussion

This first set of supplementary data investigated overall deck preferences during a series of affective labelled IGTs, and in two experiments (E1 & E2) their relationship to SCR to the associated series of emotional stimuli. Firstly, it is worthwhile noting that across the three experiments, deck preferences were clearly altered by Incongruent emotional labelling. Thus, in each of the three experiments participants failed to substantially favour the good decks over the bad, although in both incongruent race variants participants did tend to avoid the high frequency punishment bad deck (Deck A). However, in Experiment 1 deck preferences in the Control and Congruent conditions were closely comparable. Indeed, overall deck choice in the Control condition of Experiment 1 appears similar to the Congruent data found in both race-based experiments (E2 & E3). This finding further bolsters the suggestion that Congruent labelling provided minimal enhancement of emotion-based learning (cf. Hinson et al., 2006).

The relationship between SCR and deck preferences was less clear. In the IAPS-based Experiment 1, arousal responses to the unpleasant stimuli did show a marginal association with selections from Decks A and D in the Incongruent condition. Thus, higher SCRs to unpleasant stimuli was somewhat related to more selections from Deck A, but less selections from Deck D. So participants who showed strong arousal responses to negative stimuli might have switched from a low reward and punishment frequency good deck (Deck D) to a higher reward and high punishment frequency bad deck (Deck A). However, there was no indication of any notable arousal influences in either the Congruent or Control conditions. Similarly, in the race-based Experiment 2 arousal responses to Black and White faces appeared to have some marginal positive (i.e., higher SCR, more selections) influence on selections from Deck C in the Incongruent condition, but there was no notable influences on performance in the Congruent condition. Thus, here, participants demonstrating higher arousal to face stimuli of either race favoured a low reward, high frequency punishment good deck. These data are difficult to interpret, and suggest that further investigation is required to determine their reliability and potential implications.

Supplementary data 2: Performance over Block 1 in the Affective labelling IGT.

To investigate how the association of emotional labels influenced decision-making during the early part of the IGT, the individual deck preferences for the first 20 card block from three experiments (E1, E2, and E3) is presented here.

Experiment 1: Emotional bias on a task of affective decision-making

The Block 1 data showed that participants in the incongruent condition were most affected by the biasing stimuli, with a greater dissociation between the good and bad decks (see Figure 37). Indeed, participants appeared much less likely to select cards from Deck C, preferring the positively labeled (and more rewarding) Decks A and B.

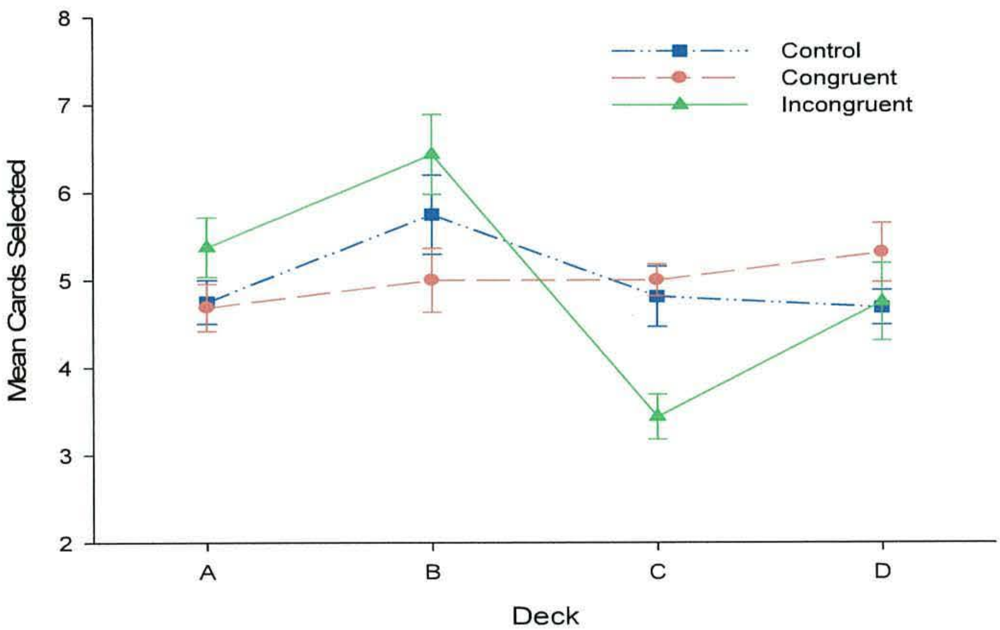

Figure 37. Mean number of cards selected from each deck during Block 1 of the emotional labeling IGT variant. The selection in the incongruent condition showed a greater dissociation between good and bad than congruent. Moreover, the shift between congruency conditions was towards the decks labeled with positive emotional labels. Error bars show SE of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; 3 levels) and dependent variable of Deck (4 levels) found a main effect of congruency, (Pillai's Trace = .371, $F(6, 88) = 3.345$, $p = .005$), and a significant between-subject difference for Deck C ($F(2, 45) = 10.006$, $p < .001$), borderline significance for Deck B ($F(2, 45) = 2.842$, $p = .069$), and non-significant effects for Decks A ($F(2, 45) = 1.729$, $p = .189$) and D ($F(2, 45) = 1.017$, $p = .370$). Tukey HSD Post-Hoc analyses demonstrated significant difference between Incongruent *vs.* Congruent ($p < .001$) and Incongruent *vs.* Control for Deck C ($p = .002$), and a borderline significant difference for Incongruent *vs.* Congruent (p = .055) for Deck B.

Experiment 2: The effect of racially salient labelling on IGT decision-making

The Block 1 data showed that participants in the incongruent condition were most affected by the biasing stimuli, with a greater dissociation between the good and bad decks (see Figure 38). Additionally, comparing between the congruency variants demonstrated greater selection *differences* (i.e., Congruent – Incongruent) in selection between the lower frequency punishment decks, B ($M = -1.2$, $SE = .80$) and D ($M = 1.1$, $SE = .52$), than the higher frequency punishment decks, A ($M = -.5$, $SE = .44$) and C ($M = .5$, $SE = .39$).

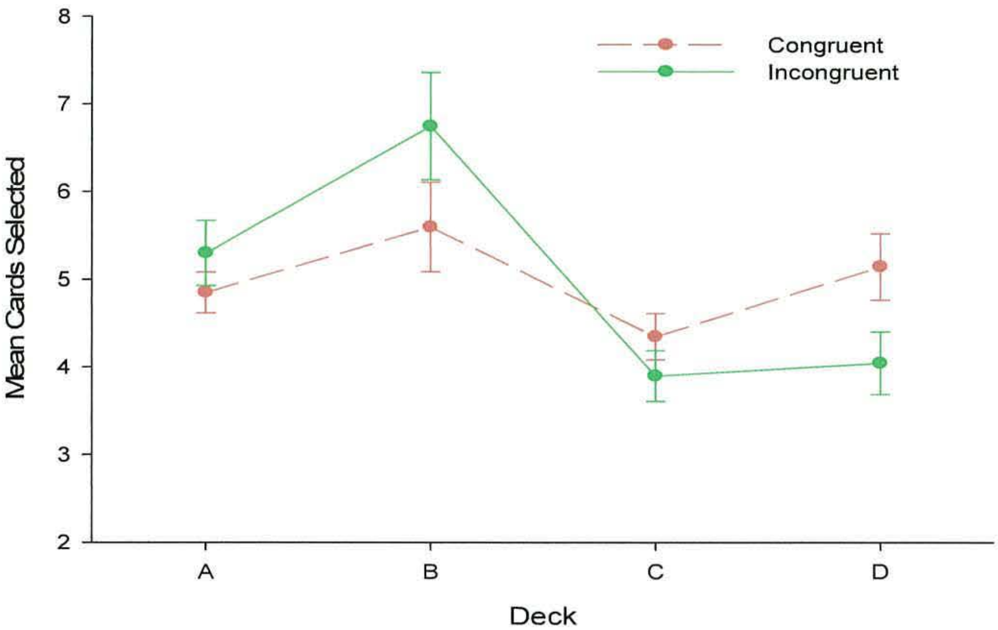

Figure 38. Mean number of cards selected from each deck during Block 1 of the race labeled IGT variant. The selection in the incongruent condition showed a greater dissociation between good and bad than congruent. Moreover, the shift between congruency conditions was towards the lower frequency punishment decks labeled with White faces. Error bars show *SE* of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; congruent *vs.* incongruent) and dependent variable of Deck (4 levels) found a marginal main effect of Congruency, (Pillai's Trace = .196, F (4, 35) = 2.133, p = .097), and a significant between-subject difference for Deck D (F (1, 38) = 4.433, p = .042), and non-significant effects for Decks A (F (1, 38) = 1.058, p = .310), B (F (1, 38) = 2.072, p = .158), and C (F (1, 38) = 1.319, p = .258).

Experiment 3: The effect of racially salient labelling on IGT decision-making II

The Block 1 data showed that participants in the incongruent condition were marginally most affected by the biasing stimuli, with a somewhat greater dissociation between the good and bad decks (see Figure 39). Comparing between the congruency variants demonstrated the greatest selection *differences* (i.e., Congruent – Incongruent) in selection between decks A (M = -.7, SE = .26) and D (M = .8, SE = .48), than decks B (M = -.3, SE = .61) and C (M = .1, SE = .37).

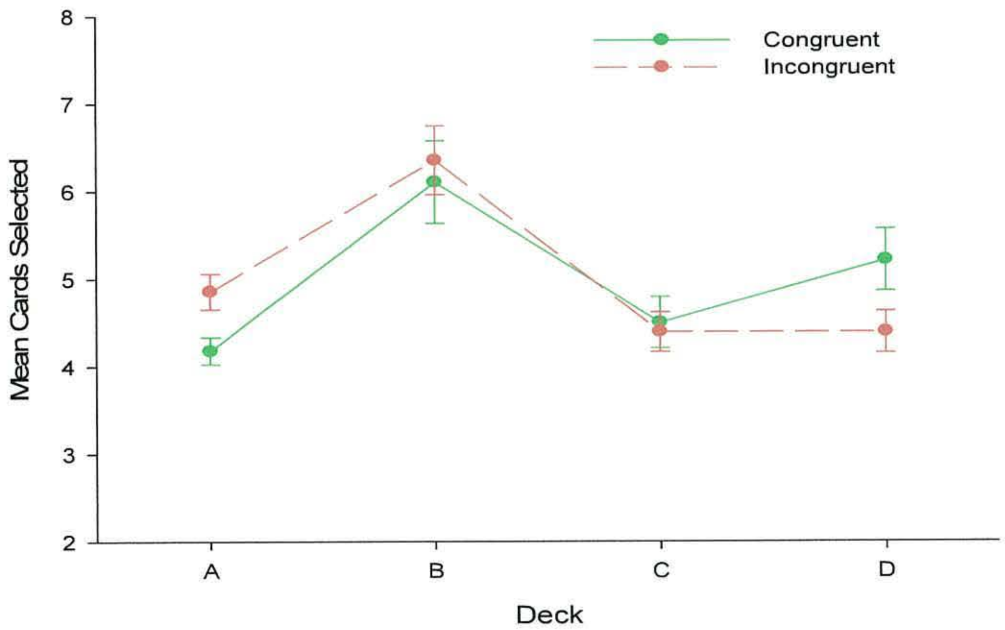

Figure 39. Mean number of cards selected from each deck during Block 1 of the second race IGT variant. The selection in the incongruent condition showed a somewhat greater dissociation between good and bad decks than congruent. Moreover, the differences between congruency conditions were most obvious between decks A and D. Error bars show *SE* of mean deck data.

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; congruent *vs.* incongruent) and dependent variable of Deck (4 levels) found a significant main effect of congruency, (Pillai's Trace = .157, F (3, 52) = 3.236, $p < .001$), and a significant difference for deck A (F (1, 54) = 7.027, $p = .011$), borderline for deck D (F (1, 54) = 3.713, $p = .059$), and non-significant for decks B (F (1, 54) = .166, $p = .686$) and C (F (1, 54) = .084, $p = .773$).

Discussion

In this second series of supplementary analyses the focus was the performance during the early part of the labeling IGT variants (Block 1). Across the three experiments (E1, E2, and E3) participants generally showed a greater dissociation in choices between good and bad decks in the Incongruent compared to the Congruent condition. Thus, in the Congruent condition participants were more likely to select cards from all the decks demonstrating less bias to the highly rewarding (but eventually punishing) decks than was found in the Incongruent condition. However, although present, this effect was less obvious in Experiment 3. A further observation was that participants did tend to favour Deck B in the majority of the experiments. This would certainly be the result of the late onset of the large low frequency punishment (-£1250) found in the classic IGT contingency for the high reward deck B. Indeed, according to the mean number of selections found in the first block data of all three experiments, few participants would experience the substantial penalty until at least Block 2. The presence of incongruent emotional labels appears to enhance the initial bias towards deck B, but also underpins a higher preference for deck A.

Supplementary data 3: Emotional labelling and outcome congruency

Along with congruency being manipulated by labelling the decks with stimuli that possess pre-existing emotional salience, another aspect of congruency within these variants of the IGT is related to hedonic outcome. Thus, the immediate financial feedback provided by each deck is often incongruent or congruent to the more stable deck emotional label. For example, under conditions of incongruency (i.e., emotional label conflicting with long-term deck valence) each individual deck trial provides short-term feedback which can either be congruent (e.g., win on positive label deck) or incongruent (e.g., lose on positive label deck). Therefore, this section of the supplementary data involves recoding the data so that the number of win and loss trials for each deck in two 10 card blocks (i.e., selections 1-20) can be compared between emotional labelling conditions.

Experiment 1: Emotional bias on a task of affective decision-making

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; congruent *vs.* incongruent) and dependent variable of outcome congruency (8 levels) found a significant main effect of Congruency, (Pillai's Trace = .478, F (7, 24) = 3.143, p = .017). For the first 10 card block, there were significant differences in outcome congruency for wins on Bad decks (F (1, 30) = 11.897, p = .002) and Good decks (F (1, 30) = 9.615, p = .004), but loss comparisons were non-significant (ps > .109). Thus, participants experienced significantly more wins in the Incongruent condition from the positively labeled decks A and B (M = 5.6, SD = 1.26) than they did when the same decks were negatively labeled in the Congruent condition (M = 4.1, SD = 1.08) decks. Similarly, in the Congruent condition participants experienced more wins from the positively labeled decks C and D (M = 4.8, SD = 1.06), than in the Incongruent condition when the same decks were negatively labeled (M = 3.5, SD = 1.21).

For the second 10 card block, there were significant differences between the losses on Good decks (F (1, 30) = 8.000, p = .008), but all other comparisons were not significant (ps > .184). Here, participants experienced more losses in the Congruent condition from the positively labeled decks C and D (M = 1.4, SD = .50), than in the Incongruent condition, where these decks were negatively labeled (M = 0.9, SD = .50).

Experiment 2: The effect of racially salient labelling on IGT decision-making

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; congruent *vs.* incongruent) and dependent variable of outcome congruency (8 levels) found no significant main effect of Congruency, (Pillai's Trace = .181, F (8, 31) = .855, p = .563). There were no significant effects in either the first 10 card (all ps > .187) or second 10 card (all ps > .207) blocks.

Experiment 3: The effect of racially salient labelling on IGT decision-making II

A Multivariate ANOVA with a fixed factor of Congruency (between-subjects; congruent *vs*. incongruent) and dependent variable of outcome congruency (8 levels) found no significant main effect of Congruency, (Pillai's Trace = .123, F (8, 47) = .823, p = .587). There were no significant effects in either the first 10 card (all *ps* > .429) or second 10 card (all *ps* > .174) blocks.

Discussion

The results from this series of analyses appears to somewhat bolster the findings discussed in the previous supplemental analysis. There, it was noted that the presence of incongruent labels appeared to underpin a bias towards more selections from deck B in particular. While the analyses of Experiment 2 and 3 were not notable, Experiment 1 did show that participants experienced more wins from decks A and B in the Incongruent condition (i.e., outcome congruent with label) compared to the congruent (outcome incongruent with label) in the first 10 cards. Whereas, participants in the Congruent condition tended to experience more wins from decks C and D (outcome congruent with label), compared to Incongruent (outcome incongruent). Further analyses showed that this effect was particularly due to wins on deck B in the Incongruent condition (Tukey's HSD; p = .010) and on deck C in the Congruent condition (p = .001). However, in absolute terms the effect was small, with participants in each condition experiencing the difference of approximately a single reward for decks B and C.

Supplementary data 4: Relationship between Stimuli Arousal differences and overall IGT performance

To examine the relationship between physiological responses to the emotional and social stimuli and performance on the Affective labelling variants of the IGT, the *differences* in participant's log normalised mean SCR responses to each set of stimuli (e.g., unpleasant/pleasant and Black/White) were correlated with overall IGT performance for all conditions in both experiments.

Experiment 1: Emotional bias on a task of affective decision-making

Overall, participants generally tended to show greater SCRs when exposed to negative stimuli compared to pleasant stimuli ($M = .103$, $SD = .149$). Pearson's Product-moment correlations showed no statistically significant relationship for the Control ($r = .281$, $N = 14$, $p = .330$), Congruent ($r = -.053$, $N = 12$, $p = .870$) and the Incongruent conditions ($r = -.384$, $N = 14$, $p = .176$).

Experiment 2: The effect of racially salient labelling on IGT decision-making

The differences in SCRs showed minimal differences between Black and White stimuli ($M = -.043$, $SD = .249$) across the participants. Pearson's Product-moment correlations showed no statistically significant relationships for both the congruent ($r = -.206$, $N = 18$ $p = .411$) and the incongruent conditions ($r = -.021$, $N = 19$, $p = .932$).

Discussion

In both Experiments no relationships were found to be significant. In one experiment which collected SCRs, however, there were suggestions of an influence from arousal differences between the categories of stimuli. Thus, in Experiment 1 the greater the difference between SCRs to negative and positive stimuli the worse was performance in the Incongruent condition. Whereas, in Experiment 2 there were no obvious signs of a relationship between differences in SCR to the two categories of facial stimuli (Black vs. White) and IGT performance.

For Experiment 1, the Incongruent condition showed the most notable relationship. Thus, participants who exhibited greater arousal to unpleasant compared to pleasant stimuli performed least effectively in the incongruent condition. This could be readily related to the findings presented in Chapter 3. Thus, higher Trait Anxiety was associated with better performance in the control IGT variant, but poorer performance in the emotional labelled conditions (Chapter 3, p. 96). This might suggest the participants were attracted to the positively labelled high reward decks when faced with the salient and arousing negative emotional labels. The lack of relationship in Experiment 2 is likely due to the weak arousal responses to either category of facial stimuli. However, as shown in

Supplementary data 1, the physiological responses to both categories were somewhat related to selections from deck C. Thus, a participant's overall 'emotional reactivity' (rather than category/valence SCR) might well influence performance on the IGT. Indeed, Northoff et al. (2006) demonstrated that activity in the ventromedial prefrontal cortex while making affective judgements of IAPS stimuli was related to overall IGT performance. This would indicate that the ability to effectively engage the VMPFC for general affective judgement is important for IGT decision-making. A further study with a larger sample would be required to clarify the potential relationship between SCR responses to emotional stimuli and deck preferences on the IGT.