Neuropsychological Trends

28
November 2020

Gambling behavior versus moral behavior: methodological perspectives in neuroeconomic decision-making

Michela Balconi [1,2] **- Laura Angioletti** [1,2]

[1] *International Research Center for Cognitive Applied Neuroscience (IrcCAN), Catholic University of the Sacred Heart, Milan, Italy*

[2] *Research Unit in Affective and Social Neuroscience, Department of Psychology, Catholic University of the Sacred Heart, Milan, Italy*

DOI: http://dx.doi.org/10.7358/neur-2020-028-bal1 laura.angioletti1@unicatt.it

ABSTRACT

Within the neuroeconomics field, there are two evident situations in which decision-making process do not respect the rule of expected utility: gambling and moral behaviors. In the case of gambling behavior, a tendency to engage in risky decision-making could lead to choose disadvantageous options (loss vs gain) and long-term negative economic consequences. Regarding moral behavior, subjects prefer options not always related to their expected utility, but more to their social and ethical significance (fair vs unfair). This commentary discusses both the theoretical and empirical basis of these behaviors, focusing on neurophysiological methods adopted to investigate commonalities and differences in physiological and behavioral subjects' responses. The dichotomy between emotions and rationality will be explored considering two popular economics games, Iowa Gambling Task and Ultimatum Game, and will be discussed in the light of somatic marker hypothesis frame. We propose a multidimensional approach to describe more in-depth real-world decision-making situations in neuroeconomics.

Keywords: neuroeconomics; moral; gambling; IOWA; Ultimatum Game

1. Introduction

This conceptual description proposes a multidimensional approach to explore people behaviors in terms of their tendency to act as gamblers or under moral "dilemmas", thus considering the propensity of choosing alternatives not only with the goal of maximizing utility but also driven by other, functional or dysfunctional, reasons and strategies. We believe that the combination of behavioral measures, such as the Iowa Gambling Task (IGT; Bechara et al., 1994) and the Ultimatum game (UG; Sanfey et al., 2003), with neurophysiological techniques may describe more in-depth decision-makers strategies and could provide a complete overview of these complex phenomena, specifically in neuroeconomics.

2. Gambling and moral behaviors in neuroeconomics

Within the neuroeconomics frame, the expected utility model (Bernoulli, 1738) is still considered a predominant theory, according to which "individuals choose between different alternatives by estimating the desirability or utility of each action's possible results, gauging those utilities by their likelihood of occurring, and choosing the course of action that provides the highest gain". Central parameters of this theory are decision predictability and the outcome value, both assessed by mainly using rationality. However, this model often fails to describe real-world decision-making situations (e.g., investment choices) being influenced by other variables such as the history of previous decisions, ambiguity of the choice, personality traits of the decision maker (i.e., risk seeker or risk-averse person), the underestimation of the likelihood of negative consequences, or their discount because they are in the future, the adaptation to social pressure or perceived norms and outcomes of social significance (e.g., altruism). This being so, alternative theories (for example the Prospect theory; Kahneman & Tversky 1979) have been formulated to explain conditions that violate classic economic decision-making rational rules, and the presence of additional moderating variables even related to emotional aspects have been proposed (such as framing effect, loss aversion, reflection effect, isolation effect and so on).

Specifically, we believe there are two evident situations in which decision-making process does not respect the rule of expected utility: these are gambling and moral behaviors.

In the case of gambling behavior, there is a tendency to engage in risky decision-making that leads to prefer immediate pay-off than delayed rewards,

potentially driving to disadvantageous options over time. This has the additional advantage to derive a supplementary utility from the costs that are avoided by winning a sum rather than earning it by working (i.e., "something for nothing") (Nyman et al., 2008). At the extremes of this behavior are located pathological and professional gamblers: the firsts, characterized by impulse control, attentional and reward sensitivity bias. These biases are often associated to an emotional impairment and are characterized by a lack of executive and inhibitory control, a flattening of social emotions, an inability to reorganize emotional representations previously associated with punishment and reward, and an impairment in anticipating future outcomes (the so-called "myopia for the future") leading to long-term negative economic consequences (Bechara et al., 1994; Bechara et al., 2000). Conversely, professional gamblers are rarer but able to engage in a functional and rational decision-making process that generates larger income through gambling, to the point to decide in advance their labor supply according to an evaluation of expected winnings (e.g. by calculating the amount of wins, they may choose to work less during a certain period of time) (Nyman et al., 2008). On the other hand, Obsessive-Compulsive Disorder (OCD) is characterized by higher impulsivity, risky decision-making but also by biased probabilistic reasoning, thus sharing similarities with pathological gambling behavior (Grassi et al., 2015).

Whilst, in the case of moral behavior, subjects prefer options not always related to their expected utility, but more to their ethical significance and to subjects' social preference.

Indeed, within the moral decision-making frame an early dual-process model has been proposed (Greene et al., 2001). According to this model, moral judgments (e.g., accepting fair or unfair offers at the UG) have been demonstrated to elicit reactions from two distinct and competing neural mechanisms, the first one leads to deontological/fair behaviors (i.e., splitting a sum of money between two because it is the right thing to do according to sense of fairness) and it has been associated with fast, automatic, emotional processing; while the other one leads to a utilitarian approach (i.e., accepting unfairness, to be sure of a minimum but certain payoff) related to more conscious, cognitive elaboration and mainly motivated by self-interest. Despite research in the neuroeconomics field supports this model and perspective, some evidence seems rather inconsistent. For instance, Sanfey and colleagues (2003) displayed that, led by fairness, subjects' self-interest may support the suppression of a more emotional desire operated by cognitive controlled processes; also Knoch and colleagues (2006) showed that, although self-interest impulses are instinctive and have a stronger impact on our behavior, they can be inhibited by fairness considerations.

Indeed, in these cases emotional choices can lead to functional and

dysfunctional conditions: functional conditions include empathic, altruistic and deontological behaviors (Greene et al., 2001). Conversely, on the other side of the coin displaying a dysfunctional emotional behavior has been previously associated to antisocial behaviors, where individuals make repeatedly impulsive decisions on the basis with no regard for social norms and a lack of emotion (e.g., individuals with psychopathic traits; Mitchell et al., 2013; Osumi & Ohira, 2010). Instead, a more rational moral reasoning, characterized by the tendency to approve harmful actions in situations they assessed as appropriate or reasonable, has been described to be typical of a utilitarian approach (Greene et al., 2001; Young et al., 2010). The dysfunctional version of this behavior could be constituted by autistic behaviors, predominantly driven by rationality with an insensitivity towards emotions (Camerer et al., 2004; Riccardi et al., 2015). This suggests that different situations and frames may influence decision-making so that in certain domains of life, like the financial markets, where individuals mainly opt for being risk-averse, people with psychopathic traits and with a lack of emotion could be more suitable in situations where risk-taking is the rational thing to do and a deficiency in somatic markers can be helpful (Shiv et al., 2005; Sobhani et al., 2011).

Although both emotional and cognitive mechanisms are recruited in gambling and moral behaviors, context decisions in the first case influence gain or loss of some money, while the second regard a decision in favor or disfavor of a specific conduct. In the case of gambling behavior, there is a strong focus on immediate outcomes without pondering eventual social and economic negative consequences, whereas moral behavior is exactly the opposite because mainly considers long-term effects of a choice and social consequences.

In addition, gamblers play in the context of decision-making under uncertainty (i.e., when implicit knowledge guides decisions), while moral judgment is usually employed in decision-making under risk conditions. Despite these differences, these two clusters of behaviors share a commonality: that is, the possibility of swinging from functional to dysfunctional poles according to the context.

3. Evidence from behavioral measures: the Iowa Gambling Task and the Ultimatum Game

Assuming that decision-making is influenced both by emotions (hot processes or "gut feelings") and cognitive (cold) processes, previous neuroeconomics research investigated these two clusters of behaviors by means of economic games and analyzed participants' behavioral responses and psychophysiological

reactions. The Somatic Marker Hypothesis (SMH; Damasio 1994) is one of the main theoretical frameworks employed to describe how decisions are made on these tasks at a covert or overt level. According to this hypothesis, any option and scenario activate somatic states (emotional signals) in the brain and body system according to the value attributed to that condition. Specifically, Skin Conductance Response (SCR) has been identified as a main peripheral somatic marker of anticipatory emotions (negative or positive) associated with possible consequences of a decision in previous studies (Bechara et al., 1996).

One of the most popular tasks used in the context of SMH in neuroeconomics is the IGT (Bechara et al., 1994). Researchers and clinicians frequently use this task to assess real-world risky decision making under ambiguity in a lab-based setting (Buelow & Blaine, 2015; Guillaume et al., 2009; Maia & Mcclelland, 2004). Several studies showed that unconscious stronger somatic responses are developed by healthy individuals before disadvantageous choices, confronted with reactions before advantageous choices. Conversely, an impairment in the generation of somatic markers in anticipation of disadvantageous choices and worse performances on this task, without any learning from repeated mistakes, has been displayed by patients with ventromedial prefrontal cortex (VMPFC) damage and individuals with addiction (Bechara et al., 2001; Bechara & Damasio, 2002). So that the occurrence of these psychophysiological responses has been claimed as crucial for an advantageous strategy at IGT (Bechara et al., 1994, 2000).

Previously, IGT characteristics have been exploited to test gambling behavior and a decrease in SCR and Heart Rate (HR) anticipatory responses to disadvantageous decisions has been identified as a marker of dysfunctional emotional system presented in pathological gamblers as opposed to controls (Angioletti et al., 2018; Balconi et al., 2017; Goudriaan et al., 2004, 2006). This was true also for patients with OCD failing to conclude IGT with a positive outcome and displaying a lower anticipatory, and subsequent to loss, SCRs compared to controls (Cavedini et al. 2012; Starcke et al., 2009; Lawrence et al. 2006). This result has been mainly addressed as related to impulsivity and emotions, however, we know that compulsions in this condition have the role of diminishing obsession-induced anxiety or distress, so that they have been related to biased cognitive reasoning becoming dysfunctional over time (Denys, 2011; Grassi et al., 2015). Instead, only one study focused on professional gamblers and even if they reported similar rates of gambling frequency as pathological gamblers, their clinical scales scores were similar to controls (Weinstock et al., 2013). Overall, it is possible to conclude that a diminished anticipatory SCR could play a pivotal role in the ability to take advantageous decisions in the economic field.

While on the side of moral behavior, decision making under risk is

prevalent, because participants are confronted with tasks where they can judge the relative risks and benefits of a choice, showing more explicit knowledge on the objective probability distribution over possible outcomes (Guillaume et al., 2009; Schiebener et al., 2011). This is the case of the UG allowing for the assessment of altruistic behavior as well as the perception of fairness.

In this game, a sum of money is split between two people, a proposer and a responder. The proposer selects how this sum should be divided between the two and the responder must decide either to accept or reject an offer of money made by the partner. If the offer is rejected, neither of the two players receive money. Classical economic game theories suggested that a rational strategy for the proposer should be to offer the smallest possible sum and for the responder to accept in turn (because some money is better than none); instead, half of the unfair offers are typically rejected and the most frequent option is a fair share (proposers tend to offer around 50% of the money) (Nowak et al., 2000; Sanfey et al., 2003). In addition to electrodermal activity, the variability of other autonomic measures, such as cardiac responses, has been identified as crucial indicators of emotional decision-making arousal in the UG.

Previous studies highlighted that SCR was higher for unfair offers and was associated with the rejection of unfair offers by healthy subjects playing the UG (Van't Wout et al., 2006). Moreover, this increase in SCR coupled with increases in HR responses when offers at the UG were framed as unfair (Sarlo et al., 2013). These results are in line with empathic and deontological behaviors. In addition, somatic states analyses during this task in clinical condition revealed that individuals with psychopathic traits more often tend to choose economic utility by accepting unfair offers and did not show differences in SCR between unfair and fair offers compared to controls (Osumi & Ohira, 2010; Sobhani et al., 2011).

On the other hand, a previous behavioral study on individuals with autism spectrum disorder (ASD) demonstrated that they are significantly more likely to accept unfair offers and were significantly less likely to reciprocate offers at a modified version of the UG (Hartley & Fisher, 2018).

Overall, autonomic measures revealed that humans seem to have an automatic aversion against perceived inequity and that emotion-based behaviors in humans cannot be fully explained by economic rationality. In the following paragraph evidence on neurophysiological parameters related to both emotions and rationality will be deepened.

4. Evidence from neurophysiological measures

Thanks to the widespread use of neuroscientific techniques in the economic field it has been possible to investigate the contribution of neural structures related to rationality and emotional processes in human decision-making (Kable, 2011). In addition to behavioral and psychophysiological evidences, neuroeconomists explored also neurophysiological correlates of gambling and moral behaviors in order to explore brain functioning related to these complex behavioral phenomena. Furthermore, nowadays research in neuroeconomics decision-making are focusing on networks of multiple brain areas rather than on localized single brain areas and somatic marker hypothesis suits more in this first holistic framework (Reimann & Bechara, 2010).

By tracking the change of neural activity with neuroimaging techniques during IGT task, previous studies showed that the neural connections between amygdala, striatum, VMPFC and dorsolateral prefrontal cortex (DLPFC) allow rational and emotional systems operating together and developing an adaptive strategy over time (Bechara et al., 1999; Bechara & Damasio, 2005; Weller et al., 2007). Accordingly, an impairment of these areas, together with orbitofrontal cortex damage, was previously found in patients with pathological gambling, impulse control disorders, and deficit in executive functions when performing the IGT (Bechara, 2005; Bechara & Martin, 2004). Moreover, findings from electrophysiological studies highlighted that gamblers' brain is characterized by a frontal hemispheric asymmetry with a left, more reward-related, unbalance even in non-clinical samples performing IGT (Balconi et al., 2014a, 2014b).

Focusing on the neural basis of moral behavior at the UG, Sanfey and colleagues (2003; 2006) studied why responders reject "gaining" offers by means of functional magnetic resonance imaging and observed that when responders accepted unfair offers activity in the DLPFC, a cortical area involved in executive control and deliberative processing, was higher than insula activity. In contrast, when responders refused unfair offers, insula activation, correlating with emotional processing, was greater than DLPFC activation. Sanfey and colleagues (2003, 2006) interpreted this pattern as evidence that the rejection of inequality is related to an activation of brain areas involving emotional processing, and regions associated with higher-level cognitive function had to overcome emotional responses in order to accept unequal offers.

Decision-making under uncertainty and moral decision making have been demonstrated to partially tap into different neural systems. Indeed, prior studies suggested that VMPFC could be considered a keystone of emotional processing also in social decision-making at the UG (Koenigs & Tranel, 2007;

Sobhani et al., 2011). In line with this, psychopathic individuals showed an increased activation of DLPFC, as a result of a diminished sensitivity to unfairness when accepting unfair offers, and also an augmented activation of VMPFC, as a result of higher emotional reaction to repeated unfair offers rejection, like VMPFC damage patients (Koenigs et al., 2010; Osumi & Ohira, 2010). So, in individuals displaying antisocial behaviors the preference of economic utility over fairness does not necessarily end in rational decisions, since a deficit in emotion regulation and reward processing could lead to the rejection of rational unfair offers during the UG (Vieira et al., 2014).

On the whole, we suggest that the integration of multilevel measures could be useful to unveil the neurophysiological complexity of normal and abnormal decision-making processes with regard to emotional and rational components in gambling and moral behaviors, as previously demonstrated even by basic research on emotions (Balconi et al., 2015; Balconi & Terenzi, 2012).

5. Conclusion: a multimodal approach

This article proposes a multidimensional model based on rationality and emotion to gain an understanding of a person's functional and dysfunctional decision-making in gambling and moral behaviors, within the neuroeconomics field.

Gambling behavior has been described in the light of SMH framework considering studies on IGT, where unconscious emotional stronger somatic responses are not developed before disadvantageous compared to advantageous choices by pathological samples versus healthy individuals over time. We concluded that the development of emotional anticipatory physiological responses to high-risk decisions, together with the learning of previous mistakes mediated by prefrontal brain structures, plays a crucial role in the ability to take rational and advantageous economic decisions.

Moral behavior has been discussed describing why people often deviate from rational and economic advantageous decisions in favor of fair and more emotional choices. Classic economic research struggles to clarify the reasons why individuals refuse utility-maximizing, even if unfair, options in the UG, when from a simply monetary viewpoint, it seems obvious that any money is better than no money at all. Our perspective will, in turn, allow scientists to offer more complete neuroeconomic models of decision-making behavior that incorporate the role of morality.

Despite gambling behavior and moral behavior have been treated independently by previous neuroeconomics research, we showed that these two

clusters of behaviors share similarities at the psychophysiological and neurophysiological level when considering both emotional and rational factors intervening in functional and dysfunctional conditions.

Given these premises, we propose a multidimensional approach composed by axes oriented on two dimensions: the functionality and dysfunctionality poles and the dichotomy between emotion and rationality. In each quadrant, an example of intersections has been proposed based on existing literature on neuroeconomics and decision-making. The results of our conceptualization can be found in Figure 1.

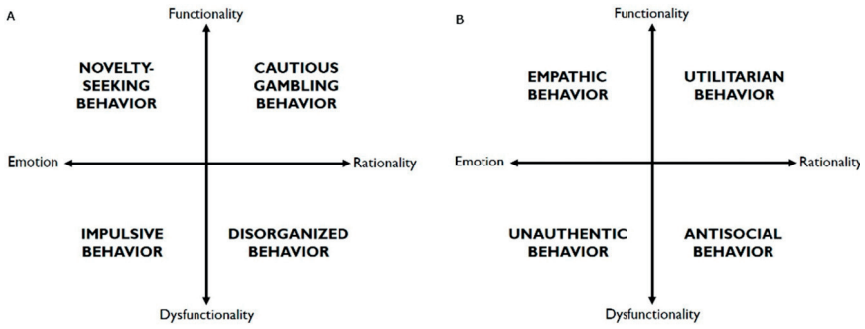

Figure 1. Multidimensional conceptualization of (A) gambling-related behaviors and (B) moral-related behaviors

References

Angioletti, L., Siri, C., Meucci, N., Pezzoli, G., & Balconi, M. (2018). Pathological Gambling in Parkinson's disease: Autonomic measures supporting impaired decision-making. *European Journal of Neuroscience, 50,* 2392–2400. https://doi.org/10.1111/ejn.13993

Balconi, M., Campanella, S., & Finocchiaro, R. (2017). Web addiction in the brain: Cortical oscillations, autonomic activity, and behavioral measures. *Journal of Behavioral Addictions, 6*(3), 334–344. https://doi.org/10.1556/2006.6.2017.041

Balconi, M., Finocchiaro, R., & Canavesio, Y. (2014a). Left Hemispheric Imbalance and Reward Mechanisms Affect Gambling Behavior. *Clinical EEG and Neuroscience, 46*(3), 197–207. https://doi.org/10.1177/1550059413513261

Balconi, M., Finocchiaro, R., Canavesio, Y., & Messina, R. (2014b). Reward bias and lateralization in gambling behavior: behavioral activation system and alpha band analysis. *Psychiatry Research, 219*, 570–576. https://doi.org/10.1016/j.psychres.2014.06.020

Balconi, M., Grippa, E., & Vanutelli, M. E. (2015). What hemodynamic (fNIRS), electrophysiological (EEG) and autonomic integrated measures can tell us about emotional processing. *Brain and Cognition, 95*, 67–76. https://doi.org/10.1016/j.bandc.2015.02.001

Balconi, M., & Terenzi, A. (2012). Neuropsychology of moral judgment and risk seeking: what in common. In A. Innocenti & A. Sirigu (Eds.), *Neuroscience and the economics of decision making* (pp. 86–108). Routledge.

Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: a neurocognitive perspective. *Nature Neuroscience, 8*(11), 1458–1463. https://doi.org/10.1038/nn1584

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior, 52*, 336–372. https://doi.org/10.1016/j.geb.2004.06.010

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*(1), 7–15. https://doi.org/10.1016/0010-0277(94)90018-3

Bechara, A., & Damasio, H. (2002). Decision-making and addiction (part I): impaired activation of somatic states in substance dependent individuals when pondering decisions with negative future consequences. *Neuropsychologia, 40*(10), 1675–1689. https://doi.org/10.1016/S0028-3932(02)00015-5

Bechara, A., Damasio, H., Damasio, A. R., & Lee, G. P. (1999). Different Contributions of the Human Amygdala and Ventromedial Prefrontal Cortex to Decision-Making. *The Journal of Neuroscience, 19*(13), 5473–5481. https://doi.org/10.1523/JNEUROSCI.19-13-05473.1999

Bechara, A., Dolan, S., Denburg, N., Hindes, A., Anderson, S. W., & Nathan, P. E. (2001). Decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in alcohol and stimulant abusers.

Neuropsychologia, 39(4), 376–389. https://doi.org/10.1016/S0028-3932(00)00136-6

Bechara, A., & Martin, E. M. (2004). Impaired Decision Making Related to Working Memory Deficits in Individuals with Substance Addictions. *Neuropsychology, 18*(1), 152–162. https://doi.org/10.1037/0894-4105.18.1.152

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain, 123*, 2189–2202. https://doi.org/10.1093/brain/123.11.2189

Bechara, A., Tranel, D., Damasio, H., & Damasio, R. (1996). Failure to Respond Autonomically to Anticipated Future Outcomes Following Damage to Prefrontal Cortex. *Cerebral Cortex, 6*, 215–225.

Bernoulli, D. (1738). Exposition of a new theory on the measurement of risk. Transl. L Sommer, 1954. *Econometrica, 22*(1), 23–36.

Buelow, M. T., & Blaine, A. L. (2015). The Assessment of Risky Decision Making: A Factor Analysis of Performance on the Iowa Gambling Task, Balloon Analogue Risk Task, and Columbia Card Task. *Psychological Assessment, 27*(3), 777–785. http://doi.org/10.1037/a0038622

Camerer, C. F., Loewenstein, G., Prelec, D., The, S., Journal, S., Economics, B., Camerer, C. F., & Loewenstein, G. (2004). Neuroeconomics: Why Economics Needs Brains. *The Scandinavian Journal of Economics, 106*(3), 555–579. https://doi.org/10.1111/j.1467-9442.2004.00378.x

Cavedini, P., Zorzi, C., Baraldi, C., Patrini, S., Bellodi, L., Freire, R. C., Perna, G., Cavedini, P., Zorzi, C., Baraldi, C., Patrini, S., Bellodi, L., Freire, R. C., Perna, G. (2012). The somatic marker affecting decisional processes in obsessive-compulsive disorder. *Cognitive Neuropsychiatry, 17*(2), 177–190. https://doi.org/10.1080/13546805.2011.614152

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

Denys, D. (2011). Obsessionality & compulsivity: a phenomenology of obsessive-compulsive disorder. *Philosophy, Ethics and Humanities in Medicine, 6*(3), 1–7. https://doi.org/10.1186/1747-5341-6-3

Goudriaan, A. E., Oosterlaan, J., Beurs, E. De, & Brink, W. Van Den. (2004). Pathological gambling: a comprehensive review of biobehavioral findings. *Neuroscience and Biobehavioral Reviews, 28*, 123–141. https://doi.org/10.1016/j.neubiorev.2004.03.001

Goudriaan, A. E., Oosterlaan, J., Beurs, E. De, & Brink, W. Van Den. (2006). Psychophysiological determinants and concomitants of deficient decision

making in pathological gamblers. *Drug and Alcohol Dependence, 84*, 231–239. https://doi.org/10.1016/j.drugalcdep.2006.02.007

Grassi, G., Pallanti, S., Righi, L., Figee, M., Mantione, M., Denys, D., Piccagliani, D., Rossi, A., & Stratta, P. (2015). Think twice: Impulsivity and decision making in obsessive–compulsive disorder. *Journal of Behavioral Addictions, 4*(4), 263–272. https://doi.org/10.1556/2006.4.2015.039

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI Investigation of Emotional Engagement in Moral Judgment. *Science, 293*(5537), 2105–2109. htpps://doi.org/10.1126/science.1062872

Guillaume, S., Jollant, F., Jaussent, I., Lawrence, N., Malafosse, A., & Courtet, P. (2009). Somatic markers and explicit knowledge are both involved in decision-making. *Neuropsychologia, 47*, 2120–2124. https://doi.org/10.1016/j.neuropsychologia.2009.04.003

Hartley, C., & Fisher, S. (2018). Do Children with Autism Spectrum Disorder Share Fairly and Reciprocally?. *Journal of Autism and Developmental Disorders, 48*(8), 2714–2726. https://doi.org/10.1007/s10803-018-3528-7

Kable, J. W. (2011). The cognitive neuroscience toolkit for the neuroeconomist: A functional overview. *Journal of Neuroscience, Psychology and Economics, 4*(2), 63–84. https://doi.org/10.1037/a0023555

Kahneman, D., & Tversky, A. (1979). Prospect Theory: an analysis of decision under risk. *Econometrica, 47*(2), 263–292.

Knoch, D., Pascual-leone, A., Meyer, K., Treyer, V., & Fehr, E. (2006). Diminishing reciprocal fairness by disrupting the right prefrontal cortex. *Science, 314*, 829–833. https://doi.org/ 10.1126/science.1129156

Koenigs, M., Kruepke, M., & Newman, J. P. (2010). Economic decision-making in psychopathy: A comparison with ventromedial prefrontal lesion patients. *Neuropsychologia, 48*(7), 2198–2204. https://doi.org/10.1016/j.neuropsychologia.2010.04.012

Koenigs, M., & Tranel, D. (2007). Irrational economic decision-making after ventromedial prefrontal damage: evidence from the Ultimatum Game. *The Journal of Neuroscience, 27*(4), 951–956. https://doi.org/10.1523/JNEUROSCI.4606-06.2007

Lawrence, N. S., Wooderson, S., Mataix-cols, D., David, R., Speckens, A., Phillips, M. L. (2006). Decision making and set shifting impairments are associated with distinct symptom dimensions in Obsessive–Compulsive

disorder. *Neuropsychology, 20*(4), 409–419. https://doi.org/10.1037/0894-4105.20.4.409

Maia, T. V, & 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 National Academy of Sciences, 101*(45), 16075–16080. https://doi.org/10.1073/pnas.0406666101

Mitchell, D. G. V, Colledge, E., Leonard, A., & Blair, R. J. R. (2013). Risky decisions and response reversal: is there evidence of orbitofrontal cortex dysfunction in psychopathic individuals? *Neuropsychologia, 40*(12), 2013–2022. https://doi.org/10.1016/S0028-3932(02)00056-8

Nowak, M. A., Page, K. M., & Sigmund, K. (2000). Fairness Versus Reason in the Ultimatum Game. *Science, 289*(5485), 1773–1776. https://doi.org/10.1126/science.289.5485.1773

Nyman, J. A., Welte, J. W., & Dowd, B. E. (2008). Something for nothing: A model of gambling behavior. *The Journal of Socio-Economics, 37*, 2492–2504. https://doi.org/10.1016/j.socec.2008.02.011

Osumi, T., & Ohira, H. (2010). The positive side of psychopathy: Emotional detachment in psychopathy and rational decision-making in the ultimatum game. *Personality and Individual Differences, 49*(5), 451–456. https://doi.org/10.1016/j.paid.2010.04.016

Reimann, M., & Bechara, A. (2010). The somatic marker framework as a neurological theory of decision-making: Review, conceptual comparisons, and future neuroeconomics research. *Journal of Economic Psychology, 31*(5), 767–776. https://doi.org/10.1016/j.joep.2010.03.002

Riccardi, I., Stratta, P., & Rossi, A. (2015). When economic theory meets the mind: Neuroeconomics as a new approach to psychopathology. *Journal of Psychopathology, 21*, 141–144.

Sanfey, A. G., Loewenstein, G., Mcclure, S. M., & Cohen, J. D. (2006). Neuroeconomics: cross-currents in research on decision-making. *Trends in Cognitive Sciences, 10*(3), 108–116. https://doi.org/10.1016/j.tics.2006.01.009

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the Ultimatum Game. *Science, 300*(5626), 1755–1759. https://doi.org/10.1126/science.1082976

Sarlo, M., Lotto, L., Palomba, D., Scozzari, S., & Rumiati, R. (2013). Framing the Ultimatum Game: Gender differences and autonomic responses.

International Journal of Psychology, 48(3), 263–271. https://doi.org/10.1080/00207594.2012.656127

Schiebener, J., Zamarian, L., Delazer, M., & Brand, M. (2011). Executive functions, categorization of probabilities, and learning from feedback: What does really matter for decision making under explicit risk conditions? *Journal of Clinical and Experimental Neuropsychology, 33*(9), 1025–1039. https://doi.org/10.1080/13803395.2011.595702

Shiv, B., Loewenstein, G., Bechara, A., Damasio, H., & Damasio, A. R. (2005). Investment behavior and the negative side of emotion. *Psychological Science, 16*(6), 435–439. https://doi.org/10.1111/j.0956-7976.2005.01553.x

Sobhani, M., & Bechara, A. (2011). A somatic marker perspective of immoral and corrupt behavior. *Social Neuroscience, 6*(5–6), 640–652. https://doi.org/10.1080/17470919.2011.605592

Starcke, K., Tuschen-caffier, B., & Markowitsch, H. (2009). Skin conductance responses during decisions in ambiguous and risky situations in obsessive-compulsive disorder. *Cognitive Neuropsychiatry, 14*(3), 199–216. https://doi.org/10.1080/13546800902996831

Van't Wout, M., Kahn, S. R., Sanfey, A. G., & Aleman, A. (2006). Affective state and decision-making in the Ultimatum Game. *Experimental Brain Research, 169*, 564–568. https://doi.org/10.1007/s00221-006-0346-5

Vieira, J. B., Almeida, P. R., Ferreira-santos, F., Barbosa, F., & Marsh, A. A. (2014). Distinct neural activation patterns underlie economic decisions in high and low psychopathy scorers. *Social Cognitive and Affective Neuroscience, 9*, 1099–1107. https://doi.org/10.1093/scan/nst093

Weinstock, J., Massura, C. E., & Petry, N. M. (2013). Professional and Pathological Gamblers: Similarities and Differences. *Journal of Gambling, 29*, 205–216. https://doi.org/10.1007/s10899-012-9308-y

Weller, J. A., Levin, I. P., Shiv, B., & Bechara, A. (2007). Neural correlates of adaptive decision making for risky gains and losses. *Psychological Science, 18*(11), 958-964. https://doi.org/10.1111%2Fj.1467-9280.2007.02009.x

Young, L., Bechara, A., Tranel, D., Damasio, H., Hauser, M., & Damasio, A. (2010). Clinical study damage to ventromedial prefrontal cortex impairs judgment of harmful intent. *Neuron, 65*(6), 845–851. https://doi.org/10.1016/j.neuron.2010.03.003