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Impulsivity is associated with behavioral decision-making deficits

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Abstract

Impaired decision-making is a key-feature of many neuropsychiatric disorders. In the present study, we examined task performance in a healthy population consisting of those whose scores indicated high and low impulsivity on several behavioral decision-making tasks reflecting orbitofrontal functioning. The measures included tasks that assess decision-making with and without a learning component and choice flexibility. The results show that subjects high on impulsivity display an overall deficit in their decision-making performance as compared with subjects low on impulsivity. More specifically, subjects with high impulsivity show weaknesses in learning of reward and punishment associations in order to make appropriate decisions (reversal-learning task and Iowa Gambling Task), and impaired adaptation of choice behavior according to changes in stimulus–reward contingencies (reversal-learning task). Simple, non-learning, components of reward- and punishment-based decision-making (Rogers Decision-Making Task) seem to be relatively unaffected. Above all, the results indicate that impulsivity is associated with a decreased ability to alter choice behavior in response to fluctuations in reward contingency. The findings add further evidence to the notion that trait impulsivity is associated with decision-making, a function of the orbitofrontal cortex.

Keywords: Reversal learning; Decision-making; Impulsivity; Frontal functions; Reward

1. Introduction

Decision-making is a cognitive function concerned with the process of reflecting on the consequences of a certain choice (Bechara, 2005). In recent years, decision-making functions have become a major research topic within neuropsychology, cognitive psychology, neuroscience, and economics. One of the topics of interest is the role of emotions on decision-making. In contrast to earlier theories that viewed decision-making as a rational choice, it is now believed that human decision-making is mainly based on emotions, especially on the expected hedonic outcome of the choice (Cabanac, 1992).[1] In some classical studies, Bechara et al. (1994, 2000a) demonstrated that patients with frontal lobe damage have problems with emotional decision-making: they often pursue actions that bring some kind of immediate reward, despite severe long-term consequences such as the loss of job, home, and family. Several psychiatric and neurological conditions have been associated with such specific disturbances in emotional decision-making (for

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[1] Recent studies highlight the importance of explicit strategy and knowledge in decision-making, especially in the Iowa Gambling Task (Maia and McClelland, 2004).

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reviews, see Rahman et al., 2001; Brand et al., 2006). For example, impaired decision-making has been reported in relation to addiction (Hester and Garavan, 2004), frontal lobe dementia (Rahman et al., 1999), borderline personality disorder (Bazanis et al., 2002), attention deficit hyperactivity disorder (Toplak et al., 2005), eating disorders (Cavedini et al., 2004), obsessive-compulsive disorders (Cavedini et al., 2002a), pathological gambling (Cavedini et al., 2002b), and disruptive behavior disorders (Ernst et al., 2003). One topic that needs to be resolved is whether these deficits are specific for clinical populations (Rogers, 2003). As it is well known that the personality trait of impulsivity is a major ingredient of several psychiatric (Moeller et al., 2001), personality (Rogers, 2003), and neurological disorders (Miller, 1992), including the aforementioned disorders. In the burgeoning neuropsychopharmacological literature on decision-making, the personality trait of impulsivity has been frequently suggested to be associated with weaknesses in decision-making. That is, impulsive persons display a decreased reflection on the consequences of their choice.

These suggestions are in keeping with the notion that real-life decision-making involves choices that are based on expected but uncertain rewards and penalties, and that optimal choices are based on well-considered strategies. As such, it seems plausible to assume that impaired decision-making reflects a variety of impulse control problems (Morgan et al., 2006). Two studies addressed the relationship between impulsivity and decision-making in healthy subjects. A first study by Franken and Muris (2005) examined the link between decision-making, as indexed by the Iowa Gambling Task, and individual differences in functional and dysfunctional impulsivity and the impulsivity-related trait of reward sensitivity. The researchers found no relation between Iowa Gambling Task performance and dysfunctional impulsivity scores. However, reward sensitivity, a trait associated with impulsivity, was significantly related to the Iowa Gambling Task score. Surprisingly, this link was positive, suggesting that a higher level of an impulsivity-related trait is associated with better decision-making. In another study, also using the Iowa Gambling Task, Zermatten et al. (2005) found that decision-making was influenced by the impulsivity-related trait of 'lack of premeditation'. Higher scores on 'lack of premeditation' were positively linked to disadvantageous decision-making. Thus, while there is certain clinical evidence for the detrimental effects of impulsivity on decision-making, studies in non-clinical samples have yielded less convincing results. This may well have to do with the fact that these studies have only employed one specific test of decision-making, the Iowa Gambling Task, so it remains to be seen whether different findings will emerge if other behavioral tests of decision-making are used.

In this study, we focus on three decision-making tasks reflecting related but distinct aspects of decision-making: the Iowa Gambling Task (Bechara et al., 1994), which measures affective decision-making and includes a learning component, the Rogers Decision-Making Task (Rogers et al., 1999a), which also taps affective decision-making but does not include a learning component, and a probabilistic reversal-learning task (O'Doherty et al., 2001), which assesses affective decision-making with a learning component as well as the ability to alter choice behavior in response to fluctuations in reward contingency. In more detail, the Rogers Decision-Making Task taps explicit decision-making strategies without a reward-based learning element. This means that for each trial, all relevant information is presented to the participant; the participant does not need previously learned information in order to make a correct decision. The Iowa Gambling Task, on the other hand, measures decision-making strategies in which the participant has to learn to discriminate the advantageous choices from the disadvantageous choices. This means that the Iowa Gambling Task, unlike the Rogers Decision-Making Task, requires reward-based learning capacity (Fellows, 2004). The reversal-learning task (Rolls, 1999), measures not only reward-based learning but is also designed to index the adaptation of behavior according to changes in stimulus–reward contingencies (i.e., reversal learning; Clark et al., 2004), a capacity which is regarded as a basic requirement for normal social and emotional behavior (Cools et al., 2002; Kringelbach and Rolls, 2003; Rolls, 1996). Emotion-related visual reversal-learning tasks reflect the ability to alter choice behavior in response to fluctuations in reward contingency (Rahman et al., 1999). To summarize, all the tasks used in the present study reflect decision-making under risk. The Rogers Decision-Making Task only measures reward-based decision-making. The Iowa task adds a reward-based learning aspect to the decision-making process, whereas the probabilistic reversal task adds both a reward-based learning aspect and a reversal aspect[2] that measures adaptive decision-making skills.

Neuroimaging studies, which employed decision-making tasks without a learning element similar to the

[2] It can be argued that the Iowa task also comprises a reversal-learning aspect as the disadvantageous decks offer higher gains at the beginning of the task compared with decks C and D. However, this reversal aspect is minimal compared with the reversal-learning task.