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Emotional decision-making and its dissociable components in schizophrenia and schizoaffective disorder: A behavioural and MRI investigation

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Abstract

Cognitive decision-making is known to be deficient, but relatively less is known about emotional decision-making in schizophrenia. The Iowa gambling task (IGT) is considered a reliable probe of emotional decision-making and believed to reflect orbitofrontal cortex (OFC) function. The expectancy-valence model of IGT performance implicates three dissociable components, namely, attention to reward, memory for past, relative to recent, outcomes and impulsivity in emotional decision-making. We examined IGT performance, its three components, and their grey matter volume (GMV) correlates in 75 stable patients with schizophrenia, relative to 25 healthy individuals. Patients, relative to controls, showed impaired IGT performance and poor memory for past, relative to recent, outcomes. IGT performance correlated with GMV in the OFC in controls, but not patients. There were associations between (a) attention to reward and GMV in the frontal, temporal, parietal and striatal regions in controls, and in the temporal and thalamic regions in patients, (b) memory for past outcomes and GMV in the temporal region in controls, and the frontal and temporal regions in patients, and (c) low impulsivity and greater GMV in the frontal, temporal, posterior cingulate and occipital regions in controls, and in the frontal, temporal and posterior cingulate regions in patients. Most IGT-GMV associations were stronger in controls. It is concluded that (i) poor memory, rather than less attention to reward or impulsivity, contributes to IGT performance deficit, and (ii) the relationship of IGT performance and its components with GMVs especially in the frontal and temporal lobes is lost or attenuated in schizophrenia.

Keywords: Reward; Impulsivity; Memory; Iowa gambling task; Grey matter

1. Introduction

Decision-making in schizophrenia has been studied in different ways and been found to be poor in certain domains (review, Jeste, Depp, & Palmer, 2006). One type of decision-making is gambling, as assessed by the Iowa gambling task (IGT), where choices are made under conditions of uncertainty. This type of decision-making is motivated by reward and has been regarded as a type of emotional decision-making (Pecchinenda, Dretsch, & Chapman, 2006; Turnbull, Evans, Bunce, Carzolio, & O'Connor, 2005).

The IGT was first used to study emotional decision-making among people with a lesion in the orbitofrontal cortex (OFC, Bechara, Damasio, Damasio, & Anderson, 1994). On this task, participants choose cards from advantageous and disadvantageous decks, such that choosing from the disadvantageous decks is associated with greater immediate monetary reward compared to the advantageous decks, but an overall greater monetary loss compared to the advantageous decks. Choices made are likely to involve a number of cognitive and behavioural functions as the four decks of cards differ in the size and frequency of rewards/punishments. Decks A and B yield larger immediate gains ($100) than decks C and D ($50), but also yield larger losses (ranging from $100 to $1250) than decks C and D (ranging from $25 to $250), so that participants would incur a net loss over time (on average, $25 loss per card selection) by picking

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cards from decks A and B and a net gain over time (on average, $25 gain per card selection) by picking cards from decks C and D. Effective task performance would draw on the ability to attend to and keep online information about reward size and frequency associated with a particular deck (Yarkoni, Braver, Gray, & Green, 2005).

The expectancy-valence model of IGT (Busemeyer & Stout, 2002; Yechiam, Busemeyer, Stout, & Bechara, 2005; Yechiam, Veinott, Busemeyer, & Stout, 2007) is a cognitive model based on reinforcement learning. By simulating behaviour using computational algorithms, the expectancy-valence model allows testable predictions to be made about performance levels at different times under different conditions (Busemeyer & Stout, 2002) and in specific clinical populations (Yechiam et al., 2007). It simulates the behaviour of a person who makes a series of choices, each based on the outcome from the previous choices, without any knowledge of the actual distribution of the pay-off associated with each choice (Yechiam et al., 2007). The decision-maker integrates the gains and losses experienced on each trial into a single affective reaction called a valence. The model assumes that three components determine an individual's pattern of performance on the IGT.

Attention to reward assesses an individual's ability to guide his/her strategy based on gains or losses received during the task. High values of this component indicate greater attention to gains rather than losses and a reward-driven performance style.

Memory for past, relative to recent, *outcomes* describes the degree to which expectancies of deck consequences reflect the influence of past experiences with particular decks, or rather appear to be affected by the most recent outcome with a deck. High values of this component indicate *strong* recency effects such that the most recent trials are more influential in determining the expectancy, whereas past outcomes are discounted.

Impulsivity evaluates the reliability with which the decision maker applies expectancies about each deck when making the card selection. High values of this component indicate that the deck with maximum expectancy will almost certainly be chosen on each trial and therefore greater choice consistency. Low values reflect an inconsistent, random and impulsive choice behaviour.

IGT performance has been studied in schizophrenia, with several studies reporting no difference between patients and controls (Ritter, Meador-Woodruff, & Dalack, 2004; Rodriguez-Sanchez et al., 2005; Shurman, Horan, & Nuechterlein, 2005; Wilder, Weinberger, & Goldberg, 1998). One study reported poorer emotional decision-making in adolescents with schizophrenia compared to healthy controls (Kester et al., 2006), and another study (Bark, Dieckmann, Bogerts, & Northoff, 2005) reported comparable emotional decision-making between patients with paranoid schizophrenia and healthy controls, but poorer emotional decision-making among patients with catatonic schizophrenia. Cognitive function and decision-making may be influenced in people with schizophrenia by emotion (Barch, 2005), and additionally by motivation (Busemeyer & Stout, 2002). There is a need for further research into motivation and emotion and their potential influences on cognitive function and decision-making in schizophrenia.

At the brain level, IGT performance is thought to reflect optimal functioning of the OFC (Bechara et al., 1994) when processing information about reward value, such as the reward size and frequency associated with a particular deck. The neural basis for reward, delineated and studied extensively among people with an addiction, is a mesolimbic thalamo-striatal prefrontal dopamingeric system (Everitt & Robbins, 2005). Dopaminergic neuronal somata in the ventral tegmentum project directly (monosynaptically) via their efferent axons to important forebrain structures that include the nucleus accumbens (ventral striatum), areas of prefrontal cortex (especially the orbitofrontal and anterior cingulate cortices) and neocortical areas, amygdala, lateral septum, thalamus, hippocampus and red nucleus of the stria terminalis (Carlson, 2007; Everitt & Robbins, 2005). Animal studies suggest that lesions in the thalamus disrupt reward-based learning (Corbit, Muir, & Balleine, 2003; Sastre & Reilly, 2006). More specifically, lesions in the medial thalamus impair learning associated with memory for reward value (Mitchell & Dalrymple-Alford, 2005). The caudate nucleus (ventral striatum) may be involved in the initial stages of emotional decision-making when reward-related contingencies are being learned (Delgado, Miller, Inati, & Phelps, 2005). The OFC is thought to hold information about reward in working memory (Gilbert & Fiez, 2004; Hikosaka & Watanabe, 2000; Schoenbaum & Setlow, 2001) and is deactivated when a reward-related cue is followed by a delay in providing the reward (Gilbert & Fiez, 2004). Lesions in the OFC impair one's ability to learn when previous reward associations no longer apply (review, Frank & Claus, 2006). The OFC has also been implicated in impulsivity. Impulsive individuals are reported to require greater OFC activity than those low on impulsivity to achieve response inhibition (Horn, Dolan, Elliott, Deakin, & Woodruff, 2003).

In this study, we examined IGT performance and its dissociable components according to the expectancy-valence model in 75 patients with schizophrenia and compared them with a group of 25 healthy controls who, on average, were matched to the patient group on age and sex. We further aimed to elucidate and compare the grey matter correlates of emotional decision-making and its dissociable components in the two groups using voxel-based morphometry. This technique allows the examination of correlations between grey matter volume and behavioural measures on a voxel-by-voxel basis across the entire brain rather than limiting the search to certain regions of interest (Gaser & Schlaug, 2003).

We hypothesized, based on previous evidence mentioned earlier, no or minimal performance impairment on the IGT in patients relative to the controls. In the case of impaired performance in patients, we expected deficient memory for previous outcomes to be the primary contributor to this deficit given that this population is frequently reported to suffer from a memory deficit (Aleman, Hijman, de Haan, & Kahn, 1999; Heinrichs & Zakzanis, 1998). We predicted stronger positive associations between IGT learning (overall) and grey matter volume in the OFC in controls than patients given previous observations of widely reported reduced grey matter volume in the prefrontal cortex (review, Molina, Sanz, Sarramea, Benito, & Palomo,