Update
TRENDS in Cognitive Sciences Vol.9 No.4 April 2005
Full text provided by www.sciencedirect.com

Research Focus

The Iowa Gambling Task and the somatic marker hypothesis: some questions and answers

A. Bechara, H. Damasio, D. Tranel and A.R. Damasio

Department of Neurology (Division of Cognitive Neuroscience), University of Iowa College of Medicine, Iowa, USA

A recent study by Maia and McClelland on participants' knowledge in the Iowa Gambling Task suggests a different interpretation for an experiment we reported in 1997. The authors use their results to question the evidence for the somatic marker hypothesis. Here we consider whether the authors' conclusions are justified.

Maia and McClelland [1] recently repeated part of our 1997 experiment [2] (in normal participants but not in patients) and without the skin conductance response component (see Box 1) in two conditions: one used precisely our method of questioning and replicated our results; another used more probing questioning and revealed that most participants have considerable knowledge of the situation. On this basis, and using selected supporting findings from the literature, they question the evidence for the somatic marker hypothesis (SMH). The significance of Maia and McClelland's study is twofold: first, it undermines traditional methods for identifyng implicit knowledge, that is, simply asking individuals to declare what they know about a given situation; second, it demonstrates yet again that even in normal participants, adequate knowledge of a situation does not guarantee correct decisions.

Maia and McClelland's study provides fascinating results relevant to any discussion of our 1997 findings (Box 1), but we do not believe they undermine the SMH. Maia and McClelland focus on the amount of conscious knowledge of the situation participants have, whereas the SMH focuses on the presence or absence of an emotion-related signal, conscious or not, independently of the conscious knowledge of the situation. For example, we have shown that patients whose knowledge of a situation is conscious and adequate can decide quite deficiently [3]. We hypothesize that they do so because an emotion-related signal, the SM (conscious or not) is missing. The central feature of the SMH is not that non-conscious biases accomplish decisions in the absence of conscious knowledge of a situation, but rather that emotion-related signals assist cognitive processes even when they are non-conscious.

It is not clear why a different interpretation for part of our 1997 study, which revolves around the amount of conscious knowledge of the situation available to the players, would undercut 'one of the main pillars of support' for the SMH. The main evidence for the SMH comes from neuropsychological studies of patients whose cognitive intelligence was largely intact but whose emotional reactions were impaired, and from experiments in which those patients failed to show emotional reactions to the implied content of social stimuli [4]. The development of the Iowa Gambling Task (IGT) offered further experimental support for the SMH, in ours [2] as well as in others' hands (e.g. [5–9]). However, the IGT was not the basis for the SMH, let alone was the SMH developed to account for the IGT results, as is surprisingly stated in an editorial following Maia and McClelland's report [10].

Reversal learning

Maia and McClelland suggest that the difficulties of patients with ventromedial prefrontal cortex (VMPC) damage in IGT performance can be explained by an inability to reverse a learned contingency that such patients sometimes exhibit [11]. Learning to reverse a contingency involves inhibition of a previously rewarded response and shifting to a newly rewarded response. Although some VMPC patients have problems with contingency reversal (e.g. those with posterior orbital lesions, as we [12,13] and others have noted [14]), this is not incompatible with the SMH because the difficulty is itself accounted for by the SMH. In order for contingency reversals to occur, a signal is required (a 'stop' signal); we have argued that such a signal is emotive, in other words, a somatic marker [15,16]. Moreover, the brain regions associated with reversal learning are the same as those associated with emotional processing, including the VMPC, as shown by Rolls [17]. In short, inhibiting the response is in itself a 'decision', albeit at a lower level of processing than the decisions carried out in the IGT.

The IGT contains elements of contingency-reversal learning, but at a more complicated level than other tasks used to investigate the phenomenon [18]. Patients who fail contingency-reversal decisions measured by simpler tasks are likely to fail the IGT; however, VMPC patients who perform well in those tasks or in probabilistic reversal learning [18], may or may not fail the IGT. It is of note that normal performance in the Wisconsin Card Sorting Task requires contingency-reversal learning and many VMPC patients perform excellently in this task [3,19].

A behaviorist account in terms of adaptation to contingency reversals does not explain why patients who conceptualize the IGT consciously fail to play advantageously. Besides, VMPC patients do switch away from the

Corresponding author: Bechara, A. (antoine-bechara@uiowa.edu).

Box 1. The somatic marker hypothesis and the Iowa Gambling Task

The somatic marker hypothesis (SMH) was developed to address the problems of decision-making encountered in patients with certain kinds of prefrontal damage and with compromised emotions.

> *'Somatic markers (SM) are a special instance of feelings generated from secondary emotions. Those emotions and feelings have been connected by learning to predicted future outcomes of certain scenarios. When a negative SM is juxtaposed to a particular future outcome the combination functions as an alarm bell. When a positive SM is juxtaposed instead, it becomes a beacon of incentive. This is the essence of the SMH…on occasion SMs may operate covertly (without coming to consciousness) and may utilize an 'as-if-loop'.* (Ref. [15], p. 174) (see also [16]).

The centrality of emotion to the SMH is evident from these and other texts, before and after, as is the notion that SMs are emotion-related signals, which are either conscious or unconscious. However, to be conscious of a SM is a very different issue from being conscious of the knowledge of facts, options, outcomes and strategies involved in deciding.

The Iowa Gambling Task (Figure I) was developed to assess and quantify the decision-making defects of neurological patients by simulating real-life decision in conditions of reward and punishment and of uncertainty, and to investigate the SMH further. The instrument is neutral with regard to the consciousness that participants might have of either SMs or the premises of the situation. We conducted an experiment [2] in which the task was interrupted by questioning regarding the conscious knowledge of the situation (but not that of SMs), in both normal subjects and patients. During the experiment skin conductance responses (SCRs) were monitored, both before and after decisions, as an index of SMs. All participants generated 'reward/punishment SCRs' after card selection. Normal participants began to trigger 'anticipatory SCRs' (occurring in the 5-s window before selecting a card) when they pondered risky decisions, and began to prefer the good decks before having adequate conscious knowledge of the situation. Patients with lesions in ventromedial prefrontal cortex (VMPC) failed to generate anticipatory SCRs, and played deficiently. Even after several of them realized which decks were bad, they still made the wrong choices (Figure II, opposite). Note that the process of pondering decisions, even during the pre-hunch period, is always a *conscious* process, whether knowledge about the task is absent (e.g. in pre-hunch) or available (e.g. in conceptual). However, the process leading to anticipatory SCRs is mostly *non-conscious*, although it might become *conscious* in the form of a 'gut feeling'. Non-conscious SCRs are triggered irrespective of the degree of knowledge available at the time of pondering a decision. We concluded that conscious knowledge of the situation alone is not sufficient for implementing advantageous decisions, and that its absence does not preclude them.

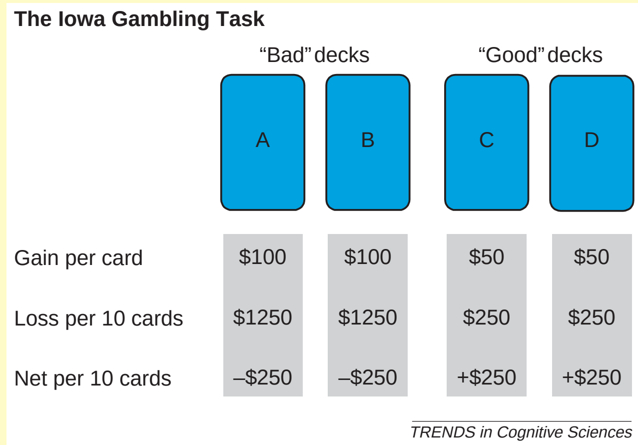


Figure I. A schematic diagram of the Iowa Gambling Task. The participants are given four decks of cards, a loan of $2000 facsimile US bills, and asked to play so as to win the most money. Turning each card carries an immediate reward ($100 in decks A and B and $50 in decks C and D). Unpredictably, however, the turning of some cards also carries a penalty (which is large in decks A and B and small in decks C and D). Playing mostly from decks A and B leads to an overall loss. Playing from decks C and D leads to an overall gain. The players cannot predict when a penalty will occur, nor calculate with precision the net gain or loss from each deck. They also do not know how many cards must be turned before the end of the game (the game in fact ends after 100 card selections).

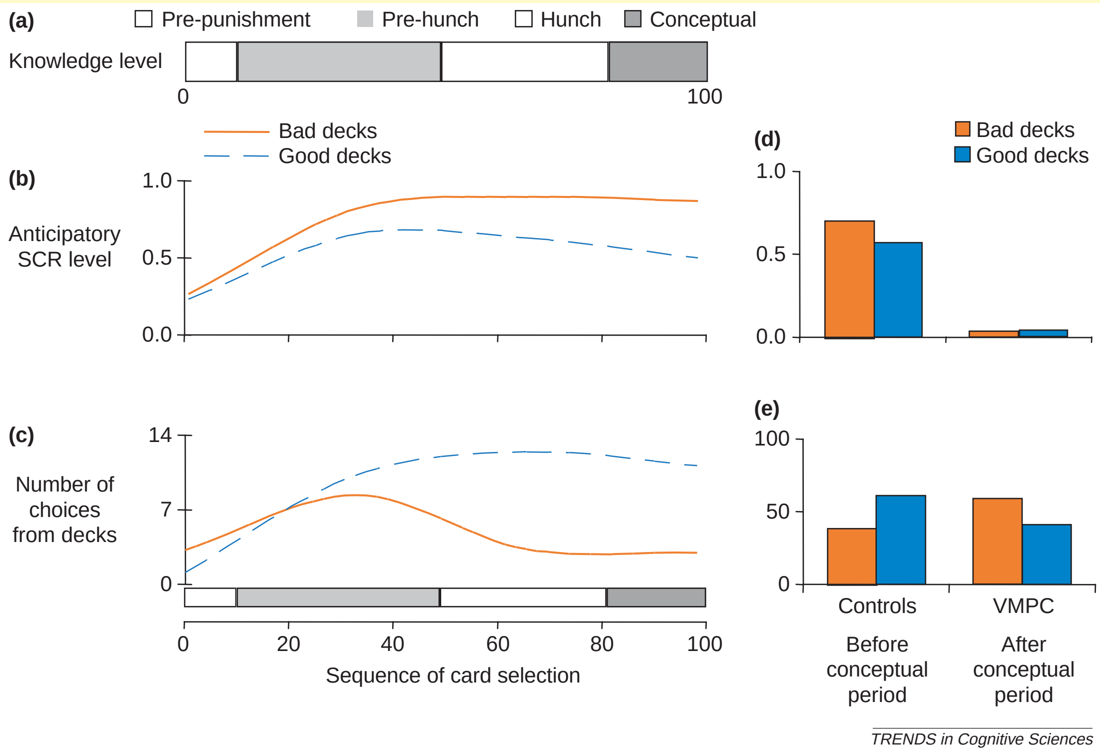
bad decks when they are faced with a loss, in the same way that normal participants do, although the patients return to those decks sooner and more often than normal participants. Stout analyzed the results of VMPC patients with an 'expectancy-valence' model [20,21], and concluded that their choices are guided by the most recent outcome rather than by outcomes of all past trials, showing that strategy reversal is a common immediate response by these patients.

Another issue raised by Maia and McClelland is that IGT impairments appear not only in VMPC patients but also in patients with dorsolateral prefrontal cortex (DLPC) lesions, so the impairments are therefore not specific to VMPC damage [14]. We entirely agree. DLPC patients have defects in working memory and other cognitive processes, which ought to impair IGT performance, albeit for different reasons. Fellows and Farah [14], and Manes and colleagues [22], have demonstrated this, as have we [23,24].

Knowledge of the situation does not guarantee advantageous decisions

Maia and McClelland state that the 'question of precisely why VMPC patients can report the changes in contingencies but perseverate in their behavior is a fascinating one that remains to be fully addressed.' The SMH addresses this question, by proposing that pure cognitive processes unassisted by emotional signals do not guarantee normal behavior in the face of adequate knowledge. Cognitive processing assisted by emotion-related marker signals, conscious or not, contributes to the proper action being taken. Again, the central issue is the relation to emotion and not the presence or absence of conscious knowledge of the situation.

The anticipatory skin conductance responses (SCRs) to the bad decks began to occur in our study at a point at which Maia and McClelland do not claim the presence of 'adequate knowledge', only 'minimal knowledge' or, in our terminology 'a hunch'. Maia and McClelland have attempted to dismiss the SCR evidence by suggesting that psychophysiological responses are caused by conscious knowledge of the situation. We disagree, based on the early appearance of anticipatory SCRs for the bad decks in the IGT, and on the time window in which the SCRs become manifest. How do Maia and McClelland explain the uniformly low anticipatory SCRs in the VMPC patients for both decks? If the patients knew what the correct response should be, and anticipatory SCRs are the result of such knowledge, why would they not produce SCRs? If an impairment in reversal learning were



Box 1, Figure II. **(a)** Levels of knowledge of the task, as normal participants made the 100 card selections in the Iowa Gambling Task (IGT). The average duration of each period is illustrated in relation to the sequence of card selection (1 to 100): the pre-hunch period began, *on average*, about the 10th card, the hunch period about the 50th card, and the conceptual period about the 80th card. The key finding of Maia and McClelland [1] is that the hunch period ('Level 1 knowledge' in their terminology) was evident at an earlier point than is shown here. **(b)** and **(c)** Normal participants (Controls) began to trigger anticipatory skin conductance responses (SCRs, shown in b), and prefer the good decks (preferences shown in c), at a time when they did not know which decks were good or bad (pre-hunch period in Bechara *et al.* [2] or Level 0 knowledge in Maia and McClelland [1]). The anticipatory SCRs were sustained, and the shift in behavioral preference for the good decks became more pronounced, as controls began to express minimal knowledge about the goodness or badness of some decks (hunch period or Level 1 knowledge). Most controls eventually reached a knowledge level in which they were confident of the goodness or badness of each deck (conceptual period or Level 2 knowledge). Anticipatory SCRs, and preference for the good decks, were maintained throughout that period. **(d)** and **(e)** Some controls did not reach the conceptual period, but generated anticipatory SCRs **(d)**, and made advantageous choices **(e)**. Several VMPC patients reached the conceptual period, just like controls, but those with adequate conceptual knowledge still failed to generate anticipatory SCRs **(d)**, and continued to choose disadvantageously **(e)**.

Box 2. Questions for future research

- As is the case for memory, there are several types of decision-making. To name but a few: (1) decisions under certainty (when the outcome is fairly certain); (2) decisions under uncertainty, which involve two sub-types: decisions involving risk (when the outcome is defined by some probability that it will occur), and decisions involving ambiguity (when the outcome is not known at all). Do such different types of decision engage the same or overlapping neural systems, or do different neural systems support different mechanisms of decisions?
- Although emotions can provide valuable explicit or implicit biases and contribute to making fast and advantageous decisions, they can sometimes exert a negative role, thus leading to bad decisions. Indeed, in certain tasks, VMPC patients deprived of normal emotional reactions actually make better decisions than normal individuals [15]. Depending on the circumstances, emotions can play useful as well as disruptive roles in the process of deciding. In which circumstances are emotions useful or disruptive?
- If decision-making is influenced by SM signals that arise in bioregulatory processes, including those that express themselves in emotions and feelings, what is the precise specification of these signals, and how or where do they exert their influence on cognition? One possibility is that some of the modulatory influence of SM on cognition is carried out through the release of neurotransmitters such as dopamine and serotonin. Future research should address the neurochemical substrates of decision-making.
- Gender differences are becoming increasingly difficult to ignore in studies of decision-making. What is the extent of these differences and which are the neural mechanisms behind them? What types of decisions give women an advantage over men, and vice versa?
- The most common approach to studying human decision-making has focused on component processes, such as learning of contingency reversals, working memory, and other executive functions. Although this approach has obvious merits, it has not lead to a satisfactory understanding of the decision impairments observed in some of our patients with VMPC lesions whose performance on such processes was intact. Our approach using complex laboratory tasks, such as the IGT, although succeeding in capturing crucial elements of decision-making that were missed by the component-process approach, does not allow for a finer resolution of the underlying processes. A third approach, that used by Stout, Busemeyer, Yechiam and their colleagues [20,21] provides a novel and intriguing way for circumventing this problem, by decomposing complex behavioral decisions into simpler elements. This approach could be adopted with advantage in future research.
- Finally, future research should also include animal models of decision-making and explore the process at basic neurobiological level.

invoked, should the patients not have even stronger SCRs when they would confront the conscious conflict between what they would like to do, and what their 'impulse' would force them to do?

In closing, Maia and McClelland state that their 'participants report knowledge of the advantageous strategy more reliably than they behave advantageously.' This important finding is in keeping with those of economists who have long recognized that decision-makers often deviate from rational choices, despite prior knowledge that could lead them in a different direction [25]. The SMH addresses the possible physiological processes, conscious or not, intervening between knowledge and behavior, between what one knows and what one does, and suggests that emotion plays a key role (see also Box 2).

References

1 Maia, T.V. and McClelland, J.L. (2004) A reexamination of the evidence for the somatic marker hypothesis: What participants really know in the Iowa gambling Task. *Proc. Natl. Acad. Sci. U. S. A.* 101, 16075–16080
2 Bechara, A. *et al*. (1997) Deciding advantageously before knowing the advantageous strategy. *Science* 275, 1293–1295
3 Saver, J.L. and Damasio, A.R. (1991) Preserved access and processing of social knowledge in a patient with acquired sociopathy due to ventromedial frontal damage. *Neuropsychologia* 29, 1241–1249
4 Damasio, A.R. *et al*. (1991) Somatic markers and the guidance of behavior: Theory and preliminary testing. In *Frontal Lobe Function and Dysfunction* (Levin, H.S. *et al*., eds), pp. 217–229, Oxford University Press
5 Bowman, C.H. *et al.* Artificial time-constraints on the Iowa Gambling Task: The effects on behavioral performance and subjective experience. *Brain Cogn.* (in press)
6 Evans, C.E.Y. *et al.* Subjective awareness on the Iowa Gambling Task: The key role of emotional experience in schizophrenia. *J. Clin. Exp. Neuropsychol.* (in press)
7 Cavedini, P. *et al*. (2002) Decision-making heterogeneity in obsessive-compulsive disorder: Ventromedial prefrontal cortex function predicts different treatment outcomes. *Neuropsychologia* 40, 205–211
8 van Honk, J. *et al*. (2002) Defective somatic markers in sub-clinical psychopathy. *Neuroreport* 13, 1025–1027
9 Jameson, T.L. *et al*. (2004) Components of working memory and somatic markers in decision making. *Psychon. Bull. Rev.* 11, 515–520
10 Sanfey, A. and Cohen, J. (2004) Is knowing always feeling? *Proc. Natl. Acad. Sci. U. S. A.* 101, 16709–16710
11 Fellows, L.K. and Farah, M.J. (2003) Ventromedial frontal cortex mediates affective shifting in humans: evidence from a reversal learning paradigm. *Brain* 126, 1830–1837
12 Bechara, A. (2003) Risky business: Emotion, decision-making and addiction. *J. Gambl. Stud.* 19, 23–51
13 Bechara, A. and Damasio, A. The somatic marker hypothesis: a neural theory of economic decision. *Games Econ. Behav.* (in press)
14 Fellows, L.K. and Farah, M.J. Different underlying impairments in decision making following ventromedial and dorsolateral frontal lobe damage in humans. *Cereb. Cortex* (in press)
15 Damasio, A.R. (1994) *Descartes' Error: Emotion, Reason, and the Human Brain*, Putnam
16 Damasio, A.R. (1996) The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 351, 1413–1420
17 Rolls, E.T. (1999) *The Brain and Emotion*, Oxford University Press
18 Clark, L. *et al*. (2004) The neuropsychology of ventral prefrontal cortex: decision-making and reversal learning. *Brain Cogn.* 55, 41–53
19 Anderson, S.W. *et al*. (1991) Wisconsin card sorting test performance as a measure of frontal lobe damage. *J. Clin. Exp. Neuropsychol.* 3, 909–922
20 Busemeyer, J.R. and Stout, J.C. (2002) A contribution of cognitive decision models to clinical assessment: decomposing performance on the Bechara gambling task. *Psychol. Assess.* 14, 253–262
21 Stout, J. *et al*. (2002) Cognitive modeling of decision making in a simulated gambling task in frontal or somatosensory cortex damage. *J. Cogn. Neurosci.* C27(Suppl.), 75
22 Manes, F. *et al*. (2002) Decision-making processes following damage to the prefrontal cortex. *Brain* 125, 624–639
23 Bechara, A. *et al*. (1998) Dissociation of working memory from decision making within the human prefrontal cortex. *J. Neurosci.* 18, 428–437
24 Bechara, A. *et al*. (2000) Emotion, decision-making, and the orbitofrontal cortex. *Cereb. Cortex* 10, 295–307
25 Loewenstein, G.F. *et al*. (2001) Risk as feelings. *Psychol. Bull.* 127, 267–286

doi:10.1016/j.tics.2005.02.002

Research Focus Response

The somatic marker hypothesis: still many questions but no answers

Response to Bechara et al.

Tiago V. Maia[1] and James L. McClelland[1,2]

[1]Department of Psychology, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, Pennsylvania 15213, USA
[2]Center for the Neural Basis of Cognition, Carnegie Mellon University, 115 Mellon Institute, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213, USA

In the short space we have to reply to Bechara, Damasio, Tranel and Damasio [1] we will focus on three issues. First, we review important problems with their interpretations of our study. Second, we address the deficits of ventromedial prefrontal cortex (VMPFC) patients, as work with these patients played a major role in the development of the somatic marker hypothesis (SMH). We end by discussing the current status of the SMH.

Problems with Bechara *et al.*'s interpretation of our study

In our study [2], we found that participants report knowledge of the advantageous strategy more reliably than they *behave* advantageously. Bechara *et al*. state that

Corresponding author: Maia, T.V. (tmaia@cmu.edu).