Revista Latinoamericana de Estudios sobre Cuerpos, Emociones y Sociedad.
N°20. Año 8. Abril 2016-Julio 2016. Argentina. ISSN 1852-8759. pp. 87-97.

Embodied Feeling and Reason in Decision-Making: Assessing the Somatic-Marker Hypothesis*

Sentimientos y razón corporeizados en la toma de decisiones:
evaluando la hipótesis de los marcadores somáticos

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Abstract
Whether or not reason and affect are complementary depends on the task at hand. In ordinary circumstances, problem-solving and decision-making involve both somatic feelings and limbic-structure-based emotions. Feelings, experienced as states of the body, can contribute to decision-making by triggering heuristic cues and rapidly eliminating negative behavioral alternatives, in part by providing what Damasio call somatic markers (Damasio, Tranel and Damasio, 1991; Damasio, 1994, 1999, 2003). However, if task-performance is motivated by potentially large rewards, with high demands on short-term memory and on concentration, the dorsolateral prefrontal cortex can inhibit affects manifested in the medial prefrontal cortex in order to carry out the necessary cognitive operations. We interpret these two different mental task situations using dual process models. Although experimental evidence from studies of normal subjects and frontal-lobe-damaged patients performing the Iowa Gambling Task has been interpreted as supportive of the somatic-marker hypothesis (SMH), we show that this evidence has been called into question due to faulty study designs. However, studies of normal and psychopathic subjects playing the ultimatum game show that pulse-rate deceleration occurring during the brief period preceding decision-making constitutes a somatic marker. Compared to normal controls, psychopaths show less somatic (electro dermal) activity and act with cool, economic rationality, accepting unfair (<50/50) offers that normal subjects reject on the basis of non-economic values of fairness. The somatic-marker hypothesis is discussed and criticized, and various theories based on this hypothesis are identified.
Keywords: Brain; Emotions; Somatic markers; Decision-making; Dual-process models.

Resumen
Ciertamente, razón y afecto son complementarios dependiendo de la tarea a realizar. En circunstancias ordinarias, la resolución de problemas y la toma de decisiones abarca no solo sentimientos somáticos sino también emociones que se fundan en el sistema límbico. Los sentimientos vividos como estados del cuerpo, pueden contribuir en la toma de decisiones abriendo pistas heurísticas y eliminando rápidamente opciones de conducta negativas, en parte, por lo que denomina Damasio como Marcadores Somáticos (Damasio, Tranel and Damasio, 1991; Damasio, 1994, 1999, 2003). Sin embargo, si la tarea es motivada por una potencial recompensa, con altas exigencias para la memoria a corto plazo y la concentración, la corteza prefrontal dorsolateral puede inhibir los afectos manifestados en la corteza prefrontal media en pos de lograr las operaciones cognitivas necesarias. Interpretamos estas dos tareas mentales utilizando modelos de procesos duales. Aunque la evidencia experimental proveniente de estudios sobre sujetos normales y pacientes con el lóbulo frontal dañado dieron lugar al Iowa Gambling Task, dicha evidencia ha sido interpretada como soporte de las hipótesis sobre marcadores somáticos (HMS). Aquí mostramos que dicha evidencia ha sido puesta en cuestión debido a defectos en el diseño de los estudios. Sin embargo los estudios sobre sujetos normales y psicopáticos que practican el juego del ultimátum muestran que la desaceleración del pulso se da en el momento antes de tomar una decisión, constituyendo un marcador somático. En comparación con controles normales, los psicópatas exhiben menos actividad somática (electro-dérmica) y actúan con indiferencia, racionalidad económica, aceptando ofertas injustas (<50/50) que sujetos normales rechazarían en tanto valores anti económicos. La hipótesis de los marcadores somáticos son discutidas y criticadas a la vez que varias teorías basadas en esta hipótesis son identificadas.
Palabras clave: Cerebro; Emociones; Marcadores somáticos; Toma de decisiones; Modelos de procesos duales.

* Portions of an earlier version of this paper were previously published in TenHouten (2013:125–31), and are included here with the permission of Taylor & Francis Group.
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Introduction

Philosophers and social theorists have long debated how feelings, emotions and related affective phenomena interact with rationality, reason and cognition. Only within the last few decades have scientists begun to investigate this seemingly intractable problem. Never a purely cognitive process, reasoning typically occurs within the context of social relationships, which can be competitive, self-interested, and market-oriented, or collegial, cooperative, and egalitarian. These social relationships and the emotions they engender can surely diminish rationality, by predisposing one to misattribute causes, distort beliefs, lose cognitive focus, or become either overly risk-averse or risk-oriented (Slovic, 2000; Pham, 2007). On the other hand, under most circumstances (where lack of information and lack of time render logical-analytic reasoning impossible), the quality of decision-making will be enhanced by feelings and signals from the body and emotions from the brain (TenHouten, 2013b).

Because emotionshave the capacity to impair cognition, under certain circumstances the brain sometimes needs to, and does, set emotions aside. Longe, Senior and Rippon (2009), as one example, conducted an fMRI study of 10 healthy subjects who had been highly motivated for successful task performance (i) where there are potentially significant financial payoffs, and (ii) heavy demands are placed on short-term memory. Under these circumstances, subjects' lateral frontal cortex — which performs hard, high-reason tasks that place heavy demands on short-term memory — inhibits and suppresses activity in the medial prefrontal cortical areas, and thereby reduces distracting emotion-laden messages. In this experiment, the *dorsolateral* frontal cortex (DLPFC) communicated or interfaced with the ventral frontal cortex (VMPFC, the portion of the frontal lobes located above the eye sockets), but not with the *medial* frontal cortex. These two areas of the frontal lobes — the DLPFC and VMPFC — are strongly connected. The VMPFC is linked to reward sensitivity and is involved in conation (motivation). This and other fMRI studies (e.g., Pochon *et al,* 2002) of humans found that, if reward levels and cognitive demands are set at high levels, activation of the lateral frontal areas (DLPFC) and of the lateral frontopolar regions ensues. At the same time, there is decreased activation in the frontal lobes' medial regions. These and other experimental results suggest an inhibitory relationship between the lateral and the medial portions of the frontal lobes of the human brain, with the lateral areas inhibiting the medial areas. Under certain circumstances, therefore, where substantial rewardsfor cognitive performance are anticipated, performance is optimized if cognition can operate freely of feelings and emotions.

In the everyday world, in contrast, beyond such unusual or contrived situations — where mental life seeks not optimizing but satisficing decision-making — this is not typically the case. Indeed, problem-solving and decision-making typically rely on feelings, emotions and simple heuristics (Gigerenzer *et al.,* 1999; Berthoz, 2006; Ohira, 2010), Evans (1989, 1998), Damasio (1994, 1999), and Anderson, Bechara, Damasio, Tranel and Damasio (1999) have persuasively championed the view that *good use* of reason depends on emotions and feelings, while Pott (1992) even sees emotions as specific forms of rationality. These and many other scholars have adduced impressive evidence showing that, under ordinary circumstances, both feelings and emotions assist reasoning, particularly in personal and social matters involving conflict and risk, and especially where information is lacking and in-depth cognitive analysis would be time-consuming and arduous.

Our focus here, however, is on the role of feelings, rather than emotions, as these feelings are involved in decision-making. The word *feeling* refers to

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the physical sensation of touch, but also connotes all conscious experiences of inner bodily states, including the experience of physical drive states, such as hunger, pain, and fatigue, sentiments, and desires. Thus, a person might have a warm feeling toward another, a feeling of unease in a social situation, a feeling that one might be falling in love, or that one's presence at a social event is unwelcome. Feelings and emotions are often conflated in everyday discourse (Arieti, 1970). Feelings are often described as emotions, as in saying, "I feel angry/jealous/happy", while emotions, in turn, are often defined in terms of feelings. In psychology, feelings refer to a person's conscious state of mind, including their evaluation of what is agreeable and disagreeable, or pleasant or painful, as experienced by the body. Feelings reflect emotions and their perturbing effects on the body, but they are also influenced by the brain's mappings of the state of the muscles, the posture and orientation of the body, and the states of the circulatory, respiratory, digestive, and nervous systems. All of these are mapped in the body-sensing region of the brain. A feeling, in its essence, then, is a mind-state expressing an idea of the body. Thus, while the object of an emotion is apt to be external —typically involving other persons with whom one is socially engaged— the *object* of a feeling is internal, for it is of the body (Damasio, 2003). Bodily feeling-states, which Damasio (1994) calls *somatic markers*, can contribute to rapid and effective decision-making, especially in risky and uncertain conditions in which a cognitive analysis would require a great deal of time and energy to carry out. A fully rational decision-making process requires formulating behavioral options, performing a cost–benefit analysis, then choosing a promising option. If a decision must be made quickly, and without much information, reactions of the body can provide important signals that assist decision-making. These bodily signals, or somatic markers, encompass affective events spanning excitement or depression, visceral activity (*gut feelings*), feelings of arousal, muscular tension, pulse-rate change, sudden sweating, a queasy feeling, a tingling sense of possible danger, a gnawing suspicion, a feeling of being refreshed, a sense of foreboding, or a feeling of anticipatory excitement. These bodily signals are *somatic markers*. The concept of somatic markers is this article's main topic, but we first further distinguish reason and affect by considering dual-process models.

Economic Behavior and Dual-Process Models

In psychology, dual process models explain how mental phenomena result from two qualitatively different processes; one is fast, automatic, and affect-laden, the other is slow, deliberate, and largely cognitive. Kahneman and Tversky (1979) and Kahneman (2011; see also Epstein, 1994; Sun, 2002; and Paivio, 2007) recognize two such styles of mental processing. System 1 is a largely intuitive, associative, fast, and automatic, affect-laden process that favors immediate rewards, and is equipped with a nuanced picture of the world. It is based on retained memory, learned patterns of association, and works with the information it presently possesses, which enables it to generate reactions, opinions, and snap judgments, often based on mere association and narrative coherence. System 2 is the conscious, thinking, mind which we think of as the *decider*, and *reasoner*. This is a slower and more deliberate logic-based process, subject to conscious judgment and control. Itis typically utilized to choose longer-term options, and involves great mental effort and will-power in the pursuit of problem-solving and goal-attainment. This kind of reasoning requires an ability to defer gratification during goal-attainment processes, an ability that can be compromised when passions and cognized interests conflict. It is when there is an inner tension between desires and goals that Systems 1 and 2 are most apt to come into conflict. An active mind, Kahneman (2011) maintains, must be able to make use of System 2, which predicts success in decision-making and goal-attainment.

The existence of these two mental systems, the feeling-, passion-, and emotion-based system (System 1), and the cognitively-based system (System 2), has been at least partially criterion validated by McClure, Laibson, Loewenstein and Cohen (2004), in an fMRI study of 14 subjects. The study hypothesized that the System 1's brain infrastructure consists of limbic structures, which respond emotionally to immediate rewards but are relatively insensitive to future rewards. In contrast, long-run patience, a capability of System 2, was hypothesized to be mediated by the future-oriented lateral prefrontal cortex and related structures; these can evaluate the utilities of possible distant-future rewards. McClure and colleagues found that, for choices in which money was immediately available (as opposed to being available after a two-week or one-month delay), System 1 areas were significantly activated, specifically the ventral striatum, the medial-

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orbitofrontal cortex (which processes emotion), the posterior cingulate cortex, and the left posterior hippocampus. These areas are limbic structures or closely associated paralimbic cortical projections; these are heavily innervated by midbrain dopamine sources, and are consequently responsive to reward expectations (Knutson, Fong, Adams, Varner and Hommer, 2001; McClure *et al.*, 2004). The contrasting System 2 areas, activated uniformly during all decision epochs, were associated with lateral prefrontal areas. These are usually implicated in higher-level cognitive deliberations, cognitive control, numerical cognition, and value assessment. In this experiment, they were activated by quantitative analysis of economic options and valuation of future opportunities for reward (see also Miller and Cohen, 2001). The lateral prefrontal cortex, which assesses reward values, irrespective of their delay, was similarly activated during all choice conditions. This and related studies (e.g., McCoy and Platt, 2005) provide neuroscientific evidence for this proposed duality of cortical processing. Under certain conditions, this processing involves a negotiation between areas of the brain that generate emotions and areas that generate the higher cognitive functions necessary for instrumental, future-oriented planning for goal-attainment.

Other studies show interactions between prefrontal and limbic mechanisms in various behavioral contexts, ranging from economic and moral decision-making, to visceral responses, to pain and disgust (Ochsner, Bunge, Gross and Gabrieli, 2002; Sanfey *et al.,* 2003; Wager *et al.,* 2004). There apparently occurs a negotiation between lower-level autonomic processes and the uniquely human capacity for abstract reasoning. If the lower-level passions do not interfere with future planning, then instrumental rationality becomes possible. Aristotle was thus correct when he proposed that it is the power of reason which sets humanity apart from the rest of the animal kingdom. While mammals in general possess a limbic system (MacLean's 1990 *mammalian brain*), only humans have developed a large and highly differentiated neocortex that enables, but hardly guarantees, the attainment of rationality.

Somatic States and Decision-Making: The Somatic-Marker Hypothesis

Kahneman (2011) provides compelling arguments that people exaggerate the extent to which their decisions and judgments are based on rational cognition. Individuals are rather predisposed to a non-analytic, non-logical reliance on heuristics, cues, and simple associations between concepts. This is especially so for decision-making in risky circumstances, wherein complex, conflicting choices and a sense of urgency can make it infeasible to rely solely on cognition. This is because computational obstacles related to the number and complexity of possible courses of action, combined with the difficulty of evaluating these options' possible long-term consequences, render decision-making excessively time-consuming and arduous. Under such constraints, affect-laden bodily responses — somatic markers, can both bias and hasten decision making (Panksepp, 1998). This System 1- based decision-making strategy– (i) focuses upon immediately-available relevant information and beliefs, (ii) uses *bounded rationality* to evaluate options as simply satisfactory or not satisfactory (Simon, 1982), and (iii) rapidly excludes bad choices from the set of possible behavioral decisions. Damasio, Tranel and Damasio (1991; see also Bechara and Damasio, 2005) propose that hunches, intuitions, and bodily signals mediated by both the peripheral and central nervous systems can also enhance goal-directed cognition. Damasio, Tranel and Damasio (1991) define a*somatic marker* as an automatic, bodily signal which influences neocortical processes that enable an individual to parse between behavioral alternatives before these are subjected to rational analysis and executive decision making. Somatic and visceral states, when mapped into body-representing structures of the brain, enable rapid elimination of negative behavioral alternatives which are as potentially harmful or painful. Damasio *et al*. (1991) hypothesize that an overall somatic feeling-state will bias cognitive assessment of present decision alternatives and, more generally, regulate decision-making.

But where in the brain is the overall state of the body represented? Craig (2009) has recently shown that the anterior insula, particularly on the right side of the brain, integrates bodily physiological states and then conveys information about these states to the prefrontal cortex via the von Economo neurons, which possess large spindle-shaped soma and long, single, one-directional, apical axons. Allman, Watson, Tetreault and Hakeem (2005) suggest that these neurons, which connect the insula and the frontal cortex, contribute to decision-making insofar as this is aided by bodily states. In Damasio's model, signals of bodily responses represented in the brain remain largely out of conscious awareness, but

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can be consciously monitored and experienced as *feelings*. Thus, somatic markers send information to the somatosensory cortices (via brainstem nuclei), especially the right insula, that map the body. Rational cognitive processing is apt to be accentuated during states of rest when such markers are inactive and peripheral feedback in sensory and motor functions is not required (Marr, 2006; Teuber, 1972). Consider as an example muscular tension, directed by non-conscious information, which can bias a choice between rational alternatives.

Some initial support for the SMH came from an Iowa Gambling Task (IGT). Bechara, Damasio, Tranel and Damasio (1997) presented four decks of cards to 10 normal subjects and 6 subjects with bilateral ventromedial prefrontal brain (VMPFC) damage. After turning over a card, subjects either win or lose varying amounts of play money. Unbeknownst to the subjects, there are two *bad* decks and two *good* decks. The game ends after the 100th card is played, or the player's money is exhausted. Skin-conductance responses (SCRs) were chosen as an indicator of body state. It was found that,after several rounds of card-picking, normal subjects learned to decide advantageously; they picked a majority of their cards from the good decks. After several picks, it was found that *anticipatory* SCRs, several seconds before each card selection, were significantly higher preceding bad-deck selection. According to Bechara *et al.* (1997), somatic markers (indicated by SCRs) had enabled subjects to make advantageous selections even before conscious knowledge was available.

VMPFC damaged patients performed poorly on the IGT (Bechara *et al.*, 1994, 1997), and continued to select from the bad decks throughout the experiment, even though some of them correctly identified good and bad decks. Unlike normal controls, they failed to develop higher anticipatory SCRs for the bad decks. Bechara, Damasio and colleagues have inferred from these results that VMPFC damage impairs the processing of somatic markers, such that these patients' *cognitive impulsiveness* rendered them largely oblivious to future losses. However, there is another possible explanation for these patients' poor performance on the IGT. In this experiment, the \$100-reward *bad* decks (compared to \$50-reward *good* decks) initially appear very good. In one of these decks, the first nine outcomes are \$100 wins, followed by a \$1,250 loss. Confronted with such an improbable winning streak ($p = 1/2^8 = 0.003$), a rational subject might well conclude that the decks had not been shuffled into randomness but were purposefully arranged, so that a deck containing one such improbable streak might well have been intentionally designed to contain other such streaks. Even without this inference, these patients would likely have experienced difficulty in overcoming a response tendency induced by their initial positive experiences (Maia and McClelland, 2004). Rolls *et al*. (1994) have shown that VMPFC-damage patients have difficulty in simple reversal tasks (e.g., first gaining a point for touches of a screen; later losing a point for each screen touch). Bechara, Tranel and H. Damasio (2000) objected to this alternative explanation of patients' behavior, pointing out that some of the Rolls *et al*. patients had damage that extended from the VMPFC laterally into the orbitofrontal cortex. But Fellows and Farah (2003), in response, demonstrated that their subset of patients with lesions confined to VMPFC also showed impaired reversal in simple reversal learning. Moreover, Fellows and Farah shuffled the same cards used in the initial IGT, after which performance of the VMPFC patients became indistinguishable from normal controls. Both Rolls *et al*. (1994) and Fellows and Farah (2005) have shown that VMPFC patients' deficit in adapting to reversal in contingencies extends beyond the laboratory to everyday life situations (e.g., when to make a follow-up doctor's appointment). Maia and McClelland (2004), in their review of this evidence, further observe that patients with only dorsolateral PFC damage also perform poorly in the IGT (Fellows and Farah, 2005), which suggests the possible involvement of working memory in the IGT, which would be inconsistent with the Bechara, Damasio, Tranel and Anderson (1998) claim that somatic markers play an unconscious role in decision making.

Maia and McClelland (2004) attempted to replicate the Bechara *et al*. (1998) study twice, each time with 20 undergraduate subjects. The first experiment fully replicated the Bechara *et al*. results. In their second replication, they used a more sensitive and detailed questionnaire, and found that players had extensive conscious knowledge about the game. Players' verbal reports indicated that they possessed even more knowledge of the advantageous strategy than their actual behavior would indicate; moreover, when they behaved advantageously, they nearly always reported knowledge about the goodness of the decks, which was sufficient to guide their advantageous behavior. Contrary to the conclusion of Bechara *et al*. (1998) the Maia–McClelland results provided no justification for the claim that non-conscious biases guide advantageous behavior; they suggest further

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that Bechara *et al*. had relied on methods insufficient to assess subjects' conscious knowledge about the game. Maia and McClelland instead found that, when subjects behaved advantageously in the IGT, (i) it was because they had conscious awareness of the relative goodness and badness of the decks, and (ii) their possession of this explicit, reported knowledge could have provided the basis for their judgments and behavioral choices.

Ian Tomb *et al.* (2002) also question the Bechara *et al*. (1997) explanation of why SCRs have been found to be higher for the bad decks than for the good decks in the IGT. Two possible explanations were compared: (i) As claimed by Bechara *et al*., anticipatory SCRs might be correlates of correct versus incorrect decision making; that is, larger anticipatory SCR magnitude for bad decks represented a net bodily state, or a crude bodily signal, that gradually biased subjects against the bad decks; (ii) The alternative explanation was that, because both the rewards and punishments were much greater for the bad decks than for the good decks, anticipatory SCRs might have been higher for bad decks because the subjects were expecting higher-magnitude gains or losses from the bad decks. To determine which explanation was likely correct, Tomb and colleagues conducted two experiments (each with 10 undergraduate subjects). In the first experiment, where the magnitudes of both rewards and punishments were higher for the bad decks than for the good decks, the SCRs were higher for the bad decks. But in a second experiment, the reward-magnitude bias was reversed; the decks were modified so that the *good* decks had both higher rewards and higher magnitudes of punishments. Following this experimental design change, the initial finding was reversed, supporting the second, alternative hypothesis: The anticipatory SCRs were now higher for the good decks than for the bad decks. This striking result further undermines the Bechara *et al*. claim. Across both experiments, deck-selection was driven by cognitions about long-term consequences, whereas anticipatory SCRs were apparently driven by the immediate acts to be performed, namely choosing the next card, independently of the positive or negative long-term impact on earnings. SCRs, it can be concluded, had not provided evidence for the presence of somatic markers in decision making.[1]

The choice of skin-conductance *response* (SCR) as a somatic marker might in itself be problematic. This is because SRC might not involve the periphery, but rather represent regulation by structures of the brain stem and hypothalamus. However, expanding the meaning of the somatic marker to include such neurological processes renders a putative somatic marker nearly equivalent to the concept of emotion. The best measure for sustained tonic levels of tension is arguably not the SCR, which measure transient responses, but skin-conductance *level*, which measures sweat gland activity in response to events. Tonic levels of muscular tension produced under continuous choice alternatives are generally known to modulate not effective choosing, but rather avoidance behaviors (Marr, 2011). Marr notes that Damasio has not provided a systematic explanation of autonomic arousal and its physiological and cognitive antecedents. SCR has, however, been found to be an effective predictor of rejecting unpleasant and psychologically distressing behavioral options (van 't Wout *et al.*, 2006).

While there have been numerous efforts to demonstrate the existence of a somatic–marker mechanism through IGT-based experimental research, this experimental paradigm has not been successful. As reviewed by Dunn, Dalgleish and Lawrence (2006), the psychophysiological data provide only ambiguous evidence, and causal evidence linking peripheral feedback to IGT performance has not been established. More recently, however, an entirelydifferent kind of evidence strongly suggests the existence of somatic markers. Osumi and Ohira (2010) conducted ultimatum-game studies, wherein two players — proposer and responder — split a sum of money provided by the experimenter. A fair offer by proposer to respondent is 50/50; if the proposer offers much less than a 50/50 split, the offer is apt to be regarded as selfish and unfair, and rejected on sociomoral grounds; in this case neither player receives a reward. If the responder is *economically* rational, he or she will accept *any* offer on the grounds that, fair or not, acquiring some money is better than no money. To reject an unfair offer is not instrumentally or economically rational, but is rather an emotional, and possibly *substantively* rational, decision (Weber, 1921; TenHouten, 2013a, 2013b).

1 While humans possess this System 2-based, episodic-futural, cognitive ability to plan ahead, deferring rewards even for decades, other species, including the advanced primates, do not plan for the future and are typically unable to defer gratification for more than a few minutes (Rachlin, 1989; Kagel, 1995). Humans' extraordinary ability to defer gratification has been linked to the development of the prefrontal cortex, the latest and highest development in human brain evolution. Studies show that human patients with frontal brain damage develop a preference for immediate rewards and become unable to plan ahead (Bechara, Damasio, Damasio and Anderson, 1994).

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Osumi and Ohira found a cardiac orienting response (pulse-rate deceleration) approximately one second after an unfair offer, but only when the offer was then rejected; this typically happened after about five seconds, the time needed to resolve the conflict between an economically-reasoned acceptance and an affect-laden, value-based rejection. This bodily response (governed by the vagus nerve system) preceded conscious decision making, suggesting the cardiac response was a somatic marker.

To investigate the hypothesized role of the insula in this somatic precursor to offer rejection, Ohira and Osumi (2009) used fMRI to study possible involvement of the insula in emotional rejection. They contrasted brain activation during ultimatum game play with activation during the similar dictator game (where money was automatically split and the responder could not reject the offer). This comparison was intended to isolate brain activation reflecting pure decision-making processes, by subtracting other processes such as fairness evaluation. Activation of the *right* anterior insula robustly predicted the rejection rate of unfair offers, with the correlation between fMRI signal change and percent rejection rate r = 0.81 (p< 0.001), which suggested that the insula was indeed involved in decision making utilizing heart-rate deceleration as a somatic marker.

Psychopaths are known to be affectively impaired in responses to aversive stimuli — as they typically show less activation than normal controls in the affective neural circuitry (e.g., Benninger, Patrick and Iacono, 2005); they also tend not to learn from negative experiences (Hare, 2001). Osumi and Ohira (2010) hypothesized that psychopathic individuals, when compared to normal controls, would show less emotion (and changed somatic activity) and thus act economically rational in the ultimatum game, that is, would be predisposed to accept *any* offer on the ground that any reward is better than none. This outcome was obtained. In a study of 28 Japanese college students, 12 (5 female) were rated high on primary psychopathy and 16 (8 female) rated low. All played the role of responder in 30 one-shot ultimatum games. The offers followed presentation of photos of the putative proposers, but the experiments actually controlled the mix of fair (50/50) and unfair (< 50/50 offers), a process known to evoke emotional states.

As hypothesized, subjects high on the psychopathy scale accepted significantly more unfair offers than did the low psychopathy subjects. Subjects with a low tendency toward psychopathy showed a greater SCR response to unfair vs. fair offers. This lower SCR was associated with a higher acceptance rate, and supports a feeling basis for irrational rejection (van 't Wout *et al.*, 2006). The psychopathic subjects were less often willing to accept the costs of rejection of unfair offers, possibly indicating their tendency to focus on short term gains while ignoring long-term reciprocal strategies in their interpersonal interactions (Rilling *et al.*, 2002). Thus, consistent with the SMH, emotions and bodily states are ordinarily activated in evaluating decision-making in situations of risk and uncertainty. Somatic markers can aid decision-making quality under such circumstances, yet their absence can lead to a kind of rationality that is narrowly instrumental while showing a pathological lack of substantive, value-based rationality.

Discussion

Somatic markers inform the brain structure that represents the state of the body, especially the right-hemisphere's insula. This brain processing comprises the feeling that precedes, and informs, decision-making, which also involves frontal-lobe processing of cognitions and emotions (largely of limbic origin). If an individual playing the ultimatum game is presented an unfair offer, at least one somatic marker (heart-rate deceleration) is apt to rapidly inform the insular cortex, which will pass along that and other representations of bodily state. Clearly, the perception that one has been presented with an unfair offer triggers a number of bodily reactions, some of which occur quickly and can serve as somatic markers, and some of which develop too slowly to be somatic markers.

The search for somatic markers involves identification of bodily responses that temporally precede cognitive representations of logically-organized ideas and of emotions. These somatic markers do not transmit it immediately to the frontal lobes, but rather are mapped, as part of a net somatic state, by the right insula. The somatic states that are mapped included hunger, thirst, sweat levels, muscular tension, and pulse rate changes. Bechara and colleagues have focused on skin-conductance responses, which they saw as enabling subjects in IGT experiments to make advantageous deck selections even before they consciously recognized which decks were *good* or *bad*. However, Maia and McClelland found that subjects had extensive knowledge about the game before making their selections, so that it cannot be inferred that non-conscious biases of somatic origin were guiding advantageous behavior.

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Other researchers (including Tomb *et al.,* 2002) have observed differences in the bad and good decks, with both rewards and punishments higher for the bad decks. This creates a bias in decision making. When they removed this bias in a replication, the *result* claimed by Bechara concerning the SRC measures disappeared. Moreover, skin-response *conductance* is less appropriate as a measure of somatic activation than is skin-response *level* (indicating sweat-gland activity). Yet another deficiency has been detected in the studies of frontal-lobe-damaged patients, who were presented a *bad* deck that began with eight wins in a row followed by a large loss. Such frontal damage, as is well known, creates a tendency to persist in established behavioral responses. This result was also virtually erased merely by shuffling the decks.

Taken as a whole, it becomes difficult to avoid concluding that the IGTis an inadequate experimental paradigm for demonstrating the existence of somatic markers. Such a conclusion, of course, does not mean there is no such thing as a somatic marker. In fact, Osumi and Ohira (2010), using a different experimental paradigm,the ultimatum game,have clearly shown the existence of a somatic marker, pulse-rate deceleration (PRD). During the brief period between being made an offer and deciding whether or not to accept or reject it, there was PRD, a cardiac activity response. Using fMRI, they found that PRD was correlated with right insular activation. By contrasting ultimatum game measures with dictator game measures — where offers were automatically set and could not be rejected — the brain-activation differences were attributable to pure decision-making. They found that offer rejection was robustly correlated with right insular activation (r = 0.80). These results strongly suggest that PRD stimulated right insular activation, and that insular evaluation of bodily state was then communicated to the frontal lobes, where cognitive and emotional processes became involved prior to decision-making.

Clearly, the SMH deserves further investigation. Further research might well determine that some somatic states which develop rapidly following perception serve as somatic markers, and other bodily reactions, especially those that are visceral and slower, do not. It is also likely that, while the right insula is a major pathway from somatic markers to the frontal lobes (and the amygdala is undoubtedly also involved), and informs both cognition and emotion. There surely are other channels as well.

The search for somatic markers is important not only for neuroeconomics, but for the social sciences as well. Various somatic theories of human social behavior have emerged, which are based loosely, and largely uncritically, on a synthesis of (i) the SMH, (ii) Bowlby's (1988) attachment theory, and (iii) the self-psychology first articulated by Kohut (1977) and elaborated by Schore (2003). This theorizing has spawned, or developed together with, applications in embodied mind theory (Lakoff and Johnson, 1999), the evolution of human morality (Narvaez, 2014), performative linguistics (Robinson, 2008), speech act theory (Felman, 2003), actor training development (Sellers-Young,1998), and notions of bodily-kinesthetic intelligence (Gardner, 1983). There is a certain wildness to such theorizing, much of which is based on shaky neuroscientific grounds, but such forays into "the wild blue yonder" (TenHouten, 1992) have endeavored to explore the interface between body, brain, mind, and society. We can only hope that clarification of the SMH will better ground such extrapolation of the SMH to the social world.

References

ALLMAN, J.M.; WATSON, K.K.; TETREAULT, N. A. and HAKEEM, A. Y. (2005) "Intuition and autism: A possible role for von Economo neurons" *Trends in Cognitive Science,* N° 9, p. 367–373.

ANDERSON, S.W.; BECHARA, A.; DAMASIO, H.; TRANEL, D. and DAMASIO, A.R. (1999) "Impairment of moral and social behavior related to early damage in human prefrontal cortex" *Nature Neuroscience* N° 2, p. 1032–1037.

ARIETI, S. (1970) "Cognition and feeling", in: Arnold, M.B. (Ed.) *Feelings and emotions: The Loyola Symposium*. New York: Academic Press. p. 135-143.

BECHARA, A. and DAMASIO, A.R. (2005) "The somatic marker hypothesis: A neural theory of economic decision" *Games and Economic Behavior* N° 52, p. 336-372.

BECHARA, A.; DAMASIO, A.R.; DAMASIO, H. and ANDERSON, S.W. (1994) "Insensitivity to future consequences following damage to human prefrontal cortex" *Cognition,* N° 50, p. 7–15.

CUERPOS, EMOCIONES Y SOCIEDAD, Córdoba, N°20, Año 8, p. 87-97, Abril 2016-Julio 2016

BECHARA, A.; DAMASIO, H.; TRANEL, D. and ANDERSON, S. W. (1998) "Dissociation of working memory from decision making within the human prefrontal cortex" *Journal of Neuroscience,* Nº 18, p. 427–437.

BECHARA, A.; DAMASIO, H.; TRANEL, D. and DAMASIO, A.R. (1997) "Deciding advantageously before knowing the advantageous strategy" *Science,* Nº 275, p. 1293–1295.

BECHARA, A.; TRANEL D. and DAMASIO, H. (2000) "Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions" *Brain,* Nº 123, p. 2189–2202.

BENNINGER, S. D.; PATRICK, C. J. and IACONO, W. G. (2005) "Psychopathy, startle blink modulation, and electrodermal reactivity in twin men" *Psychophysiology,* Nº 42, p. 753–762.

BERTHOZ, A. (2006) *Emotion and reason: The cognitive neuroscience of decision making*. Oxford: Oxford University Press.

BOWLBY, J. (1988) *A secure base: Parent-child attachment and healthy human development*. New York: Basic Books.

CRAIG, A. D. (2009) "How do you feel – now? The anterior insula and human awareness" *Nature Reviews Neuroscience,* Nº 10, p. 59–70.

DAMASIO, A. R. (1994) *Descartes' error: Emotion, reason, and the human brain*. New York: Putnam.

___________ (1999) *The feeling of what happens: Body and emotion in the making of consciousness*. New York: Harcourt Brace.

___________ (2003) *Looking for Spinoza: Joy, sorrow, and the feeling brain*. Orlando: Harcourt.

DAMASIO, A. R., TRANEL, D. and DAMASIO, H. (1991) "Somatic markers and the guidance of behavior: Theory and preliminary testing", in: Levin, H. S.; Eisenberg, H. M. and Benton, A. L. (Eds.) *Frontal lobe function and dysfunction*. New York: Oxford University Press. pp. 217-229.

DUNN, B. D.; DALGLEISH, T. and LAWRENCE, A. D. (2006) "The somatic marker hypotheisis: A critical evaluation" *Neuroscience and Biobehavioral Reviews,* Nº 30, p. 239–271.

EPSTEIN, S. (1994) "Integration of the cognitive and psychodynamic unconscious" *American Psychologist,* Nº 49, p. 709–724.

EVANS, J. St. B. T. (1989) *Bias in human reasoning: Causes and consequences*. Hillsdale: Lawrence Erlbaum.

___________ (1998) "Matching bias in conditional reasoning: Do we understand it after 25 years?" *Thinking and Reasoning*, Nº 4, p. 45–82.

FELLOWS, L. K., and FARAH, M. J. (2003). "Ventromedial frontal cortex mediates affective shifting in humans: evidence from a reversal learning paradigm". *Brain,* 126(8), p. 1830-1837.

___________ (2005) "Different underlying impairments in decision-making following ventromedial and dorsolateral frontal lobe damage in humans" *Cerebral Cortex,* Nº 15, p. 58–63.

FELMAN, S. (2003) *The scandal of the speaking body: Don Juan with J. L. Austin, or seduction in two languages*. Stanford: Stanford University Press.

GARDNER, H. (1983) *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

GIGERENZER, G; TODD, P M. and The ABC Research Group. (1999) *Simple heuristics that make us smart*. New York: Oxford University Press.

HARE, R. D. (2001) "Psychopaths and their nature: Some implications for understanding human predatory violence", in: Raine, A. and Sammartin, J. (Eds.) *Violence and psychopathy*. New York: Klewer Academic/Plenum Press.

KAHNEMAN, D. (2011) *Thinking, fast and slow*. New York: Farrar, Strauss & Giroux.

KAHNEMAN, D. and TVERSKY, A. (1979) "Prospect theory: An analysis of decision under risk" *Econometrika*, Nº 47, p. 263–291.

CUERPOS, EMOCIONES Y SOCIEDAD, Córdoba, N°20, Año 8, p. 87-97, Abril 2016-Julio 2016

KNUTSON, B.; FONG, G. W.; ADAMS, C. M.; VARNER, J. L. and HOMMER, D. (2001) "Dissociation of reward anticipation and outcome with event-related fMRI" *Neuro Report,* Nº 17, p. 3682–3687.

KOHUT, H. (1977) *The restoration of the self*. New York: International Universities Press.

LAKOFF, G. and JOHNSON, M. (1999) *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.

LONGE, O.; SENIOR, C. and RIPPON, G. (2009) "The lateral and ventromedial prefrontal cortex work as a dynamic integrated system: Evidence from FMRI connectivity" *Journal of Cognitive Neuroscience,* Nº 21, p. 141–154.

MacLEAN, P. D. (1990) *The triune brain in evolution: Role of paleocerebral function*. New York: Plenum Press.

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" *Proceedings of the National Academy of Sciences USA*, Nº 101, p. 16075–16080.

MARR, A. J. (2006) "Relaxation and muscular tension: A biobehavioristic explanation*" International Journal of Stress Management*, Nº 13, p. 131–153.

___________ (2011) "Freud's signal anxiety: A better explanation for Damasio's somatic marker?" <http://mezmer.blogspot.com /2007/freud-signal-anxiety-better.html>, retrieved September 25, 2011.

McCLURE, S. M.; LAIBSON, D. I.; LOEWENSTEIN, G. and COHEN J. D. (2004) "Separate neural systems value immediate and delayed monetary rewards" *Science*, Nº 306, p. 503–507.

McCOY, A. N. and PLATT, M. L. (2005) "Expectations and outcomes: Decision-making in the primate brain" *Journal of Comparative Physiology*, Nº 191, p. 201–211.

MILLER, E. K. and COHEN, J. D. (2001) "An integrative theory of prefrontal cortex function" *Annual Review of Neuroscience*, Nº 24, p. 167–202.

NARVAEZ, D. (2014) *Neurobiology and the development of human morality: Evolution, culture, and wisdom*. New York: W. W. Norton.

OCHSNER, K. N.; BUNGE, S. A.; GROSS, J. J. and GABRIELI, J. D. (2002) "Rethinking feelings: An FMRI study of the cognitive representation of emotion" *Journal of Cognitive* Neuroscience, Nº 14, p. 1215–1229.

OHIRA, H. (2010) "The somatic marker revisited: Brain and body in decision making" *Emotion Review,* Nº 2, p. 245–249.

OHIRA, H. and OSUMI, T. (2009) "Body knows decision: Neural and physiological bases of emotional decision-making in the Ultimatum Game" Paper presented at the *Annual Meeting of the International Society for Research on Emotions*, August 7 2009, Leuven, Belgium.

OSUMI, T. and OHIRA, H. (2010) "The positive side of psychopathy: Emotional detachment in psychopathy and rational decision-making in the ultimatum game" *Personality and Individual Differences*, Nº 49, p. 451-456.

PAIVIO, A. (2007) *Mind and its evolution: A dual coding theoretical approach*. Mahwah: Lawrence Erlbaum.

PANKSEPP, J. (1998) *Affective neuroscience: The foundations of human and animal emotions*. New York: Oxford University Press.

PHAM, M. T. (2007) "Emotion and rationality: A critical review and interpretation of empirical evidence" *Review of General Psychology*, Nº 11, p. 155–178.

POCHON, J. B., LEVY, R.; FOSSATI, P.; LEHERICY, S.; POLINE, J. B.; PILLON, B.; LE BIHAN, D. and DUBOIS, B. (2002) "The neural system that bridges reward and cognition in humans: An fMRI study" *Proceedings of the National Academy of Sciences USA*, Nº 99 p. 5669–5674.

POTT, H. (1992) *De Liefde van alcibiades: Over ratinaliteit en moties* [*Alcibiades' Love: On rationality and emotion*]. Amsterdam: Boom.

RACHLIN, H. (1989). *Judgment, decision, and choice: A cognitive/behavioral synthesis*. WH Freeman/ Times Books/Henry Holt & Co.

RILLING, J.; GUTMAN, D.; ZEH, T.; PAGNONI, G.; BERNS, G. and KILTS, C. (2002) “A neural basis for social cooperation” *Neuron*, Nº 35, p. 395–405.

ROBINSON, D. (2008) *Estrangement and the somatics of literature: Tolstoy, Shklovsky, Brecht*. Baltimore: Johns Hopkins University Press.

ROLLS, E. T.; HORNAK, J.; WADE, D. and MCGRATH, J. (1994) “Emotion-related learning in patients with social and emotional changes associated with frontal lobe damage” *Journal of Neurology Neurosurgery and* Psychiatry, Nº 57, p. 1518–1524.

SANFEY, A. G.; RILLING, J. K.; ARONSON, J. A.; NYSTROM, L. E. and COHEN, J. D. (2003) “The neural basis of economic decision-making in the Ultimatum Game” *Science*, Nº 300, p. 1755–1758.

SCHORE, A. N. (2003) *Affect regulation and the repair of the self*. New York: W. W. Norton.

SELLERS-YOUNG, B. (1998) “Somatic processes: Converged of theory and practice” *Theatre Topics*, Nº 8, p. 173–87.

SIMON, H. A. (1982) *Models of bounded rationality*, vol. 2: *Behavioral economics and business organization*. Cambridge: MIT Press.

SLOVIC, P. (2000) *The perception of risk*. London: Earthscan Publications.

SUN, R. (2002) *Duality of the mind*. Mahwah: Lawrence Erlbaum.

TenHOUTEN, W. D. (1992) “Into the wild blue yonder: On the emergence of the ethnoneurologies” *Journal of Social and Biological Structures*, Nº 14, p. 381–408.

___________ (2013a) “A neurosociological model of Weberian, instrumental rationality: Its cognitive, conative, and neurobiological foundations”, in: Franks, D. D. and Turner, J. H. (Eds.) *Handbook of neurosociology*. New York: Springer. pp. 207-230.

___________ (2013b) *Emotion and reason: Mind, brain, and the social domains of work and love*. New York: Routledge.

TEUBER, H. L. (1972) “Unity and diversity of frontal lobe function” *Acta Neurobiologia e Experimentalis*, Nº 32, p. 615–656.

TOMB, I.; HAUSER, M.; DELDIN, P. and CARAMAZZA, A. (2002) “Do somatic markers mediate decisions on the gambling task?” *Nature Neuroscience*, Nº 5, p. 1103–1104.

VAN ’T WOUT, M.; KAHN, R. S.; SANFEY, A. G. and ALEMAN, A. (2006) “Affective state and decision-making in the ultimatum game” *Brain Research*, Nº 169, p. 564–568.

WAGER, T. D., RILLING, J. K.; SMITH, E. E.; SOKOLIK, A.; CASEY, K. L.; DAVIDSON, R. J.; KOSSLYN, S. M.; ROSE, R. M. and COHEN, J. D. (2004) “Placebo-induced changes in FMRI in the anticipation and experience of pain” *Science*, Nº 303, p. 1162–1167.

WEBER, M. ([1921] 1978) *Economy and society: An outline of interpretive sociology*, 2 vols. Berkeley: University of California Press.

Citado. TenHOUTEN, Warren (2016) “Embodied Feeling and Reason in Decision-Making: Assessing the Somatic-Marker Hypothesis” en Revista Latinoamericana de Estudios sobre Cuerpos, Emociones y Sociedad - RELACES, N°20. Año 8. Abril 2016-Julio 2016. Córdoba. ISSN 18528759. pp. 87-97. Disponible en: http://www.relaces.com.ar/index.php/ relaces/article/view/454.

Plazos. Recibido:15/02/2016. Aceptado 02/04/2016.