EMOTION AND COGNITION IN THE IOWA GAMBLING TEST

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The purpose of this study was to investigate how personality and affect influence the results of the Iowa Gambling Test, and to discuss the implications for the somatic marker concept. Affect and personality, as measured by the PANAS and BIS/BAS scales, were correlated to Iowa Gambling Test results for fifty-seven volunteers. In contrast with previous studies, no significant correlations between Iowa Gambling Test performance and personality or affect dimensions were found. This could be due to the relatively low number of participants, or to the fact that the Iowa Gambling Test was web-based. Also, it is proposed that somatic markers are an integral part of an emotion-cognition system for decision-making, and that it is difficult to study decision-making without taking the whole system into account. This integrative view on emotion-cognition offers new perspectives on both the Iowa Gambling Test and decision-making in general.

Emotion is a fundamental part of human life. Without emotion, life would not only be bland and empty, human beings would also be deprived of the motivation to act (Lewis & Todd, 2005). Indeed, emotions can be seen as the driving force that propels mankind forward and enables people to work towards goals (Freeman, 2001). Yet, experts cannot agree on the definition of emotion (Izard, 2007). Different researchers use the term emotion in different ways, and there is a continuous debate on the nature and function of emotions.

A central problem for emotion theory is how emotion interacts with cognition. Emotion theorists often contrast emotion with appraisal, where the latter is referring to the cognitive interpretation of the situation in terms of its relevance for the individual (Lewis 2005). Lewis lists three main approaches to cognition-emotion relations taken by different emotion theorists: appraisal theory, functional emotion theory and personality emotion theory. The first of these, appraisal theory, posits that cognitions (or appraisal sets) precede and indeed cause an emotional response. Hence, appraisal theorists view the interaction between cognition and emotion as a top-down flow, where higher functional brain systems responsible for cognition influence the lower systems responsible for emotion. This point of view is supported by the observation that the relevance of the situation influences the emotional response. The top-down perspective is also prevalent in cognitive psychology, where cognitive representations are believed to have a strong influence on emotions (Derryberry & Tucker 2006). The second approach to cognition-emotion interaction, functional emotion theory, focuses on the effects that emotions have on cognitive functioning. In a sense, functional emotion theory is the opposite of appraisal theory, as it describes the bottom-up flow from emotion to cognition. Several lines of research support the idea that emotional states influence attention and other cognitive processes (e.g. Bower, 1992, in Lewis, 2005). For these theorists, the source of the emotion is less important than its effect on subsequent cognitive events (Lewis, 2005). A third approach to describing cognition-emotion relations is personality emotion theory, where different personality traits are seen as causes of emotional
biases. For example, the personality traits optimism and pessimism have been shown to increase the probability of eliciting certain emotions (Carver & Scheier, 1991, in Lewis, 2005).

Common to all these approaches are that they assume that there are simple, linear, cause-effect relations between cognition and emotion (Lewis, 2005). Taking together evidence from all these disciplines indicate, however, that many cognitive processes influence emotions and that emotions influence many cognitive processes. According to Lewis, this calls for complex, bidirectional causal relations between cognition and emotion. Acknowledging the importance of both cognition and emotion, Lewis states that the different constituents of cognition and emotion influence each other to form a unified cognition-emotion amalgam (as depicted in Figure 1). Further, Lewis points out that even developmental processes are based on bidirectional relations, suggesting that individual trait differences may result from emotional biases as well as cause them.

![Figure 1. Relations between cognition and emotion (adapted from Lewis (2005), p. 173).](image)

Yet, even with this flexible and very inclusive model a number of questions need to be clarified. How does the interaction of emotion and cognition affect people’s daily activities and pursuits? Are there certain situations where people rely more on cognition and other when they fall back on emotion? Is emotion more important to some people, and cognition to others? One way to study the interaction of emotion and cognition is to use the Iowa Gambling Test (Bechara, Damasio, Damasio & Anderson, 1994). This test was originally devised to study how emotions influence decision-making, but has later been used to study numerous aspects of the interaction between emotion and cognition (Hinson, Whitney, Holben & Wirick, 2006). In this study, the Iowa Gambling Test will be used to investigate the relation between emotion and cognition for different personality types.

What is the Iowa Gambling Test?

The Iowa Gambling Test was developed by Bechara, Damasio, Damasio and Anderson (1994) as a means to model decision-making in a realistic setting. The procedure was as follows: the subject was told that he or she was to perform a task where the objective was to maximize the revenue from drawing cards from four decks of cards in front of them. The subject was also told that some of the decks were better than others, and that they should try...
to stay away from the “bad” decks. The four decks of cards were in fact prepared so that two of them resulted in more good cards in average, and two of them resulted in more bad cards in average. As it turned out, normal subjects learned to discriminate between the “good” and the “bad” decks after some practice. In fact, it seemed as if the subjects were able to do this even before they became consciously aware of the difference between the decks. By measuring the skin conductance response of the subjects performing this game Bechara et al. (1999, in Bechara & Damasio, 2004) showed that normal subjects generated a skin conductance response when receiving a good or bad card. As they gained experience of the decks they generated anticipatory responses before actually seeing the card.

The explanation offered by Damasio (1999) was the so-called somatic marker theory. A somatic marker was defined as a change in body state that indicates the emotional consequence of a particular alternative. The idea was that instead of using the brain’s raw computational capacity to evaluate every possible action alternative, the brain focuses directly on the alternatives associated with a positive somatic marker and immediately discards those associated with a negative somatic marker. This mechanism was thought to be particularly important in personal and social situations, where the number of alternatives typically is large. The case for somatic markers was strengthened by the fact that patients with ventromedial (VM) prefrontal brain lesions – who behaved normally in most situations but irrationally in emotional situations – neither showed any learning in the Iowa Gambling Test nor displayed any anticipatory skin conductance responses. It was assumed that the behavior of this group of patients was due to their inability to form and use somatic markers (Damasio, 1999).

To develop a somatic marker, a connection between a stimulus and a somatic state needs to be established. According to Damasio (1999), most such connections (somatic markers) are established during childhood, but they can change throughout life. Although a large number of somatic markers are bound to be the same among people with a normal upbringing, Damasio have emphasized the importance of personal experience in the creation of somatic markers. For example, a traumatic event related to a dog may well result in a fear of dogs. Further, somatic markers have been thought to operate largely at an unconscious level (Damasio, 1999). Thus, somatic markers can be seen as the emotional memories that correspond to “gut feelings” or “hunches”. It was originally proposed that somatic markers would prevail in personal situations while conscious cognitive reasoning would be dominant in impersonal situations (Bechara, Damasio & Damasio 2000, in Hinson, Jameson & Whitney, 2002).

From a neuropsychological perspective, the prefrontal cortex is the most important area for the establishing and use of somatic markers (Bechara & Damasio, 2004). Especially the ventromedial (VM) part of the prefrontal cortex is considered important, with its many connections to different parts of the brain. Another important structure is the amygdala, which has a role in fast, non-conscious and emotional responses. When a stimulus associated with a somatic marker is encountered, the VM and amygdala signal to the brain stem, from where an actual somatic state is implemented in the body. This somatic state is then interpreted in the insula/somatosensory cortex. The interpretation of the body state (somatic marker) is fed back to the prefrontal cortex, where it can be taken into account in a decision-making process. In this way, the somatic state becomes a description of the feeling that the person, based on previous experience, associate with choosing a particular alternative. For a schematic view of the neural signalling, see Figure 2.
Two prerequisites were behind the early research on the Iowa Gambling Test. It was claimed that (1) the Iowa Gambling Test is too complex for participants to use explicit awareness and (2) it is possible for them to rely on emotion-based learning systems (somatic markers) instead (Turnbull, Berry & Bowman, 2003). While extensive evidence has been presented to support the latter of these prerequisites (Bechara, Damasio, Tranel & Anderson, 1998, in Turnbull, Berry & Bowman, 2003), some studies have come to the conclusion the former prerequisite is not fulfilled. For example, Maia and McClelland (2005) concluded that healthy participants are able to consciously discriminate between the decks in the Iowa Gambling Test much earlier than previously assumed. This could indicate that the decision-making in the Iowa Gambling Test to a large extent is based on conscious cognitive reasoning and not so much on emotion-based somatic markers.

To investigate in what way cognition and emotion interact in the Iowa Gambling Test, a number of researchers have studied how results on the Iowa Gambling Test are affected if the participants are asked to carry out a secondary task while performing the Iowa Gambling Test. In these studies, the underlying assumption was that if Iowa Gambling Test decisions are primarily based on unconscious emotional information (somatic markers) then the results should not be affected if the participants simultaneously perform a secondary task (Turnbull, Evans, Bunce, Carzolio & O’Connor, 2004).

Different studies have come to different conclusions regarding the effects of secondary tasks and the Iowa Gambling Test. Turnbull, Evans, Bunce, Carzolio and O’Connor (2004) conducted a study where the learning curves on the Iowa Gambling Test were compared for three different groups. The first group performed a secondary task known to consume executive resources (random number generation), the second group performed a secondary task known not to consume any executive resources (articulatory suppression), and the third group did not perform any secondary task. In this study, there was no significant difference between the three groups, although there was a marginal (non-significant) decrease in performance for both secondary task groups.

**Figure 2.** Somatic markers appear when the VM and/or amygdala signal to the brain stem (arrows 1a and 1b, respectively), the signals are sent to the body (arrow 2) and the implemented body state is interpreted in the insula/somatosensory cortex (arrows 3). Please note that this figure is highly simplified. To display the actual locations of the involved regions a sectioned brain image needs to be used (e.g. the VM is on the inside of the prefrontal cortex).

**Emotion and cognition in the Iowa Gambling Test**

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Hinson, Jameson and Whitney (2002) used a modified version of the Iowa Gambling Test to study the effects of secondary tasks. In their version of the Iowa Gambling Test there were more choices and less extreme payoffs, making it more difficult to rate the different decks. The secondary task that was used was to remember a string of five digits while performing the gambling task, a task that is known to load executive resources. The results showed that not only did the participants with the secondary task show poorer decision abilities, there was also a corresponding absence of anticipatory skin conductance response (indicating the absence of a somatic marker). Hinson, Jameson and Whitney (2002) conclude that somatic markers and working memory are interdependent systems, and that working memory seems to be necessary for developing somatic markers. In a follow-up study, Hinson, Jameson and Whitney (2004) examined different types of secondary tasks and concluded that only the executive attention component of working memory affect somatic markers.

Not only cognitive interference but also emotional biases have been studied in relation to the Iowa Gambling Test. Bechara and Damasio (2005) referred to preliminary results where the induction of strong emotional states (such as recall of personal emotional experiences) impairs the performance on the Iowa Gambling Test. Bechara and Damasio have also predicted that background feelings that are congruent with the somatic marker associated with an alternative work to strengthen the somatic reaction, while background feelings that are incongruent with the alternative’s somatic marker work to weaken the somatic reaction. Further, they have stated that the effect of such unrelated background feelings can be quite strong. For example, it is probably not a good idea to take an important decision when one is very tired or immediately after receiving disturbing news.

Hinson, Whitney, Holben and Wirick (2006) investigated this issue by studying how affectively valued words interfered with performance on their version of the Iowa Gambling Test (described above). Before each choice the participants were asked to hold an emotionally valenced word in memory. The researchers knew from previous investigations (Hinson, Jameson & Whitney 2004) that holding a single (neutral) word in a phonological buffer does not influence the results of the Iowa Gambling Test (as this does not load executive resources), but now the word was emotionally valenced. Would this interfere with somatic markers? There was indeed a strong impact on performance on the Iowa Gambling Test, but not in the way the researchers had expected. Instead of interference from both negative and positive load, they found that keeping a negative word in memory decreased performance while keeping a positive word increased it. The authors noted that there are general findings that working memory performance is enhances by positive emotion, but impaired by negative emotion. Their interpretation of the results was that decision-making is dependent on working memory. Also, they noted that somatic markers (skin conductance responses) only appeared some time into the test, after good performance had been achieved. In other words, the markers only appeared when the person had enough knowledge of the task to predict choice outcome. Hinson, Whitney, Holben and Wirick interpreted this as an indication that somatic markers merely are affective by-products of conscious knowledge, and not in themselves important to decision-making.

Evidence from these and other studies have led Bechara and Damasio (2005) to propose somatic markers interact with conscious reasoning. According to these researchers, somatic markers may develop and influence decision-making even when the participant has conscious knowledge of the test contingencies. Bechara and Damasio (2005) have also suggested that a strong somatic reaction increase the likelihood that the thought that triggered the reaction will
enter working memory. According to this point of view, conscious goal states (in working memory) sometimes arise from somatic markers and sometimes from cognitive reasoning.

Further, there may be numerous and often conflicting somatic states triggered at the same time (Bechara & Damasio, 2005). For example, a person may have the ambition to exercise every day but still feel too tired at the end of the day to actually do it. To select which somatic marker that will prevail, Bechara and Damasio (2005) suggest a survival of the fittest principle. According to this idea, the strength of a somatic state (positive or negative) triggered by a thought in working memory determines if the same thought will return to working memory. If the somatic marker associated with a certain thought is strong, the strong somatic reaction will increase the likelihood that the thought returns to working memory. Once back in working memory, the thought triggers a new strong somatic reaction that reinforces the previous one. In this way, strong somatic markers are reinforced and weak somatic markers are eliminated.

The notion that emotion and cognition interact in the Iowa Gambling Test is strengthened by recent neurobiological findings that indicate that there is no clear partitioning between the “affective” VM part of prefrontal cortex and the “reasoning” DL part of prefrontal cortex (including working memory) (Hinson, Whitney, Holben & Wirick, 2006). Several studies suggest that it is an oversimplification to consider decision-making to be divided into two separate pathways (one emotional and one reasoning), as was originally proposed by Bechara, Damasio and Damasio (2000, in Hinson, Jameson & Whitney, 2002). Indeed, Kane and Engle (2002) have suggested that attention and working memory are two aspects of the same phenomenmen. Hence, as attention is considered to be driven mainly by emotions (Lewis & Todd, 2005) it follows that working memory and emotions must be closely related.

**An integrative view on emotion and cognition**

Lewis (2005) takes the integration between emotion and cognition one step further when he suggests that emotion and cognition were never two separate systems at all. Instead of dividing an emotional experience into emotion and appraisal, Lewis proposes that it should be seen as a unitary experience where emotion and cognition interacts. Lewis bases his theory on a dynamic system framework, asserting that the brain is a distributed, non-linear system where new patterns and structures can arise though complex interaction of the different parts. According to this point of view, it is not possible to say that one event (e.g. emotion) invariably cause another (e.g. appraisal). Instead, all different brain systems involved in emotion and the cognitive evaluation of emotion influence each other until a stable mode of thinking, feeling and acting is reached. Lewis refers to this as an emotional-interpretation (EI) state, corresponding to the cognition-emotion amalgam in Figure 1.

But how does this stable mode of thinking, feeling and acting occur? Lewis (2005) has described two main mechanisms, self-organization and neuromodulator release. Self-organization is defined as "the spontaneous emergence of order from nonlinear interactions among the components of a complex dynamic system" (Lewis 2005, p. 173). In the human brain, this implies that new patterns and structures arise as responses to external and internal events. Patterns are, in this case, the tendency to synchronise the neural firing frequency among distant neural structures.

Knyazev (2007) has reviewed the evidence for brain oscillations as a means of cerebral integration, and concluded that different frequency rhythms are relevant for different
functional domains. For example, he asserts that delta oscillations (< 1Hz) depend on activity of motivational systems and theta oscillations (4-8 Hz) are involved in learning and emotion regulation. Paré and Collins (2000, in Lewis 2005) have shown that theta-band oscillations are present in the amygdala during emotional states only, and Paré et al (2002, in Lewis 2005) have suggested that amygdala and hippocampus (related to memory and context) activities become coupled at theta frequency in emotional circumstances. Lewis (2005) points in the same direction when he proposes that amygdala, hippocampus, anterior cingulate cortex, orbitofrontal cortex and sensory association areas (all important areas for emotion) may be synchronised at theta frequency when tasks or situations become emotionally relevant. If so, the level of theta band synchrony might be seen as an index of the emotional relevance of the task or situation.

A second mechanism of cognitive-emotional integration is neuromodulator release. According to Lewis (2005), EI states maintain the flow of neuromodulators (e.g. dopamine, acetylcholine) from the brain stem and basal forebrain, thereby enhancing/inhibiting synapses in all other regions of the brain. Neuromodulator release can be seen as a means to obtain phase synchronisation across distant brain regions. In particular, Lewis asserts that acetylcholine release is critical for generating theta-band oscillations across cortical and limbic structures. Lewis also couples theta-band synchrony with skin conductance response. The reasoning behind this assumption is that brain stem release of neuromodulators should induce both arousal (that is accurately measured by skin conductance response) and theta-band synchrony. Hence, one interpretation of the somatic marker hypothesis could be that somatic markers arise as a result of brain stem neuromodulator release (that work to integrate cognition and emotion through theta-band synchronisation). Further, Lewis suggests that this neuromodulator release (and corresponding theta-band synchronisation) in e.g. an anxiety-provoking situation might be stronger in individuals that have a strong anxiety trait.

To account for the fact that knowledge is sometimes pre-attentive and sometimes conscious, Lewis and Todd (2005) suggest that the different brain systems can be partly or completely synchronised. For example, when performing routine tasks there is no need for the prefrontal cortex to be consciously aware of every detail. A challenging task, however, results in a full-blown emotional episode where a large number of brain systems are synchronised. According to Lewis and Todd (2005), there are three different levels of EI synchronisation, each corresponding to a different degree of consciousness. At the first level, there is only background awareness of emotional feelings. These background feelings, mediated to the orbitofrontal cortex by the insula, are enough to perform the task at hand. Synchronisation has now coordinated activities from the brain stem up to the posterior cortex, but the prefrontal cortices are not yet involved. This has been hypothesised to result in a state that is focused on automated routines, with only small modifications to what has already been learned (Gabriel et al., 2002, in Lewis & Todd, 2005). At this stage the person may remain consciously aware of a previous EI, as the prefrontal cortices are not yet involved in the new EI. It is noteworthy that the insula has also been proposed as a key mediator of somatic markers (Damasio, 1999). In fact, Lewis’s background emotional information is very similar to Damasio’s somatic marker concept. Although there might be some minor differences between the two concepts, it is clear that both claim that unconscious emotional information contributes to decision-making.

While some tasks can be carried out with knowledge of background feeling only, more complex tasks require more brain systems to get on board. Notably, dorsal ACC (anterior cingulate cortex) often gets involved at this level (Lewis & Todd, 2005). The ACC is known
to be active in choosing between a number of competing alternatives, and in monitoring the results of the performed choices. This level of synchronisation is very action-oriented – the individual’s focus is on evaluating alternative actions and their anticipated consequences rather than on the goal itself. Indeed, the individual need not necessarily be aware of the goal or the emotions arising from it (Lewis & Todd, 2005).

At the final level of synchronisation, prefrontal activity is coordinated with both the limbic system and the brainstem (Lewis & Todd, 2005). At this stage, the individual is typically aware of the goal and the emotions arising from it. Attention to action (mediated by dorsal ACC) is integrated with attention to the emotional relevance of the situation (mediated by the ventral prefrontal cortex) and the emotional feelings themselves (mediated by the insula). In this way, action, cognition/appraisal and emotion are finally integrated. According to Lewis and Todd (2005), this final stage of synchronisation only occurs if the goal can not be achieved on the lower levels. For example, if one is trying to escape from a lion, fear and anxiety will rise until they cannot be ignored. In this case, the involvement of the prefrontal cortex may inhibit panic reactions (just run!) and facilitate taking conscious evaluation into account (where can I hide?). Further, Lewis and Todd emphasize that the ventral prefrontal cortex and the dorsal prefrontal cortex (working memory, response selection and planning) probably need to be synchronised to result in comprehensive awareness of emotional states.

In the Iowa Gambling Test, the subject gradually develops conscious knowledge about which decks that should be avoided. In the beginning of the test the subject will pick cards more or less randomly from the different decks. Then, there may be a period of time where the subject has a subconscious hunch about which decks to avoid. Finally, the subject will be aware of which decks that generate big losses and consciously stay away from those decks. In Lewis’s and Todd’s (2005) terminology, this would mean that only part of the neuroaxis is synchronised when relying on emotional information only while the whole neuroaxis is synchronised when conscious knowledge is achieved. At this state, emotional information (somatic markers) interacts with cognition.

**Influence of personality and affect on the Iowa Gambling Test**

It is well-known that personality differences are related to different tendencies for different types of emotions. For example, Canli et al. (2001) performed an fMRI study where healthy women were shown emotional stimuli. It turned out that brain response to positive stimuli was correlated with the personality trait extraversion and brain response to negative stimuli was correlated to the personality trait neuroticism.

As has already been discussed, Lewis (2005) has suggested that the same mechanisms (theta-band synchronisation) are behind personality development and cognition-emotion interaction. According to him, personality differences can be seen as different tendencies to activate certain neural patterns. This view has been supported by Izard (2007), who claim that frequently occurring emotion schemas (defined as the integration between emotion and cognition) constitute the motivational component of personality traits. This is consistent with Damasio (1999), who has stressed the importance of establishing a relevant set of somatic markers during childhood and indeed the rest of life.

In the Iowa Gambling Test, it seems likely that a person who is sensitive to punishment should develop a stronger somatic marker when loosing money on a particular deck in the Iowa Gambling Test. Hence, somatic marker theory predicts that different personalities
should perform differently on the Iowa Gambling Test. It could therefore be argued that the observation of such personality differences in performance on the Iowa Gambling Test could strengthen the case for somatic markers actually contributing to decision-making (and not appearing after the decision has been made).

Davis, Patte, Tweed and Curtis (2006) performed an Iowa Gambling Test study where impulsivity, sensitivity to reward and punishment, and addictive personality were measured. High scores on these personality measures all correlated with some kind of impairment in the Iowa Gambling Test. The personality measure that impaired performance most was, unexpectedly, sensitivity to punishment. Davis, Patte, Tweed and Curtis assumed that individuals with a high sensitivity to punishment would form strong somatic markers that would help them to stay away from bad decks, but this turned out not to be the case. One interpretation of these results is that individuals with high sensitivity to punishment could be more prone to test anxiety, which could impair their performance. Another interpretation is that sensitivity to punishment could be related to negative affect, which has been shown to impair performance on the Iowa Gambling Test (Hinson, Whitney, Holben & Wirick 2006, as described above).

Suhr and Tsanadis (2007) performed a study on healthy subjects to where they included the effects of both personality and affect on the Iowa Gambling Test. Personality (considered to be a relatively stable individual characteristic) was assessed by the Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS scale, Carver & White 1994) and affect (seen as the present state of mood) was estimated by the Positive Affect Negative Affect Schedule (PANAS, Watson, Clark & Tellegen 1988, in Suhr & Tsanidis 2007). The results showed that Iowa Gambling Test performance is independently negatively correlated with both negative affect and the BAS subscale Fun Seeking. Suhr and Tsanadis concluded that it is important to consider both affect and personality in Iowa Gambling Test studies.

The purpose of this study was to investigate whether or not personality and affect influence the result of the Iowa Gambling Test and to discuss the implications for the somatic marker concept. It was attempted to replicate the results of the Suhr and Tsanadis (2007) study using a web-based version of the Iowa Gambling Test. The reason for doing this was that it might shed some light on the question about whether decision making in the Iowa Gambling Test depend on emotional information (somatic markers), conscious cognitive evaluations, or both. If there is a performance difference between different personality types performing the Iowa Gambling Test, then at least part of the result of the test could be argued to depend on emotional information rather than cognitive evaluations.

M e t h o d

Subjects

68 participants completed the PANAS questionnaire, the Iowa Gambling Test and the BIS/BAS questionnaire. Of these, only the 57 persons that submitted complete questionnaires were considered. The participants were undergraduate psychology students, whose participation in the experiment was part of a course requirement. It was required that the participants had no previous knowledge of the Iowa Gambling Test and that they were proficient in understanding written English. 45 of the participants were female, 12 male. The mean age was 27.0 years (s = 9.7).
Instruments

Positive Affect and Negative Affect Scales (PANAS) (Watson, Clark & Tellegen, 1988) consists of 20 questions, of which 10 are relevant for positive affect and 10 for negative affect. Watson, Clark and Tellegen describe high positive affect as a state where a person feels enthusiastic, active and alert while low positive affect is characterized by sadness and lethargy. It should be noted that low positive affect is not the same as high negative affect. High negative affect is characterized by distress and unpleasurable engagement, while low negative affect involves serenity and calmness. The items measure to what extent the subjects agree with a statement (e.g. Right now I feel interested or Right now I feel distressed). A five-point answer scale is used, ranging from very slightly or not at all to extremely. The questionnaire was presented in English, but certain words and phrases were translated into Swedish.

Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS) (Carver & White, 1994) were used to assess personality. BIS has been thought to reflect sensitivity to punishment, often resulting in anxiety and withdrawal behavior, while BAS has been linked to reponse to reward and impulsive behavior. A number of studies (e.g. Carver & White, 1994) indicate that the BAS scale is not a unitary concept, as it can be divided into three subscales that are only moderately correlated with each other. The three BAS subscales Reward Responsiveness, Drive and Fun Seeking are thought to indicate a person’s response to different types of rewards. The BIS/BAS scales used was Carver and White’s (1994) 20 question format, where 7 questions reflect BIS, 5 Reward Responsiveness, 4 Drive and 4 Fun Seeking. It is noteworthy that Drive and particularly Fun Seeking are related to extraversion and novelty seeking/risk taking, while Reward Responsiveness is not. The items measure to what extent the subjects agree with a statement (e.g. If I think something unpleasant is going to happen I usually get pretty "worked up"(känslomässigt påverkad) or I worry about making mistakes). A four-point answer scale is used, ranging from strongly agree to strongly disagree. The questionnaire was presented in English, but certain words and phrases were translated into Swedish.

Procedure

The participants were recruited by a posted sign at a message board in the psychology department, as well as by a mass email to the introductory psychology course. As the experiment was web-based, the participants were free to perform the experiment at a time and place that was convenient to them. The results of the experiment were automatically submitted by email. The experiment was anonymous. The only identification of the records was an identity number (that the participants chose themselves). The participants were also asked to provide information about their age and sex. The importance of performing the test seriously was stressed, and there was a box to be ticked to indicate that the test was indeed performed seriously. The PANAS questionnaire was presented to the participants before the Iowa Gambling Test (Bechara, Damasio, Damasio & Anderson, 1994). The instructions for the gambling test were similar but not identical to those given by Bechara, Damasio, Damasio and Anderson (1994). The instructions are given in Appendix A. Further, to give the participants an idea of what they were aiming for, it was stated that 3000$ was a good result (the experiment starts with 2000$). The actual program was downloaded from http://users.fmg.uva.nl/rgrasman/jscript/2005/09/iowa-gambling-task.html). The BIS/BAS questionnaire was presented after the actual gambling test. Feedback on Iowa Gambling Test
performance, PANAS and BIS/BAS results were given on the screen after the test was completed.

Results

Descriptive statistics for the measured variables are given in Table 1. The spreading of the Iowa Gambling Test score was quite large (start value = 2000 $, skewness = -0.42, kurtosis = 0.13). Note that positive and negative affect ranged from 10 to 50, while BIS ranged from 7 to 28, Reward Responsiveness from 5 to 20 and Drive and Fun Seeking from 4 to 16 (depending on the scoring and number of questions).

Table 1: Mean values, standard deviations, maximum and minimum values for Iowa Gambling Test score, PANAS and BIS/BAS dimensions.

<table>
<thead>
<tr>
<th></th>
<th>Mean value</th>
<th>Standard dev.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa Gambling Test score</td>
<td>1926</td>
<td>936</td>
<td>3850</td>
<td>-500</td>
</tr>
<tr>
<td>Positive affect</td>
<td>24.2</td>
<td>7.3</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Negative affect</td>
<td>15.4</td>
<td>5.3</td>
<td>39</td>
<td>10</td>
</tr>
<tr>
<td>BIS</td>
<td>21.3</td>
<td>2.7</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>Reward Respons.</td>
<td>16.4</td>
<td>2.3</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Drive</td>
<td>10.8</td>
<td>2.0</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Fun seeking</td>
<td>10.6</td>
<td>2.2</td>
<td>16</td>
<td>5</td>
</tr>
</tbody>
</table>

Pearson correlation coefficients between Iowa Gambling Test performance, age, PANAS and BIS/BAS scales are displayed in Table 2. None of the correlations were significant on the 0.05 level (or, indeed, on any conceivable level).

Table 2: Correlations between Iowa Gambling Test performance, age, PANAS and BIS/BAS dimensions.

<table>
<thead>
<tr>
<th></th>
<th>Correlation coefficient</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.053</td>
<td>0.70</td>
</tr>
<tr>
<td>Positive affect</td>
<td>-0.10</td>
<td>0.44</td>
</tr>
<tr>
<td>Negative affect</td>
<td>-0.013</td>
<td>0.92</td>
</tr>
<tr>
<td>BIS</td>
<td>0.019</td>
<td>0.87</td>
</tr>
<tr>
<td>Reward Respons.</td>
<td>-0.001</td>
<td>0.99</td>
</tr>
<tr>
<td>Drive</td>
<td>-0.093</td>
<td>0.49</td>
</tr>
<tr>
<td>Fun seeking</td>
<td>-0.036</td>
<td>0.72</td>
</tr>
</tbody>
</table>
The purpose of this study was to investigate if personality influences the result of the Iowa Gambling Test after controlling for affect. It turned out that neither affect (as measured by the PANAS questionnaire) nor personality (as measured by the BIS/BAS questionnaire) correlated with Iowa Gambling Test performance.

Personality differences in the Iowa Gambling Test have been showed by others. In the Suhr and Tsanadis (2007) study, the largest factor contributing to Iowa Gambling Test result was negative affect, but the BAS subscale Fun Seeking also correlated significantly to the Iowa Gambling Test result (even after controlling for negative affect). Both negative affect and Fun Seeking were negatively correlated to Iowa Gambling Test result, indicating that a high level of negative affect as well as a high inclination for Fun Seeking impairs the results on the Iowa Gambling Test.

There are several possible reasons for the discrepancy between the current study and the Suhr and Tsanadis (2007) study. An obvious difference between the two studies was that Suhr and Tsanadis performed their experiment in a laboratory (on a computer but in a controlled setting), while the present study was completely web-based. The main objection against web-based tools is that the participants may not take the test as seriously if they perform it at home rather than in a laboratory. It may be that it is difficult for participants to remain focused on a test like this when performed at home in front of a computer. Another concern is that the participants may misunderstand the instructions if they are only given in written form and not by an instructor. This could be particularly troublesome if (as in this case) the experiment is performed in a language that is not the participants’ native language. The overall impression of the web-based tool used here was, however, that it was easy to use and that it was unlikely that the participants should have misunderstood the instructions. Also, all participants but one ticked the box that indicated that the test was performed seriously. Further, a goal result (3000$) was indicated to the participants, to keep them on their toes and make them try to achieve as good as possible even if the test was performed at home (or another relaxed environment). Hence, it seems unlikely that the fact that the experiment was web-based should have corrupted the results.

A further difference between the two studies was that in the present study affect was estimated immediately before the Iowa Gambling Test, and not 15 minutes before the test as in the Suhr and Tsanadis (2007) experiment (where the participants were required to perform tasks for a different experiment as well). This should, however, rather increase than decrease the correlation between Iowa Gambling Test result and affect.

A possible reason why the present study failed to achieve significance could be that the number of participants was too low. The Suhr and Tsanadis (2007) had 87 participants, while this study only had 57. Indeed, power calculations imply that to detect a correlation of -0.37 (the strongest correlation in the Suhr and Tsanadis study) the number of participants needs to be at least 57 ((power = 80%). Also, there is always the risk of making type I errors when calculating multiple correlations. According to mass significance, there is a 26.5% risk of at least one type I error when six correlations are calculated and their significance is tested at the 0.05 level.

It may be that other factors than affect and personality are more important contributors to Iowa Gambling Test results. For example, it has been claimed by Balodis, MacDonald and
Olmstead (2006) that the single most important predictor of Iowa Gambling Test result is whether or not the participant has encountered the Iowa Gambling Test before (this greatly enhances performance). The same researchers (2006) have also shown that the instructions given in the Iowa Gambling Test do influence the results. Possible sources of error could therefore be the instructions and the fact that some participants may have heard about the test before (even if we specifically asked for people who had not).

Another aspect that has been pointed out by Davis, Patte, Tweed and Curtis (2006) is that age may be an important predictor. According to these researchers, results may be misleading if all participants are of similar age. In particular, Davis, Patte, Tweed and Curtis claim that among late adolescents and young adults, the brain is in a state of transition which induces risky and reward-driven behavior. In this study, however, age was not an important predictor (no significant correlation with Iowa Gambling Test result).

A general observation is that it is difficult to interpret results from the Iowa Gambling Test. After reviewing a large number of studies using the Iowa Gambling Test, I have the impression that the conclusions often are contradictory and sometimes a bit arbitrary. Perhaps the key point is to discuss what the Iowa Gambling Test actually measures. A lot of researchers are interested in decision-making, and the Iowa Gambling Test is a test that is quite common and very easy to use. But what does it really say about decision-making? Decision-making seems to be a complex process where a large number of brain systems interact. I find it unlikely that decision-making (e.g. in the Iowa Gambling Test) depend solely on emotional information (somatic markers) or solely on conscious cognitive evaluation. If somatic markers actually contribute to decision-making or arise as an affective response when the person already has conscious knowledge of the outcome seems to be only part of the question. They may interact. And there may be a number of other factors influence decision-making as well. Anyhow, it seems improbable that a simple test as the Iowa Gambling Test could capture all aspects of such a complex process. This unclear mapping between the decision-making process and Iowa Gambling Test results opens for speculative interpretations of the results obtained. A risk with using such a test is that researchers may be tempted to interpret the results in a way that supports their own point of view in the debate about somatic markers vs. conscious cognition.

It is noteworthy that even the researchers who discard somatic markers as unimportant recognise that emotion influences cognition. Hence, the debate is not primarily between cognition and emotion but rather about how the emotional component of decision-making is mediated. One group of researchers claim that emotional influence is mediated by somatic markers, while others (e.g. Hinsen, Whitney, Holben & Wirick, 2006, see above) believe that the impact of emotional states is due to the fact that working memory functions better in a positive emotional state (and worse in a negative emotional state). Lewis and Todd (2005) provide a fresh way at looking at these issues with their notion of a partially or completely synchronised neuroaxis. It could be that the process where a participant develops more and more conscious knowledge of which decks to avoid could correspond to the synchronisation of more and more brain systems. This would mean that there is no synchronisation in the beginning of the Iowa Gambling Test (when the person has no knowledge at all), partial synchronisation when the person has some (sub-conscious) knowledge and complete synchronisation when the person is consciously aware of which decks to avoid. Further, it is conceivable that at the first level of synchronisation the somatic markers are so weak that they cannot be measured (or that there are none). As more systems get involved, it may be possible to measure somatic markers. This could be a continuous process, where the somatic marker
grows in strength as synchronisation gets more complete. This would mean that somatic markers are an integral part of cognition. Looking at decision-making in this way, somatic markers do indeed contribute to decision-making but not by themselves. They are an integral part of the emotion-cognition interaction, and it is not so important to distinguish between the different parts of this whole.

To conclude, the Iowa Gambling Test has been very useful in establishing the fact that emotional information is indeed involved in decision-making, but it may be too simple to capture all aspects of the decision-making process. My impression is that research trying to prove either the importance or non-importance of somatic markers is at the road’s end. To learn more about decision-making, a wider scope must be adopted. It has to be recognized that decision-making depend on the interaction of emotional and cognitive information, and that it is maybe not so important to consider in detail how the emotional information is mediated while the big picture is still unknown. In this way, the debate about somatic markers remind me of the story of two blind men trying to describe an elephant, one standing at the tail and one at the trunk. Their descriptions of the elephant (decision-making process) naturally differ substantially, yet are both true about part of the animal (process).

Further studies of decision-making should preferably include the development of new methods, that take into account both emotion and cognition aspects. This is by no means easy. One way to start out could be to accept Lewis’s (2005) assumption about synchrony between different brain systems being an important part of decision-making, and trying to measure this synchrony while the participants perform a decision-making task (e.g. the Iowa Gambling Test). According to Lewis (2005), such synchrony measurements could possibly be done by performing EEG measurements of theta band oscillations. These results could then be compared with skin conductance measurements performed during the decision-making task. By studying in detail how theta band synchrony and skin conductance response evolve during the task, it may be possible to learn more about in what way somatic markers are part of the emotion-cognition interaction that constitutes human decision making.

**References**


Appendix A

In this experiment, you'll be asked to repeatedly pick a card from one of four decks of cards (such as the ones displayed below).

Each time you select a card, the computer will tell you that you won some money. Sometimes the computer will tell you that you won some money as usual but that you lost some money as well.

The goal of the game is to win as much money as possible and lose as little money as possible. The trick is that some decks will be more profitable than others. Try to find out which deck(s) that are most profitable as you go along. You are absolutely free to switch from one deck to another as often as you want. The deck(s) that are favourable remain favourable throughout the experiment, and the deck(s) that are less favourable remain less favourable throughout the experiment.

You will get 100 opportunities to select a card from the deck that you think will give you the highest revenue. Your performance (current earnings) and your advance in the experiment will be displayed on screen.

You start with 2000 $. Click Start to start the experiment.