

DECISION-MAKING IN EARLY PSYCHOSIS

An Exploration of Decision-Making by Individuals Who Have Received Specialized
Treatment for Early Psychosis

by

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Abstract

Decision-making is a critical life skill, integral for guiding behaviour. Previous research has demonstrated that decision-making is frequently impaired across a range of psychiatric disorders including schizophrenia. Although a concerted research effort has recently been focused on understanding decision-making in chronic schizophrenia, the current study was conceived to provide an initial exploration into the decision-making process of individuals who received specialized treatment for early psychosis. We investigated the decision-making ability of 16 patients enrolled in an early psychosis (EP) program and 20 healthy controls based upon their performance on the Iowa Gambling Task (IGT) and Game of Dice Task (GDT). Additional measures of neuropsychological functioning were also examined. Differences in ambiguous decision-making (IGT) were observed, with the EP group performing significantly worse than the healthy control group. Additionally, there were no differences between the two groups observed in risky decision-making (GDT). The only neuropsychological variable that correlated with decision-making performance across tasks was that of working memory. More specifically, measures of IGT ability significantly correlated with working memory performance for the EP group but not the healthy controls. As such, the current study illustrates an important role for working memory in making ambiguous decisions. It is possible that individuals with EP experience difficulty maintaining mental representations of expected value. Therefore, it is more difficult to utilize feedback from the previous trials to impact positively on future choices and rewards that are not immediately present in the environment. The clinical implications of these findings are discussed for

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understanding decision-making by individuals who experienced early psychosis, and how decision-making impairments could be accommodated for by treatment programs.

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Introduction

Importance of decision-making

In everyday life the ability to make decisions based on past experience and to modify those decisions to optimize outcomes is an essential skill (Ernst & Paulus, 2005). Decision-making refers to the selection of a specific option from a set of alternatives anticipated to produce varying results (Lee, 2013). Learning the consequences of an action and the value of those consequences are necessary precursors for making adaptive decisions (Griffiths, Morris, & Balleine, 2014). The integration of causal knowledge and reward value is essential for successful decision-making and failure to do so can lead to detrimental consequences for real-world functioning (Barch & Dowd, 2010).

Dysfunctional decision-making is common across a range of psychiatric disorders including schizophrenia (Larquet, Coricelli, Opolczynski, & Thibaut, 2010; Griffiths et al., 2014). Often considered the most debilitating mental illness, schizophrenia affects 1% of the population and leads to significant economic burden on society (Chong et al., 2016). Positive and negative symptoms, such as hallucinations, delusions, blunted affect, cognitive impairments, and lack of motivation can have considerable impact on functioning (Lee, 2013; Walker et al., 2004). However, it has been suggested that one of the greatest functional impacts of schizophrenia is not related to symptoms such as delusions and hallucinations, but its role in the inability of the individual to make successful decisions (Caceda, Nemeroff, & Harvey, 2014).

Managing an illness such as schizophrenia requires numerous decisions, including adherence to medications, attending outpatient appointments, and minimizing the use of

drugs and alcohol, be made on a daily basis (Caceda et al., 2014). Successful decision-making can help to prevent negative consequences such as deterioration of symptoms, relapse and rehospitalization (Caceda et al., 2014). For these reasons, studies focused on understanding decision-making impairments in schizophrenia are of critical importance.

Recent explorations of decision-making impairments in schizophrenia have focused on the mechanisms of reinforcement learning and reward processing (Gold, Waltz, Prentice, Morris, & Heerey, 2008; Strauss, Waltz, & Gold, 2014; Chang, Waltz, Gold, Chan, and Chen, 2016). An expanding neuroscience literature has begun to outline critical frontostriatal circuitry that translates reward and penalty signals into value estimates to be used in decision-making (Barch & Dowd, 2010). It has been hypothesized that individuals with schizophrenia have difficulty utilizing internal representations of prior rewards to facilitate successful decision-making (Barch & Dowd, 2010).

To date there is a relatively small body of research exploring the struggles that individuals with schizophrenia experience when making decisions (Struglia et al., 2011). The majority of this research has been conducted in individuals with chronic schizophrenia with less attention spent on examining whether those in the early stages of the illness suffer the same degree of decision-making impairment. Research suggests that the six-month period following onset of psychosis may be a particularly important period for intervention (Addington et al., 2015; Birchwood et al., 2013). Johansen and colleagues (2011) concluded that adaptive decision-making during the early stages of psychosis is important for treatment engagement, which is critical for functional recovery.

While the aforementioned study highlighted the importance of successful decision-making by those enrolled in early psychosis programs, the literature to date has only minimally explored decision-making during the early stages of the disease progression. It is well established in the research literature that individuals experiencing early psychosis have fewer neurocognitive deficits compared to those who have had multiple psychotic episodes with periods of nonadherence to medical treatment (Addington & Addington, 2002). Therefore, the current study will examine the relationship between neurocognitive functioning and decision-making in early psychosis. It is expected that common neurocognitive impairments associated with psychosis, such as working memory and executive functioning will lead to significant difficulties in decision-making. The current study will examine whether neurocognitive functioning in individuals with early psychosis impacts their ability to interpret both ambiguous and explicit or risky information necessary for successful decision-making. To the best of our knowledge, the present study is the first to examine the association between neurocognitive functioning and both ambiguous and risky decision-making in individuals receiving specialized treatment for early psychosis. Given the paucity of research findings in decision-making and early psychosis patients, this study will be primarily exploratory in nature with a naturalistic sample enrolled in an outpatient Early Psychosis Program at a local psychiatric hospital.

The remainder of the introduction aims to further elaborate on decision-making and its relevance for individuals experiencing symptoms of early psychosis, who might benefit most from interventions. Specific emphasis is placed upon reinforcement learning

theory, dysfunction of the orbitofrontal cortex (OFC), and explorations of ambiguous and risky decision-making to date. It is important to note that a majority of the previous research exploring decision-making has been conducted on individuals diagnosed with schizophrenia, who have progressed past the point of early psychosis. Where possible, effort has been made to include relevant data from studies of individuals experiencing early psychosis.

Theories of decision-making

Early probabilistic theories operated largely on assumptions that humans were capable of utilizing statistical probabilities in order to make the best possible decisions (Lee, 2013). Individuals utilized rational principles in order to estimate probable costs and benefits associated with various outcomes thereby guiding decision-making to theoretically select the option associated with the best expected value. These theories addressed the issue of what was the best or optimal choice for a given type of decision-making problem (Lee, 2013). A challenge arose in that these theories required the potential outcomes of choices to have objective values that could be captured by an associated number and probability.

The Expected Utility theory (EU theory) of rational decision-making was first postulated by Daniel Bernoulli and expanded upon by von Neumann and Morgenstern (1944). This important economic theory described individual rational decision-making and introduced the concept of utility associated with various options. The utility, or subjective value, based upon personal preferences, was incorporated into the calculations

individuals made when choosing between different alternatives. Utilities can be modelled as functions to indicate preferences for risk-averse and risk-prone behaviour. In EU theory it is suggested that individuals generally dislike risk and are risk averse, however a challenge to EU theory stemmed from the demonstration that this is not always the case (Kahneman & Tversky, 1979).

In order to address some of the limitations of EU theory, Kahneman and Tversky (1979) developed Prospect Theory based in part on observations that in everyday life people often violate the rules of rational decision-making. A major advance was the recognition that most people respond differently towards gambles involving gain and those involving loss. As such, Prospect Theory proposes that the subjective value attributed to an outcome is in part based upon whether there is the potential of either gain or loss. A key characteristic is that the value function is inverse for gains and losses in that individuals tend to be risk averse for potential gains while seeking risk when faced with potential losses (Tversky & Kahneman, 1981). Tversky and Kahneman (1981) conducted a now famous study highlighting how changes in perspective often reverse the relative desirability of choices. Data were obtained from brief questionnaires given to students at the University of British Columbia as well as Stanford University. As described in Tversky and Kahneman (1981) participants were told to imagine that the US was preparing for an outbreak of an unusual disease expected to kill 600 people. Two different programs were proposed to combat the disease. One group of study participants were informed that if Program A was adopted, 200 people would be saved, while if Program B was adopted, there was a 1/3 probability that 600 people would be saved, and

a $2/3$ probability that nobody would be saved. The majority of participants opted to be risk averse, concluding that the prospect of definitely saving 200 lives was a better option than the risky prospect of equal expected value, namely a $1/3$ chance of saving all 600 people (Tversky & Kahneman, 1981). A second group of participants were informed that if Program C was adopted 400 people would die, whereas if Program D was adopted there was $1/3$ probability that nobody would die, and a $2/3$ probability that 600 people would die. When faced with these options, the majority of participants were more inclined to take the risk, that is the certain death of 400 people was less acceptable than the $2/3$ chance that 600 would die. As demonstrated, when given a decision between a certain gain and a gamble with the same expected value, most people are risk averse. In contrast, when faced with a decision involving a certain loss and a gamble, people are much more likely to take the risk and select the gamble (Tversky & Kahneman, 1981).

EU and Prospect Theory sought to provide rational models for the decision-making process. However, the actual behaviour of humans is frequently unpredictable. Therefore, more recent research has sought to identify a set of principles that can account for the actual choices made by humans and animals (Lee, 2013). Choices made in real life are complex, and it is often necessary to make appropriate changes based upon experience. More specifically, the probability that a particular choice will again be made will vary depending on whether its previous outcome was either punishing or reinforcing (Thorndike, 1911; Lee, 2013). In addition, new information about events in our environment can be used to improve the outcomes of our choices (Lee, 2013; Sutton & Barto, 1998; Tolman, 1948). As new information is attained, individuals can utilize this

knowledge to update the expected outcome from specific choices, resulting in improved decision-making strategies (Lee, 2013; Tolman, 1948).

Reinforcement learning theory

The objective of reinforcement learning is to maximize future rewards by taking into account previous experience. Reinforcement learning theory provides an important computational framework for exploring the impact of experience upon decision-making strategies (Glimcher, Camerer, Fehr, & Poldrack 2009; Lee, 2013; Sutton & Barto, 1998). In reinforcement learning theory, it is assumed that the individual's action and environment determine the amount of reward received (Lee, 2013; Lee & Seo, 2007). The objective of learning is to maximize future rewards referred to as return. The individual estimates the expected return, referred to as value function, which cannot be completely known because of the individual's limited knowledge of its environment. If the value functions correctly predict the future rewards, then the actual reward and the expected reward estimated from the value functions will be equal. If they are not the same, then value functions can be updated based upon the difference between the expected and actual rewards (Lee & Seo, 2007). Reinforcement learning theory explains how experience allows an individual to modify value functions for a certain action under certain conditions, thereby influencing future decisions (Khani & Rainer, 2016).

Value functions can be updated according to the reward or penalty received following each action. If the outcome of a decision was always perfectly predicted from the current value functions, then value functions would not change and no learning would

be necessary (Lee, Seo, & Jung, 2012). Otherwise, value functions must be modified to reduce errors in reward predictions. The reward prediction error (RPE) refers to the difference between the actual reward and the reward expected by the current value functions (Sutton & Barto, 1998). Seminal work by Schultz (1998) and others has highlighted an important role for dopamine in reward prediction. More specifically, dopamine cell firing appears to code RPEs. Dopaminergic cell firing briefly ceases when outcomes are worse than expected (negative RPE) and increases when presented with better than expected outcomes (positive RPE). Research indicates that positive RPE signals are transmitted to dopamine cell target areas thereby reinforcing currently active motor responses and representations (Gold et al., 2012). In contrast, decreases in dopamine cell activity indicate that current actions should be avoided as they have led to poorer-than-expected outcomes. Reinforcement learning algorithms have successfully modeled this pattern of dopamine cell firing, providing reliable support for the idea that phasic dopaminergic signaling modifies synaptic plasticity in circuits associated with action selection (Gold et al., 2012). In summary, the dopamine system seems to be involved in identifying and learning about new rewards and associations, and utilizing this information to facilitate decision-making (Kapur, 2003; Deserno, Schlagenhauf, & Heinz, 2016; Schultz, 2013).

Reinforcement learning research regularly demonstrates that subjective values are learned through frequent updating based on experience, with the goal of reinforcement learning being the maximization of future rewards (Lee et al., 2012). Considerable research has studied value function estimations according to multiple different

algorithms, with computational theories of reinforcement learning playing a key role in the developing field of decision neuroscience (Gold et al., 2012; Lee et al., 2012). While advanced computational algorithms move beyond the scope of the current research, a detailed review of the neural basis of reinforcement learning and decision-making was provided by Lee and colleagues (2012).

Time scales of reinforcement learning

In order to maximize adaptive performance reinforcement learning occurs on multiple time scales (Gold et al., 2008). The basal ganglia (BG) has been shown to play an important role in integrating longer term reinforcement outcomes in the “slow” or procedural reinforcement learning system. In the BG, reinforcement outcomes influence subsequent behavioural choices through synaptic plasticity in response to RPEs signaled by dopamine neurons (Gold et al., 2012). The activity of midbrain dopaminergic neurons plays an important role. Rewards function as teaching signals about which stimuli and responses are associated with specific outcomes (Stopper & Floresco, 2015). Learning in such cases is often slow because many trials are needed to develop dependable predictions based upon outcomes (Ziauddeen & Murray, 2010). As such, specific motor habits begin to develop as the BG system slowly integrates positive and negative outcomes over multiple trials (Frank & Claus, 2006). Over a number of learning trials, dopamine is thought to mediate the motivational salience. As such, reward-associated stimuli come to demand attention and therefore become a focus when making decisions.

In contrast to the slow reinforcement learning system, the second system which governs rapid learning is mediated by the prefrontal cortex, particularly the OFC. The OFC plays a critical role in the “rapid” reinforcement learning system by functioning on a trial-by-trial basis to update mental representations of the relative value of different alternatives (Strauss et al., 2014; Fellows, 2011). The OFC is a complex structure that receives widespread input from limbic, sensory, and basal ganglia regions (Wallis, 2007). The OFC receives and codes sensory and perceptual information for reward value and plays an important role in feedback processing and decision-making (Krawczyk, 2002; Wallis, 2007). In addition, the OFC serves as an interface between subjective reward value and the subsequent processing associated with alternate regions such as the dorsolateral prefrontal cortex (DLPFC) (Krawczyk, 2002).

OFC dysfunction in schizophrenia

Disruption in OFC function may lead to impairments in the ability to successfully integrate relevant sensory stimuli and previously learned associations (Bechara, Damasio, & Damasio, 2000a; Homayoun & Moghaddam, 2008). This mode of disruption may be a critical component of schizophrenia symptomatology as considerable research has demonstrated the occurrence of OFC abnormalities in schizophrenia (Homayoun & Moghaddam, 2008; Larquet et al., 2010; Barch & Dowd, 2010). Structural neuroimaging studies have explored reduction of grey matter volume (GMV) in the OFC of patients with schizophrenia. A study by Nakamura and colleagues (2008) compared 24 patients with schizophrenia with 25 age-matched healthy controls, looking specifically at OFC volume. The results demonstrated OFC GMV deficits for those with schizophrenia. The

authors reported that those with a longer duration of illness exhibited greater OFC GMV deficits. Similarly, a more recent study also reported reductions of GMV in the bilateral OFC for schizophrenia patients (Liao et al., 2015). Liao and colleagues tested 93 patients and reported that 50% were experiencing their first episode of psychosis. Therefore, the presence of OFC deficits in individuals early in disease progression suggests that OFC irregularities are not a consequence of chronic treatment with antipsychotic medication, but more likely a disease component (Liao et al., 2015).

The OFC utilizes different sources of information about value over a short period of time (Barch & Dowd, 2010; Frank & Claus, 2006; Wallis, 2007), and this type of rapid learning is critical for behavioural flexibility and subsequent decision-making in the presence of changing outcomes. As such, individuals with schizophrenia demonstrate impairments when performing cognitive tasks, such as the Iowa Gambling Task, a task which involves feedback processing and has typically been used to assess OFC function (Homayoun & Moghaddam, 2008; Bechara, Damasio, Damasio, & Anderson, 1994). There is also consistent evidence that patients are impaired at making rapid behavioural adjustments in response to feedback on a trial-by-trial basis to guide response selection (Gold et al., 2008). The OFC seems to be particularly involved in complex situations where significant processing is required to determine the value of the outcome, something that is crucial to making decisions under conditions of ambiguity. Ambiguous situations require an individual to decide between different options without explicit knowledge about the outcomes or the possibilities for punishment and reward (Euteneuer et al., 2009).

Decision-making under ambiguity and decision-making under risk

Not all decisions are made under the same circumstances and from a neuropsychological perspective, many decision situations can be categorized into decisions under ambiguity or decisions under risk (Gleichgerrcht, Ibanez, Roca, Torralva, & Manes, 2010). The OFC has been posited to play an integral role in making decisions under ambiguity (Bechara, Dolan, Denburg, and Hindes, 2002). Ambiguous situations require decisions to be made without knowledge of the possible outcomes or the probabilities for punishment or reward. The OFC is believed to play such a critical role at least in part because of its ability to integrate information and update representations of value on the basis of feedback (Brand, Recknor, Grabenhorst, & Bechara, 2007). On tasks assessing ambiguous decision-making, participants typically must be able to utilize the feedback following a choice in order to identify successful strategies. In other situations, the possible outcomes are also uncertain, but depend on known probabilities, and these decisions are often referred to as decisions under risk (Brand et al., 2007). The dorsolateral prefrontal cortex (DLPFC) has been implicated in decisions under risk. Research has demonstrated a role for the DLPFC in control of planning and cognitive processing (Wallis, 2007; Krawczyk, 2002). Studies have highlighted the importance of cognitive flexibility and performance on categorization tasks in regard to making successful decisions in risky situations (Brand, Labudda, & Markowitsch, 2006; Brand et al, 2005a; Brand et al., 2005b). Furthermore, in many tasks assessing decisions made under risk, the importance of using cognitive strategies in order to make successful

choices is apparent as the rules, gains and losses are precisely defined (Delazer et al., 2009).

Measuring ambiguous decisions

In 1994, a seminal paper was published which first described the Iowa Gambling Task (Bechara et al., 1994). Since that time, the Iowa Gambling Task (IGT) has been used extensively to examine decision-making in ambiguous situations. The IGT was developed to simulate decision-making processes thought to be associated with how the OFC processes and integrates feedback specific to uncertainty, punishment, and reward (Bechara et al., 1994; Struglia et al., 2011). In the computerized version of the IGT, individuals are asked to choose between four separate decks of cards (A, B, C, D) in order to accumulate as much fictional money as possible. Each card choice leads to either a variable financial gain or loss as possible choices are either advantageous or disadvantageous (Dunn, Dalgleish, & Lawrence, 2006). Each choice is full of ambiguity and prior to selection, it is impossible to exactly calculate the outcome of each choice. The rules for gains and losses are implicit, thus, participants have to learn to avoid the disadvantageous choices and prefer the advantageous by using the feedback (amount of gain or loss) following each trial. The goal is to maximize profit across the 100 choices by making advantageous choices more frequently (Bechara et al., 1994; Weller, Levin, & Bechara, 2010). Normal performance on the IGT appears to require reversal learning, which necessitates individuals update stimulus-reinforcement associations as changes to reinforcement contingencies occur (Fellows & Farah, 2005). Initially, cards are presented

in a fixed order that induces a preference for the riskier decks, however, that strategy needs to be modified as losses begin to accumulate (Fellows & Farah, 2005).

Previous research has shown impairments in IGT performance in individuals with schizophrenia (Brown et al., 2015). Given the links between schizophrenia and the OFC, and OFC dysfunction and impairments on the IGT it is important to consider IGT performance for individuals' experiencing schizophrenia. Brown and colleagues (2015) conducted a small meta-analysis based on eight previous studies indicating that in comparison to controls, patients with schizophrenia made more selections from disadvantageous decks and less from the advantageous decks. The disadvantageous decks (A and B) yield larger immediate gains than decks C and D, but also lead to greater losses, ultimately making them disadvantageous over time. The meta-analysis also demonstrated that the two decks which showed the most divergence across groups were decks B and D, the decks which deliver larger but less frequent punishments and require a more complex calculation of expected value across trials (Brown et al., 2015). Patients responded significantly more for deck B compared to controls and significantly less than controls for deck D. This raises the possibility that the IGT deficit in schizophrenia arises from a problem in calculating expected value rather than a reduced awareness of punishment. Brown and colleagues (2015) sought to explore possible sources of IGT deficits in schizophrenia. While patients selected more frequently from disadvantageous decks, patients and controls did not differ in their rates of choosing from decks with frequent punishments. This suggests patients can effectively use information about outcome frequency but struggle to use information about the magnitude of outcomes. The

authors suggested that a deficit in integrating information about outcome magnitude and frequency is particularly problematic. Subsequent challenges in reinforcement learning occur as the lack of integration can lead to problems in precisely representing and updating the expected value on a trial-by-trial basis (Brown et al., 2015).

The impact of neurocognitive impairments on ambiguous decision-making by those with early psychosis or schizophrenia

Research suggests that cognitive impairments in schizophrenia reduce the ability to use immediate reinforcements to alter behaviour across trials during ambiguous decision-making tasks (Heerey, Bell-Warren, & Gold, 2008). Neurocognitive impairments have been explored at various stages in the psychosis continuum. In general, research has shown that people experiencing their first episode of psychosis are typically already experiencing cognitive deficits (Addington & Addington, 2002). While these individuals may not demonstrate the severity of cognitive impairment of those who have experienced multiple psychotic episodes, research suggests they are more impaired than normal controls (Addington & Addington, 2002). For example, in a one-year follow-up study, individuals with first episode psychosis had superior test results on a number of neurocognitive tasks compared to those who had experienced multiple psychotic episodes. It is important to note that while the first episode psychosis individuals performed better than those who experienced multiple episodes, their overall performance was still lower than the normal range, indicating a degree of impairment (Addington & Addington, 2002). A comprehensive meta-analysis conducted by Mesholam-Gately and colleagues (2009) examined the results of 43 studies with a total of 2,204 participants

categorized as first episode psychosis compared to 2,775 control participants. Overall, the results demonstrated that first episode psychosis or early phase schizophrenia individuals showed statistically significant deficits across a number of neuropsychological domains. In fact, it was shown that there were significant differences at the group level between psychosis and control groups for all cognitive variables examined (Mesholam-Gately, Giuliano, Faraone, Goff, & Seidman, 2009). Considerable impairments were noted across processing speed and immediate verbal memory. Deficits were also observed in full-scale IQ estimates as well as measures of attention and executive functioning (Mesholam-Gately et al., 2009). Research has demonstrated that once treatment has been initiated for first-episode psychosis that the neurocognitive deficits remain relatively stable over time (Rund et al., 2007), further highlighting the need for early intervention and maintenance in specialized treatment programs.

Individuals experiencing schizophrenia and first episode psychosis demonstrate impairments across a range of cognitive domains in comparison to control groups (Addington & Addington, 2002). Executive functioning, attention, general problem-solving, and processing speed are some of the areas in which these patients exhibit difficulties (Mesholam-Gately et al., 2009). However, research has shown that of these deficits, impairment of working memory perhaps has the greatest negative impact on decision-making (Gold et al., 2008; Heerey et al., 2008).

Working memory and decision-making

Working memory has recently been demonstrated to play an important role in decision-making under ambiguity (Gold et al., 2008). In order to better understand how working memory might play a role in decision-making, it is important to review Baddeley's model which proposes four major components of working memory, including the visuo-spatial sketch pad, the phonological loop, the central executive, and the episodic buffer (Baddeley, 2000). The sketch pad and phonological loop are short-term storage buffers for their respective sensory stimuli, while the central executive supports the manipulation and transformation of information held within the buffers. The episodic buffer allows for multifaceted events to be integrated and retained (Baddeley, 2000; Barch & Caesar, 2012). There is minimal evidence supporting deficits in either the sketch pad or phonological loop for individuals with schizophrenia, however, stronger evidence supports deficits attributed to the central executive (Barch & Caesar, 2012). Kim and colleagues (2004) sought to examine the impairments in the central executive for individuals with schizophrenia. Ultimately, they demonstrated that individuals with schizophrenia had difficulty on tasks which required the manipulation of internal representations. Furthermore, the results indicated that there was not an appreciable effect of sensory domain throughout the study. The authors suggested that this provided support to the idea that challenges within the central executive occur independently of sensory domain (Kim, Glahn, Nuechterlein, & Cannon, 2004).

Seminal research by Waltz and Gold at the University of Maryland has shown a critical role for working memory in the ability to establish the value of an experience during decision-making. Initial experiments explored how patients with schizophrenia

consider the value of an immediate versus delayed reward using delayed discounting paradigms (Heerey, Robinson, McMahon, & Gold, 2007; Gold et al., 2008). Subjects were asked to choose between varying rewards, such as “would you prefer \$36 today or \$80 in 59 days,” with the presumption that the inclusion of time decreases the value of future rewards. Ultimately, the researchers found that patients discounted the value of future rewards significantly more than control participants. Therefore, they chose to forego a larger delayed reward for a much smaller immediate reward. A key finding was that better performance on measures of working memory was positively correlated to successful decision-making (Heerey et al., 2007).

The researchers suggested that the delayed discounting deficit in patients might reflect a difficulty in integrating multiple features of a decision. To examine the impact of integrating multiple features of a decision, subjects completed a probabilistic decision-making task (Heerey et al., 2008). Individuals were presented with two gambles which differed in the probability of winning and the size of the potential reward. Further, on some trials, no loss was possible, but on others trials a loss resulted from losing the chosen gamble. Consistent with the results from the delayed discounting research, the ability to successfully consider potential outcomes was correlated with measures of working memory. As such, schizophrenia patients with better working memory made more optimal decisions, and the difference between patients and control participants ceased to be significant when the impact of working memory was statistically controlled (Heerey et al., 2008; Gold et al., 2008). The positive correlation of decision-making impairments and working memory has been reliably observed when patients must use

feedback on a trial-by-trial basis, or when multiple representations of the value of response options must be considered.

The Game of Dice Task and decision-making under conditions of risk

The IGT is purported to examine decisions made under conditions of ambiguity, where multiple features need to be incorporated for successful decision-making. While this may represent many real-life decision scenarios, individuals also make decisions based on explicit information. Known as decision-making under risk as opposed to ambiguity, the future consequences of specific decisions as well as the probabilities for reward and punishment are explicit (Brand et al., 2005). Executive functions are thought to impact decision-making processes when rules for reinforcement and punishment are clear. Decisions under risk are made on the basis of some knowledge about the situation and associated consequences, allowing different options to be systematically evaluated regarding their long-term gains and losses (Brand et al., 2005).

Brand and colleagues (2004) developed the Game of Dice Task (GDT), which differs from the IGT by presenting the decision-maker with explicit rules for gains and losses. In the computerised GDT individuals are asked to increase their fictional money within 18 rolls of a virtual dice. Prior to each roll, individuals have to guess which number will be thrown next and have the option of picking from one to four numbers in order to increase their odds of successfully picking the number rolled on the dice (Brand et al., 2004). Additionally, the GDT has winning probabilities which are stable during the entire task duration and visualized on the screen (Brand et al., 2004). Neuropsychological

studies of GDT task performance have demonstrated that performance relies particularly on the functioning of the DLPFC (Starcke, Tuschen-Caffier, Markowitsch, & Brand, 2009). The DLPFC is believed to play an important role in decision-making, namely generating and executing goal-directed action plans necessary to achieve the valued outcome (Wallis, 2007). From its inception in 2004, a number of studies have used the GDT to demonstrate impaired risky decision-making in various populations, such as Korsakoff Syndrome, borderline personality disorder, and pathological gamblers with these disturbances correlating with executive functions (Brand et al., 2005; Svaldi, Philipsen, & Matthies, 2012).

In summary, research indicates that there are at least two types of decisions, namely decisions under ambiguity as measured largely with the IGT, and decisions under risk as measured with the GDT. The decision-making processes assessed by these tasks most likely share several basic components but also differ regarding specific neuropsychological and neural correlates. The OFC is purported to play a major role in making decisions under ambiguity by updating mental representations of the relative value of different stimuli and response alternatives on a trial-by-trial basis (Barch & Dowd, 2010; Frank & Claus, 2006; Wallis, 2007). This type of rapid learning is critical for behavioural flexibility in the presence of changing outcomes, and it seems clear that working memory is related to making decisions under ambiguity. In contrast, the DLPFC is believed to play a major role in decisions in which explicit information is provided. Research has suggested that a role for the DLPFC in decision-making may be the

translation of value information into goal representations and action plans that allow for successful decisions to be made (Brand et al., 2004; Brand et al., 2005).

IGT and GDT Performance in Individuals Experiencing Psychosis

To date the research literature includes three studies that examined IGT and GDT performance in the same individuals with schizophrenia spectrum disorders. Lee and colleagues (2007) compared the performance of 23 patients with schizophrenia to healthy controls on the IGT and GDT. The primary treatment for the patient group was antipsychotic medication. They found that while the patients displayed impaired performance on the IGT relative to the healthy controls, their performance on the GDT was not impaired suggesting that decision-making problems were primarily associated with ambiguous stimuli. Conversely, a study by Fond and colleagues (2012) demonstrated that 63 medically treated patients with paranoid schizophrenia had impaired performance on both the IGT and the GDT in comparison to healthy controls, indicating deficits in both ambiguous and risky decision-making. Similar findings were observed in a study by Zhang and colleagues (2015) who found that first-episode psychosis patients demonstrated impairments in both ambiguous and risky decision-making (Zhang et al., 2015).

Notable methodological differences existed between the aforementioned studies that may explain the divergent findings. Specifically, Fond and colleagues (2013) studied a patient group consisting of individuals with a history of multiple psychotic episodes and a chronic course of schizophrenia. Lee and colleagues (2007) studied a patient group

diagnosed with schizophrenia, and Zhang and colleagues (2015) studied a patient group experiencing their first episode of psychosis. As described earlier, the timing of the intervention has a significant impact on the severity of symptoms and the course of the illness. Another important methodological issue was whether patients were medically stabilized at the time of the assessment. The majority of the patient group comprising the Fond and colleagues (2013) study was receiving first generation antipsychotic medication, including haloperidol, a drug known to impact cognition (Lustig & Meck, 2005). Patients from Lee and colleagues' (2007) study were predominantly receiving second generation antipsychotic treatment. By contrast, the work of Zhang and colleagues (2015) was conducted in first episode psychosis patients who were hospitalized and receiving no medical intervention. Therefore, it brings into question whether psychotic symptoms were stabilized, and the impact that might have on definitive conclusions that were made in regards to decision-making. Given the significant methodological differences in these studies, it is important to further investigate the relationship between ambiguous and risky decision-making in first episode psychosis populations. These individuals are at a critical stage of illness progression where adaptive decision-making may be beneficial to treatment engagement and retention.

Objectives and Hypotheses

There have been few studies of decision-making in patients experiencing symptoms of early psychosis. There is clear evidence of the benefits of specialized treatment during the early stage of disease progression during which maintaining treatment engagement and retention are critical. Studies have shown that patients not in

dedicated early psychosis treatment programs have a dropout rate as high as 80% within the first year of care (Dixon, Holoshitz, & Nossel, 2016). Enrollment in early psychosis programs places a number of requirements on the individual, including frequent decisions regarding medication adherence, attending appointments, and following through on treatment recommendations from various health professionals. The current research represents, to the best of our knowledge, the first study designed to explore ambiguous and risky decision-making by individuals receiving specialized treatment for early psychosis. Additionally, the current study aims to examine relationships between neurocognitive functioning and ambiguous and risky decision-making. Increased understanding of decision-making during this period is an important topic for further study because of the potential impact it may have on future treatment planning.

Therefore, the current research will address a number of objectives. Firstly, how will a group of individuals in a specialized early psychosis program perform on tasks of ambiguous and risky decision-making when compared to a group of control participants? It is hypothesized that performance on the IGT will be impaired in the early psychosis group when compared to healthy controls and that individuals in the early psychosis group will demonstrate IGT impairments in calculating expected value on a trial-by-trial basis. Furthermore, it is hypothesized that risky decision-making, as assessed with the GDT, will not be significantly impaired in the early psychosis group compared to the control group. This study will also examine other neurocognitive measures in an attempt to further explore interactions between decision-making and neurocognitive deficits. It is

hypothesized that there will be deficits in neurocognitive functioning within the early psychosis individuals compared to the control group.

Method

Subjects

Early psychosis participants

A total of 16 participants currently enrolled or previously enrolled in the three-year outpatient PIER program at the Waterford Hospital were recruited for the study. In collaboration with the PIER psychiatrists the patients were informed about the study and invited to participate in the research. Exclusion criteria from the current study included the presence of active psychotic symptoms or a previous diagnosis of a cognitive or neurological disorder, however none of the participants met either criterion. Subjects were provided with background information about the study and required to give their written consent prior to participation, as per the Health Research Ethics Board (HREB) and the Research Proposal Approval Committee (RPAC) of Eastern Health. Participants were compensated with a gift card for a local grocery store or coffee shop at a rate of \$10 per hour of participation.

Control participants

A total of 20 undergraduate students at Memorial University of Newfoundland were recruited using information sessions and flyers posted within the Department of Psychology and the School of Pharmacy. It is not uncommon for individuals to

experience their first episode of psychosis while enrolled in school settings, making this an appropriate sample for inclusion as a control group. For example, of the 91 individuals participating in the McLean OnTrack Program, 60.4% were enrolled in post-secondary school when they experienced their first episode of psychosis (Shinn et al., 2015). As with the PIER participants, all subjects were provided with background information outlining the nature of the study and were required to provide written consent in order to participate. Individuals were remunerated with a gift card for a local grocery store or coffee shop at a rate of \$10 per hour of participation.

Neuropsychological Test Battery

Premorbid estimate of intelligence

The Wide Range Achievement Test- 4th Edition, Reading subtest (WRAT-4) is a brief measure that provides a premorbid measure of intelligence by assessing single-word reading skill. During this task each subject is required to read 55 words of increasing difficulty with scoring based upon correct pronunciation. It has been suggested that single word reading is particularly resistant to deterioration associated with neurological compromise (Spren and Strauss, 1998), and therefore is frequently included as a measure of premorbid intelligence.

Overall intelligence

The Wechsler Abbreviated Scale of Intelligence - II (WASI-II) (Wechsler, 2011) provides a score of overall intelligence using similar subtests to those found on the Wechsler Adult Intelligence Scale, 4th edition (WAIS-IV). In utilizing two tests of

perceptual reasoning and two tests assessing verbal reasoning the WASI-II provides a composite full-scale intelligence quotient (FSIQ) in a relatively short amount of time.

Auditory attention and verbal working memory

The WAIS-IV digit span subtest (Wechsler, 2008) is a frequently used measure of immediate span of attention, immediate verbal recall, verbal short-term memory and verbal working memory (Lezak, Howieson, & Loring, 2004). Individuals are required to repeat lists of different numbers either forwards, backwards, and then in ascending sequence, with the memory span corresponding to the largest consecutive group of numbers repeated correctly. For the analysis, a composite digit span score was derived from the three variations of the task, with a higher score indicating better verbal short-term memory and verbal working memory.

Executive functioning

The Trail Making Test (TMT) Parts A and B are measures of mental tracking, attentional resources, and cognitive flexibility. The TMT A requires simple scanning and for the subject to connect 25 randomly located numbers in ascending order as quickly as possible. Part B requires subjects to sequentially alternate between numbers and letters (Spreeen & Strauss, 1998). For both parts A and B, completion time was the dependent variable with higher times representing worse performance.

The modified Wisconsin Card Sort Test (m-WCST; Nelson, 1976) is an abbreviated version of the Wisconsin Card Sort Test (WCST). Frequently used as a measure of executive functioning (Brand et al., 2006), the m-WCST was developed to

assess problem solving and the ability to shift cognitive strategies in response to changing environmental contingencies. In general, it requires the use of planning, attentional flexibility, and response inhibition as participants are required to match response cards according to different parameters. Following six correct matches a new categorization principle is incorporated and the test continues until all six consecutive categories of cards are correctly sorted or all 48 cards are used. Dependent measures from this task included the total number of categories completed (maximum of six), the total number of items correctly sorted, and the number of incorrect responses. Furthermore, incorrect responses were divided into perseverative errors and non-perseverative errors.

Perseverative errors indicated the participant did not incorporate the feedback that their previously successful response strategy no longer applied. Non-perseverative errors occurred when the error was unrelated to the previous rule (Nelson, 1976; Spreen & Strauss, 1998).

Decision-making tasks

Ambiguous decision-making

The computerized version of the Iowa Gambling Task (IGT) requires the participant to win as much fictitious money as possible by choosing cards from four different decks (A, B, C, and D). Following each selection the participants win or lose a specified amount of money (Bechara, Tranel, & Damasio, 2000b). Decks A and B are disadvantageous in that they provide high immediate gains, but even higher losses, resulting in an overall negative final balance. Decks C and D are advantageous as they

provide small immediate gains, with even smaller losses over the duration of the task.

There are also differences within the advantageous and disadvantageous decks. Although decks A and B both lead to long-term loss, selections from deck A are punished more frequently whereas deck B selections are punished less frequently but at a much higher magnitude. Similar differences exist for decks C and D (Bechara et al., 2000b) with deck C providing more frequent losses and deck D leading to less frequent but greater losses. Individuals are not informed at the beginning of the task that the game ends following the selection of 100 cards. To analyze performance a net score was obtained by subtracting the total number of disadvantageous selections from the total number of advantageous selections. Additionally, the 100 trials were divided into five equal blocks of 20 cards in order to measure performance over time. The number of cards selected from individual decks was also calculated in order to examine specific deck preferences.

Risky decision-making

The Game of Dice Task (GDT), designed by Brand and colleagues (2004) assesses the influence of executive functions on decision-making. In this task participants are given 18 rolls of a dice to maximize their fictional starting capital. Prior to each roll they must bet on the number they will roll. Individuals can chose 1 possible number (winning probability 1:6) with the potential of \$1000 gain/loss, 2 possible numbers (winning probability 2:6) with the potential of \$500 gain/loss, 3 possible numbers (winning probability 3:6) with the potential of \$200 gain/loss and 4 possible numbers (winning probability 4:6) with the potential of \$100 gain/loss (Brand et al., 2005). Unlike the IGT, participants are informed of the number of turns they have prior to starting. To analyze

decisions, Brand and colleagues (2004) classified the choices of one or two numbers as risky or disadvantageous in that they give the potential for big gain but also big losses. Conversely, the choices of three or four numbers are classified as non-risky or advantageous. A net score was calculated to examine task performance by subtracting disadvantageous choices from advantageous choices. The frequencies of the four different alternative categories (1 number, 2 numbers, 3 numbers, and 4 numbers) were also calculated.

Procedure

All testing took place at either the PIER program at the Waterford Hospital (PIER group) or the Psychology Department of Memorial University (control group). All testing was completed by the Psy.D. Candidate and lasted for approximately two hours in total on one occasion. Following an explanation of the study, individuals who wished to participate provided written informed consent. Subsequently, the researcher asked the participants questions specific to their age, gender, and how many years of education they had achieved. Following that, individuals were asked about substance use during the 30 days prior to testing (Appendix C). All participants completed the Brief Symptom Inventory (BSI; Derogatis, 1993) prior to beginning the neuropsychological test battery. This 53-item questionnaire provides insight into an individual's current symptom presentation and psychological functioning.

The neuropsychological assessment was the same for all participants. Individuals completed the WRAT – 4, the TMT A and B, the m-WCST, the WASI-II, and the Digit

Span subtest of the WAIS-IV. All participants completed the computerized versions of the IGT and the GDT. The order of the two decision-making tasks was counterbalanced across participants in order to avoid any possible confounding effects.

Data analysis

Statistical Package for the Social Sciences (SPSS) v. 20 (Chicago, SPSS Inc.) was used to perform the statistical analyses. The PIER and control groups were compared using either a Chi-square test for categorical variables, such as gender, or independent t-tests for continuous variables such as those attained on the neuropsychological tasks. In instances where the Levene's Test for equality of variances was significant, results based on equal variances not being assumed are reported. Pearson correlations were conducted primarily to explore relationships between neuropsychological tasks and decision-making tasks. The IGT results yielded not only a total net score but also the net scores of the advantageous decks minus disadvantageous decks across the duration of the task. As such, it was possible to explore participants' performance over time using a repeated measures analysis of variance (RM ANOVA) with the repeated factor of net scores, and between factors of group. A RM ANOVA was also used to examine deck choice comparisons between PIER and control participants. A RM ANOVA was utilized with the repeated factor of choice, and between factors of group to analyze the results from the GDT, specifically the selection of alternative categories between the groups. Bonferroni corrections were used to adjust for multiple comparisons. The threshold of statistical significance was set to $p < 0.05$. A more stringent value of $p < 0.01$ was adopted in order to confer significance for correlational analyses. This was similar to the strategy used by

Fond and colleagues (2013) in an effort to reduce Type I error where a considerable number of comparisons were examined.

Results

Demographics and clinical information for PIER participants

As seen in Table 1 (pg. 84) the majority of PIER individuals identified as Caucasian and there were an equal number of male and female participants with an average age of 28 years. At the time of testing approximately 65% of participants had been diagnosed with schizophrenia by their PIER psychiatrist. The remaining participants were diagnosed with either schizoaffective disorder, bipolar disorder, or psychotic disorder NOS. Over 30% of participants were prescribed Clozapine, 25% were prescribed Seroquel, 19% were prescribed Olanzapine and Risperidone respectively, and one individual was prescribed Ziprasidone. Four of the participants were also taking a mood stabilizer, with lithium being the predominant choice. Also shown in Table 1 is information pertaining to the length of involvement that participants have had with the PIER program. Individuals had been involved with PIER for an average of approximately 60 months, although there was considerable range between participants as the standard deviation was almost 50 months. The mean global assessment of functioning (GAF) score as indicated by the PIER psychiatrists was 70. 44% of individuals were living with family and 31% were living independently at the time of testing. 75% of respondents reported their relationship status as single.

Group demographics and results of the neuropsychological test battery

As seen in Table 2 (pg. 85) there was no significant difference in average age between the PIER participants and the control group and equal numbers of male and female participants were tested in each. The PIER group had accumulated fewer years of education on average ($t = -6.543$, $p < 0.0001$) and had a higher Global Severity Index score on the Brief Symptom Inventory ($t = 3.249$, $p = 0.0013$) compared to the control participants. Table 2 also illustrates drug use during the 30 days prior to testing. There was relatively little cannabis and alcohol use reported across groups, although, the PIER group smoked significantly more cigarettes in the 30 days prior to testing ($t = 3.25$, $p = 0.004$). Table 2 also illustrates the performance on the neuropsychological tasks for both groups. The control group performed better on the WRAT-4 reading subtest ($t = -3.335$, $p = 0.002$) and exhibited higher overall general intelligence (FSIQ) as assessed by the WASI-II ($t = -4.625$, $p < 0.0001$). While there was a significant difference between the two groups regarding FSIQ, the scores of both PIER (89.7) and control (108) fell at the low and high scores of the average range (90-109) of the normative sample. The PIER group took significantly longer to complete both Trail Making Tests A and B respectively ($t = 2.801$, $p = 0.008$; $t = 5.071$, $p < 0.0001$). Three different measures associated with the m-WCST were compared in order to examine planning, attentional flexibility, and response inhibition. As seen in Table 2 there were no differences observed in either the mean number of categories correct or the mean number of perseverative errors. However, the total number of errors committed was significantly different, with the control group outperforming the PIER group ($t = 2.344$, $p = 0.03$).

Ambiguous decision-making (IGT)

To examine performance on the IGT a RM ANOVA was conducted with the repeated factor of net scores, and between factors of group. As seen in Figure 1 (pg. 86), significant differences were observed between the two groups as well as across trials. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $X^2(9) = 23.533$, $p = 0.005$, and therefore, a Greenhouse-Geisser correction was used. There was a significant main effect for block of trials, $F(3.1, 104) = 13.36$, $p < 0.001$, as well as a significant main effect of group, $F(1, 34) = 14.76$, $p = 0.001$, and a significant interaction between the two, $F(3.1, 104) = 3.33$, $p < 0.05$. Group differences on each block of trials were statistically significant for all but the first block of trials ($p < 0.01$ after Bonferroni correction). There were no within-group differences between any of the blocks of trials for the PIER participants ($p > 0.05$), however, for the control participants, the first block of trials was significantly different than all others ($p < 0.05$, after Bonferroni correction). Specifically, the first 20 trials for the control participants differed significantly from the next four trials, suggesting they successfully learned the contingencies for positive performance. Figure 2 (pg. 87) shows enhanced IGT responding by the control group. Specifically, the control group had a higher overall net score at the completion of IGT ($t = 3.988$, $p < 0.001$). Additionally, Figure 3 (pg. 88) demonstrates a significant difference between both groups in regards to final monetary balance at the completion of the task ($t = -4.655$, $p < 0.001$). At the end of the task the PIER group had gained significantly less money. Figure 4 (pg. 88) demonstrates the pattern of IGT deck choices for both the PIER and control groups. Panel A illustrates greater responding by the PIER group across both disadvantageous decks A and B, $F(1,$

35) = 14.76, $p < 0.01$. Conversely, panel A also illustrates greater responding on both advantageous decks C and D for the control group when compared to the PIER group, $F(1, 35) = 14.76$, $p < 0.01$. Figure 4, panel B illustrates all responding across decks for each group. Mauchly's Test of Sphericity was violated, $X^2(6) = 31.32$, $p < 0.001$, and therefore the Greenhouse-Geisser correction was used. There was a significant main effect of deck choice, $F(2.2, 76) = 9.64$, $p < 0.001$, and a significant interaction between deck choice and group, $F(2.2, 76) = 5.30$, $p < 0.005$. Bonferroni corrected pairwise comparisons demonstrated that the PIER group responded more for both decks A and B than control participants ($p < 0.05$) while the control group responded more for deck D ($p < 0.05$) than the PIER group. Additionally, Figure 4, panel B also illustrates significantly more responding for deck B than deck A by the PIER group ($p < 0.05$). Figure 5 (pg. 89) demonstrates responding for both PIER and control groups for the decks that provide infrequent loss, specifically decks B and D. There were no significant differences between groups.

Risky decision-making (GDT)

In order to explore the results of the GDT a RM ANOVA was conducted, which indicated no group differences, $F(1, 34) = 0.266$, $p > 0.05$, as seen in Figure 6 (pg. 90). For choice within groups, Mauchly's Test of Sphericity indicated that sphericity had been violated, $X^2(5) = 50.912$, $p < 0.001$, and therefore the Greenhouse-Geisser correction was used. Results indicated a significant main effect of choice, $F(1.7, 56) = 27.5$, $p < 0.001$. Bonferroni corrected pairwise comparisons indicated that both groups responded significantly more for the four choice option when it was compared against all the other

choices ($p < 0.01$). Therefore, both groups were successfully choosing the less risky option on the GDT.

Relationships between decision-making and neuropsychological functioning

Correlational analyses were conducted for both the PIER and control groups, to explore relationships between the neuropsychological variables and decision-making tasks. For both groups there were high correlations amongst variables that measured a similar construct. For example, net total on the IGT was highly correlated with IGT total money, a finding that would be expected given the nature of the two measures. Similar correlations were observed for both groups on multiple measures of the m-WCST and the GDT.

Correlational analyses for the PIER group are shown in Table 3 (pg. 91), indicating FSIQ was related to the reading score of the WRAT-4. Additionally, the WRAT-4 was positively correlated with the digit span (working memory) score. In examining relationships between decision-making and neuropsychological functioning there was a significant correlation between the IGT and digit span. The results indicated that as performance on the digit span increased, there was also an increase on measures indicative of successful IGT performance (Decks C&D, Net total, and Total Money) and a decrease on measures indicative of poorer IGT performance (Decks A&B). No correlations were observed between measures of the GDT and any of the other variables.

Correlations between neuropsychological functioning and decision-making for the control participants are shown in Table 4 (pg. 92). There was a positive correlation

observed between age and the years of education. There were no correlations between any measures of decision-making and neuropsychological functioning for the control group.

Discussion

A major goal of the current study was to explore how individuals receiving specialized treatment for early psychosis make ambiguous and risky decisions. Although early intervention for psychosis has proven to be successful in engaging young people in care and keeping them in treatment longer, more research is needed into the reasons that contribute to drop-out and withdrawal. Little is known about decision-making processes in individuals experiencing the early stages of disease progression. To the best of our knowledge, the current study represents the first time that decision-making has been explored in individuals participating in specialized early psychosis treatment. Understanding potential deficits and challenges in making adaptive choices is critical to our understanding of the experience of early psychosis treatment and possible remediation efforts. An additional aim of the current research was to investigate the relationship between decision-making and neurocognitive impairments. Considerable research has explored neurocognitive function for those experiencing psychosis (Insel, 2010). By contrast, very little is known about how these impairments interact with decision-making.

At the time of assessment, approximately two-thirds of the PIER participants were diagnosed with schizophrenia. Furthermore, 12% of the PIER participants were diagnosed with schizoaffective disorder, 12 % with bipolar disorder, and 12% with psychotic

disorder NOS. The percentage of individuals with specific diagnoses within the PIER population is similar to other research studies exploring early psychosis. For example, Murray and colleagues (2008) explored reinforcement learning in first episode psychosis patients and reported 81 patients as schizophrenia-spectrum psychosis and 31 as affective psychosis. Furthermore, a recent study in a large population of individuals receiving treatment for early psychosis reported that 80 individuals (63%) were diagnosed with schizophrenia (Norman, Manchanda, Harricharan, & Northcott, 2015).

While the majority of patients within the present study met the criteria for schizophrenia it is important to consider the impact of psychosis irrespective of clinical diagnoses. A study by Simonsen et al. (2011) examined neurocognitive dysfunction in both schizophrenia and bipolar disorder. The crucial finding was the impact that psychosis had on impairment. More specifically, bipolar patients with a history of psychosis showed similar cognitive dysfunction as observed in schizophrenia and schizoaffective disorder. By contrast, bipolar patients without a history of psychosis only showed poor performance in processing speed (Simonsen et al., 2011; Nieto & Castellanos, 2011). Psychosis clearly has a negative impact on neurocognitive functioning which supports the grouping of PIER participants as early psychosis patients, as opposed to focusing on their diagnostic differences. Furthermore, within early psychosis treatment programs it is not uncommon for patient diagnoses to change over time. For example, Shinn and colleagues (2015) indicated that 50.5% of all patients within the McLean OnTrack program for early psychosis had experienced a change in diagnosis over a 2.5

year time span. As such, focusing on specific diagnoses might provide less insight when considering decision-making during treatment for early psychosis.

The demographic data of the PIER group was comparable to other early psychosis studies, although, the level of functioning, as measured by the GAF score, was somewhat higher (Murray et al., 2008; Kenney et al., 2015). This was somewhat anticipated since the PIER participants were outpatients at the time of assessment, had been taking stable doses of medication, and were chosen for potential participation on the basis of psychiatrist referral. In the current study some of the PIER participants had completed the 3 year program (~70%) and were on a maintenance program that primarily involved regular appointments with psychiatry. The overall mean time since starting initiating PIER treatment was 59 months. The PIER group represents a sample of early intervention patients, some of whom had been involved in a comprehensive treatment program for a prolonged period of time compared to the majority of studies exploring early psychosis.

Ambiguous decision-making

Consistent with our hypothesis, patients in an early psychosis treatment program exhibited impaired decision-making under uncertainty in comparison to a control group. The PIER group was outperformed by the control group and had a significantly lower monetary balance and net total at the conclusion of the IGT. While there have been at least two studies which did not demonstrate such impairments in individuals with schizophrenia and early psychosis (Cavallero et al., 2003; Rodriguez-Sanchez et al., 2005) the current findings are consistent with the majority of previous research (Fond et

al., 2013; Lee et al., 2007; Sevy et al., 2007; Raffard et al., 2011; Cella, Dymond, Cooper, & Turnbull, 2012; Brown et al., 2015; Zhang et al., 2015).

Decision-making was also analyzed across the duration of the task in order to explore performance over time. The results indicated a pattern of reinforcement learning occurring within the control group, but not for the PIER participants. There were group differences on all but the first block of trials, suggesting the control group learned how to respond advantageously and outperformed the PIER group from the second block of trials onward. Within the PIER group there were no significant differences across the blocks of trials, although the difference between the first and last block was approaching significance ($p = 0.07$). This slow shift has previously been reported (Ritter, Meador-Woodruff, & Dalack, 2004; Kim, Lee, & Lee, 2009). The lack of a learning curve, however, indicates a deficit in reinforcement learning for the PIER participants. They were impaired in their ability to use feedback to continually update evaluations of expected value and potential outcomes. These deficits impacted the PIER participants' ability to make decisions to avoid large losses. This is in line with the findings of Brambilla and colleagues (2013) who used expectancy-valence modeling to conclude that associative learning underlying the representation of expectancies was disrupted in individuals with schizophrenia (Brambilla et al., 2013; Brown et al., 2015). As IGT trials progressed, the PIER patients failed to learn from previous outcomes thereby demonstrating functional deficits in reinforcement learning (Collins, Brown, Gold, Waltz, & Frank, 2014).

In addition to examining ambiguous decision-making over time, response patterns were also analyzed in order to further assess decision-making strategies. The control group responded significantly more for the advantageous decks C & D as opposed to the disadvantageous decks A & B. The reverse was observed in the PIER group. Consistent with our hypothesis, the PIER group responded significantly more for deck B, which provided low-frequency but high-magnitude losses. Brown and colleagues (2015) highlight the importance of deck choice within the IGT by individuals with schizophrenia. They observed a preference in schizophrenia patients to choose deck B, the deck with infrequent but large losses. This reflected a tendency to utilize outcome-frequency information at the expense of outcome-magnitude information which was also observed in the present study.

In summary, ambiguous decision-making in the PIER group was significantly impaired when compared to the control group. This is consistent with the majority of IGT research conducted within schizophrenia and the small body of literature exploring early psychosis decision-making. The PIER group responded significantly more for the disadvantageous decks, responding the most for deck B, which provided infrequent but large losses.

Risky decision-making and executive functioning

As hypothesized, the control group did not demonstrate superior risky decision-making in comparison to the PIER group, as performance on the GDT did not differ significantly. The pattern of GDT decision-making was comparable, with both the control

and the PIER groups utilizing successful strategies when it came to completing the task. Both groups responded significantly more for the four choice option, thereby maximizing the probabilities of a successful roll of the dice.

Impairments on the GDT are often attributed to deficits in executive functioning (Brand et al., 2004; Brand et al., 2008). From the inception of the GDT, Brand and colleagues have reported decision-making deficits in patients with Korsakoff's syndrome (Brand et al., 2005), Parkinson's disease (Brand et al., 2004), and pathological gambling (Brand et al., 2005). In these studies, GDT performance was correlated with executive functioning, which was primarily assessed using the modified Wisconsin Card Sort Test. As indicated by the results of the current study, the PIER group committed more total errors than the control group on the m-WCST. However, they did not make significantly more perseverative errors, or show impairments with their ability to make correct categorizations. As such, the PIER group performed significantly below the control group on one of the three measures of the m-WCST.

Brand and colleagues (2006) have highlighted the importance of utilizing feedback in terms of gains and losses when making decisions under explicit conditions with the GDT. The GDT provides considerable and constant feedback, including observing the roll, visualizing gains or losses, and visual aids, such as a green bar for winning (increases) and a red bar for losing (decreases), both indicated by different sounds (Brand et al., 2006; Brand et al., 2008). It has been postulated that successful decision-making under conditions of certainty relies on both the ability to process feedback as well as intact executive functioning (Brand, 2008). It may well have been the

case for the PIER group that they were able to integrate information about consequences, probabilities, and subsequent and clear feedback, to perform well on the GDT.

While the PIER group exhibited some similarities to the control group in regards to executive functioning, results clearly indicated discrepancies between the two groups. More specifically, the PIER participants were slower than the control participants on both versions of the Trail making tasks, and made more total errors on the m-WCST. A recent study by Schiebener and Brand (2015) explored the impact of executive functioning on making decisions under explicit conditions. They found that individuals did not need to have particularly strong executive functioning skills to be able to incorporate GDT feedback into strategic planning for the task. It has been suggested that individuals with lower executive functioning ability need to avail of the feedback, while those with higher executive functioning ability apply strategies for decision-making that are somewhat independent of task feedback (Schiebener & Brand, 2015). Additionally, Brand (2008) explored the influence of feedback on subsequent decision-making using a modified version of the GDT compared to the original version. The modified GDT removed the visual cues of the dice roll and the participants were not informed about the result when it occurred. The responses for all 18 rolls were visible at the end of the task. Feedback associated features, such as the bars representing the monetary balance were removed. Healthy participants, comprised largely of university students, performed well on the task overall, but there was a significant decrease in performance on the version without feedback. In particular, the participants selected the risky alternatives more frequently in the version without feedback compared to the regular GDT. This occurred independently

of which task they completed first (Brand, 2008). It was also demonstrated that there was a greater tendency to switch response strategies more during the modified GDT in which feedback was withheld. Over the 18 trials participants switched significantly more often when they were not provided with the standard GDT feedback (Brand, 2008). Further analysis indicated that only during the final two thirds of the trials was performance on the original GDT more stable compared to the performance on the modified version. This result indicates that participants may begin with similar strategies, however the provision of feedback leads to participants learning to prefer non-risky alternatives and make advantageous decisions. These results highlight the importance of feedback from previous trials in making advantageous decisions. Processing feedback may support strategy development and monitoring or may lead to modification of decision-making strategies (Brand, 2008).

In summary, responses by the PIER group on the GDT were not significantly different from the control group. While there were some performance differences observed in measures of executive functioning by the PIER group compared to control participants there were also certain measures which were similar. For example, the PIER participants performed successful categorizations on the m-WCST as well as the control group. Previous research indicates executive functioning to be an important ability in relation to GDT performance. While the PIER group had lower overall executive functioning ability relative to controls, the GDT provided feedback to the participants in a way that allowed them to integrate feedback and executive functioning into effective strategies for decision-making.

Neurocognitive functioning

Consistent with our hypothesis, the control group outperformed the PIER group on tests of neurocognitive functioning. More specifically, the control group achieved higher scores of perceptual and verbal reasoning, thereby attaining a greater overall FSIQ. Additionally, the control group outperformed the PIER group on tests of auditory attention, verbal working memory, and certain components of executive functioning as described previously.

Previous research has demonstrated that people suffering from their first episode of psychosis are typically already experiencing neurocognitive deficits and are more impaired than healthy controls (Addington & Addington, 2002). A recent meta-analysis by Nieto and Castellanos (2011) explored neuropsychological functioning in individuals diagnosed with early onset schizophrenia. Their analysis included 12 separate studies comprising 296 patients with early onset schizophrenia (mean age of 15.8 years). They found that, when compared to control groups, the patient groups were impaired across numerous cognitive domains (processing speed, general cognitive ability, attention, working memory, visuospatial skills, executive control, verbal fluency, verbal learning/memory, and visual memory) (Nieto & Castellanos, 2011). This paper highlights the impact that psychosis has on neurocognitive functioning, even in those individuals with minimal duration of illness. A recent review by Aas and colleagues (2014) sought to further elucidate the neurocognitive profile of individuals experiencing first episode psychosis. This large meta-analysis compared 24 studies and indicated that in comparison to healthy controls, first-episode psychosis patients showed significant cognitive

impairments across a number of domains, with the largest effect sizes observed for verbal memory, executive function, and overall intelligence (Aas et al., 2014). The current research shows similarities to prior research in that there were neurocognitive impairments observed in the PIER group.

The PIER group's neurocognitive profile exhibited deficits in comparison to the control group. Of the few studies that have explored neurocognitive deficits in early psychosis intervention treatment program patients, the majority have conducted their neurocognitive assessment within the first year of treatment. In the current study a number of the PIER participants had completed the 3 year program, and the mean PIER involvement time across the group was 59 months. This finding in the current study suggests that regardless of the stage of early psychosis treatment neurocognitive impairments are observable.

Relationships between decision-making and neurocognitive functioning

Correlational analyses were conducted to explore potential relationships between the measures of neurocognitive functioning and the decision-making tasks. A positive correlation was found between working memory (digit span) and IGT performance for the PIER group, but not the control group. The results from the digit span were the only variable that significantly correlated with IGT performance. This indicated an important role for working memory in the PIER group's ability to perform the decision-making task. As working memory ability increased, indicated by longer retention spans, so did performance on the IGT measured by the net total, total monetary balance, and

responding for advantageous decks C and D. Conversely, with improved digit span ability came a significant negative correlation with responding for disadvantageous decks A and B. While there was a significant relationship between working memory and ambiguous decision-making for the PIER group, there was no observation of a correlation between working memory and risky decision-making. Therefore, of the two decision-making tasks, only ambiguous decision-making seemed to be impacted by working memory deficits and subsequent challenges with temporary online storage and mental manipulation of information in the PIER population. There were no correlations between neurocognitive measures and performance on the GDT.

An important role for working memory

The current research suggests working memory plays an important role in decision-making, especially when individuals are required to mentally represent expected value of varying choice options. Deficits in working memory are considered a key feature of schizophrenia (Lee & Park, 2005; Barch and Ceasar, 2012; Collins et al., 2014). One reason working memory has been a focus within the schizophrenia literature is that it is critically important for many other aspects of cognition (Johnson et al., 2013; Collins et al., 2014). As such, working memory impairments could account for many of the cognitive deficits characteristic of schizophrenia. The course of neurocognitive functioning in first episode psychosis and relapse has been examined. Increased deficits in working memory and verbal learning were associated with more relapses during the first year (Rund et al., 2007; Torgalsboen, Mohn, & Rund, 2014).

A study by Gold et al. (2008) explored reward processing in schizophrenia and psychosis and led to some interesting conclusions in relation to decision-making and working memory. They suggested that the failure of normal experience and feedback processing to guide decision-making may be a consequence of a larger deficit. Individuals with psychosis struggle to mentally represent expected value of multiple choices. Decision-making tasks require the ability to simultaneously represent and contemplate the multiple attributes associated with different options (Gold et al., 2008). It may be the case that the impaired ambiguous decision-making in the PIER group resulted at least in part from challenges maintaining representations from the four decks, leading to disadvantageous response patterns. As such, the PIER group could not maintain mental representations of the expected value that develops in a normal population when performing the IGT. In addition, individuals had difficulty using feedback to develop adaptive decision-making strategies. Furthermore, Heerey and colleagues (2008) demonstrated in schizophrenia patients that rewards that are not immediate and salient can lose their ability to impact decision-making, and the degree to which they do so correlates with working memory. Therefore, the PIER group may have undervalued delayed rewards relative to immediate rewards because of difficulties maintaining reward-value representations over time (Heerey et al., 2008; Heerey, Matveeva, & Gold, 2011).

The impact of working memory on IGT performance in a normal population was examined by Pecchinenda and colleagues (2006). The subjects within this study were tested with a version of the IGT that was designed to further challenge working memory.

More specifically, participants completed the IGT under different working memory loads. The addition of this working memory task led to IGT responding that was poorer than the performance without the working memory challenge. Pecchinenda and colleagues (2006) suggested there is an involvement of working memory in performing tasks, such as the IGT, which provide ambiguous conditions that require an individual to consider different choices.

Prior research has explored the involvement of working memory for IGT performance by normal participants with varying working memory capacity. Bagneaux and colleagues (2013) used an individual differences approach to examine the relationship between ambiguous decision-making and working memory. University undergraduate students completed a working memory task and were then assigned to groups based on their performance. Subsequent IGT responses were analyzed across groups and it was demonstrated that the higher working memory capacity group exhibited more advantageous response patterns (Bagneaux, Thomassin, Gonthier, & Roulin, 2013). According to Bagneaux and colleagues (2013) a possible explanation for the IGT performance differences was that individuals with lower working memory capacity struggled to remember the outcome of the various IGT choices.

On the test of risky decision-making the PIER group performed as well as the control group and performance did not correlate with working memory. This is, however, not entirely surprising given prior research. For example, Schiebener and Brand (2015) describe risky decision-making as requiring minimal working memory when it comes to determining a specific strategy for the task. There is a reduced role for working memory

because decisions during tasks such as the GDT are made with all relevant information available. As such, there is little need to keep it available in working memory. In fact, in the very first study of the GDT, that used a Korsakoff patient sample, working memory was not associated with decision-making (Brand et al., 2005). The authors posited that this could be attributed to the task procedure and presentation. The rules for gains and losses were shown to the participants during the completion of the GDT task. Therefore, working memory capacity did not seem to be crucial for task performance (Brand et al., 2005).

In summary, the current study illustrates an important role for working memory in making ambiguous decisions. Previous research highlights the importance of working memory for IGT performance by normal participants with varying working memory capacity. Individuals with psychosis experience difficulty maintaining mental representations of expected value. The working memory requirements of a task such as the IGT appear to be high given the ambiguity of the task (Pecchinenda, Dretsch, & Chapman, 2006; Fellows and Farah, 2005). Therefore, it is more difficult to utilize feedback from the previous trials to impact positively on future choices. Research in schizophrenia, has shown that rewards that are not immediately present in the environment quickly lose their ability to impact behaviour. This finding correlated with working memory. By contrast, the GDT is a task that provides constant feedback to the participant. Current and previous research indicates a reduced role for working memory in making explicit decisions.

Comparing the current findings with previous studies

A major finding from the current study was the differential pattern of results demonstrated by the PIER groups when performing two different decision-making tasks. The IGT, a measure of ambiguous decision-making without clear performance guidelines, was challenging for the PIER group. More specifically, the PIER group were impaired at learning the requirements for successful IGT performance, and struggled to utilize feedback from previous trials to modify their responses. Conversely, the control group showed clear evidence of reinforcement learning on the IGT, responding advantageously from the second block of trials onwards. When feedback was explicit, as was the case when both groups performed the GDT, there were no differences observed. Both groups chose advantageously for the majority of the trials. Previous research has highlighted the importance of both feedback processing and executive functioning in performing the IGT and GDT. Brand and colleagues (2007) demonstrated that in healthy controls the earlier IGT trials are less related to executive functioning, such as ability to categorize, as opposed to the ability to use feedback in order to determine the rules for successful responding. The results of the current study suggest that the PIER group struggled to integrate feedback given the lack of successful responding throughout the duration of the IGT.

In general, the neurocognitive functioning of the PIER group was shown to be significantly below the control group. However, some of the measures of executive functioning, specifically those assessed using the m-WCST, were not significantly different than the control group. Therefore, it seems plausible that while there were executive functioning challenges overall for the PIER group, the functioning was

adequate to perform well on the GDT. As described by other researchers, executive functioning can vary in ability and still integrate feedback into a successful strategy to complete the GDT (Schiebener & Brand, 2015).

To our knowledge, there are currently only two other studies that used the same assessment measures to explore both ambiguous and risky decision-making within a medicated population diagnosed with schizophrenia. One group of participants was comprised of individuals with chronic paranoid schizophrenia treated predominantly with first generation antipsychotics (Fond et al., 2013). Lee and colleagues' (2007) sample included schizophrenia patients, whose treatment was limited to second generation antipsychotics without any other interventions.

Compared with the current study, Lee and colleagues (2007) reported similar levels of overall intelligence. However, they reported no significant difference between patient and control group for overall intelligence. This was not the case in the present study. Fond and colleagues (2013) did not assess general intelligence, however they assessed premorbid intellectual capacity using a reading test. The scores on this reading test were comparable to the scores attained by the PIER participants on the WRAT-4. Consistent with the current study, Fond and colleagues (2013) reported that their patient group demonstrated impaired working memory performance in contrast to their control group. Lee and colleagues (2007) did not assess working memory. Using the WCST to assess executive functioning, Lee and colleagues (2007) found the patient population had significantly more total errors than the control group. A similar result was observed for the PIER participants using the m-WCST. There were no significant differences in

perseverative errors between the patient and control groups across both studies. In general, the patient groups across the studies demonstrated neurocognitive deficits in comparison to the respective control groups. Some differences were observed between the current study and the work of Fond and colleagues (2013) suggesting fewer impairments in certain neurocognitive domains, such as executive functioning. This finding is consistent with the literature describing the importance of early intervention for preservation of cognitive functioning. The current study and the work of Lee and colleagues (2007) were conducted in individuals with a shorter duration of illness than the population of Fond and colleagues (2013).

The IGT findings from the current study mirror the results of both Lee and colleagues (2007) as well as Fond and colleagues (2013). All studies showed that patient groups struggled to integrate feedback from previous trials in order to improve responding, thereby maintaining disadvantageous strategies. The patients in the study by Lee and colleagues (2007) also exhibited the same preference and avoidance for decks as the PIER participants. In both studies, the patient groups responded more for deck B and less for deck D in comparison to control groups. The study by Fond and colleagues (2013) did not analyze deck choice to allow for a comparison. In general, similar patterns of disadvantageous responding on the ambiguous decision-making IGT task were observed.

In contrast, differing patterns of risky decision-making were observed across the research studies. The GDT results from the current study are comparable with the findings of Lee and colleagues (2007), who reported that risky decision-making was

intact. In contrast, however, Fond and colleagues (2013) reported impaired risky decision-making as assessed using the GDT.

There are some possible explanations for this divergence of findings within the small body of literature. Firstly, the subjects of Lee and colleagues' (2007) study were more similar to those in the current study as they were within a similar age range (mean age 28 years) and the majority were taking stable doses of second generation antipsychotic medication. In comparison, Fond and colleagues (2013) conducted their study in individuals with chronic paranoid schizophrenia, who had an average age of 34.6 years. More than half (51.7%) were taking 1st generation antipsychotic medication.

Another possible explanation for the divergence of GDT results across the three studies may relate to differences in executive functioning. The results of the current study and that of Lee and colleagues (2007) indicated certain domains within executive functioning which were not impaired for the early psychosis groups. In both the current study and the work of Lee and colleagues (2007), the patient groups performed similarly to control groups when it came to making a minimal number of perseverative errors. In the current study, the PIER group also performed as well as the control group at making categorizations within the m-WCST. The findings of Fond and colleagues (2013), found impairments in measures of executive functioning for the chronic paranoid schizophrenia group compared to the control group. Furthermore, these authors reported a significant correlation between GDT performance and executive dysfunction. It is therefore possible that the divergence of findings relating to the GDT is the result of less impaired executive

functioning which allowed the patient groups in both the current study and the Lee and colleagues (2007) study to perform as well as the control groups.

This is the first time, to our knowledge, that these measures of decision-making have been used in research within an early psychosis treatment program and an interesting finding is the dissociation between ambiguous decision-making and risky decision-making. As described previously, it is likely that feedback played an important role in the performance on the GDT. Similarly, it is possible that challenges in processing feedback from previous trials affected performance on the IGT. At the same time, it is important to note that working memory was the only neurocognitive variable that correlated with IGT performance.

Clinical contributions of the current study

The current study builds on previous literature exploring decision-making in early psychosis, and provides a novel investigation of decision-making in individuals enrolled in a specialized treatment program. Key differences were found between performance on tasks of ambiguous and risky decision-making. More specifically, the PIER participants demonstrated impaired ambiguous decision-making on the IGT and intact risky decision-making on the GDT. It should be noted that the average global functioning score was relatively high in comparison to other studies exploring early psychosis (Murray et al., 2008), and furthermore, a number of the PIER participants had completed the three year program at the time of testing. As such, these results are of importance given that these PIER participants still struggled to make ambiguous decisions advantageously.

Decision-making is a crucial life skill necessary for successful everyday functioning (Lee et al., 2012). Individuals being treated for early psychosis are constantly faced with choices which impact clinical outcome. Some of these include medication adherence, when and how to attend appointments with the staff at PIER, and more generally, making decisions in a world of ambiguity. Impairment in ambiguous decision-making is important to consider, as the PIER participants struggled to make appropriate and effective decisions where the outcome was not clear and feedback was limited. In terms of the functional impairments associated with early psychosis, these results imply that deficits in decision-making may be related to the consistency and immediacy with which rewards are present in the environment. Difficulty maintaining mental representations of expected value, especially when the decision-making situation contains ambiguity seems related to the degree of cognitive impairment, especially that of working memory.

There are a number of ways that these research findings could perhaps be integrated into early psychosis treatment. Firstly, the use of explicit cues and reminders appear to be of particular importance. More specifically, the treatment team could positively impact future decisions by communicating explicit directions where needed, perhaps writing them down, and making sure the PIER participants are receiving clear messages. Coordinating knowledge across multiple interventions could be very important. This would allow reinforcement by all health professionals. Where appropriate, health professionals should make sure that the patients understand what is being requested by asking them to repeat the instructions. Grant and colleagues (2012) have developed a

cognitive behavioural therapy (CBT) approach in an effort to assist with some of the challenges with value representations demonstrated by patients with schizophrenia. As part of that CBT program, therapists are required to adopt an engaging and direct speaking style, while being enthusiastic, commanding and confident. Additionally, a goal of this CBT program is to provide patients with considerable visual aids, such as laminated cards for remembering key take-home messages. Regular reinforcements for positive goal-directed behaviour and decision-making are also key components of this therapy (Grant, Huh, Perivoliotis, Stolar, & Beck, 2012). PIER participants may struggle to generate precise mental value representations, and therefore, the enhanced use of external cues may help facilitate adaptive decision-making (Strauss et al., 2014).

The current research suggests that a challenge for early psychosis patients might be related to an inability to hold information in working memory, especially in those instances in which a decision involves some degree of uncertainty. As such, it is crucial that information be conveyed in a way that would allow it to be consolidated as best as possible. Strategies might be developed that assist individuals in downloading and processing information therefore reducing some of the demands on working memory. External compensation techniques are strategies that have been used to enhance memory organization in individuals experiencing impairments from traumatic brain injury (Cicerone et al., 2011). Examples of such techniques that might be useful for individuals in PIER include written planning systems, apps for smartphones or other electronic devices, which could deliver selective and frequent cues and reminders, and task-specific aids (such as home calendars, etc.). Mobile technology, specifically ecological

momentary intervention (EMI), could also be used to assist treatment (Strauss et al., 2014). EMI could be used by clinicians to send reminders for patients to engage in specific activities and have apps deliver customized feedback based upon patient behaviour.

There is a considerable line of research exploring cognitive rehabilitation in early psychosis. Hargreaves and colleagues (2015) explored the efficacy of cognitive remediation with a focus on working memory with 56 individuals diagnosed with psychosis. The participants underwent eight weeks of cognitive remediation using a variety of working memory tasks, with subsequent testing indicating improvements in working memory (Hargreaves et al., 2015). It is possible that cognitive rehabilitation could lead to improvements in working memory of the PIER participants. Additionally, working memory has been found to be one of the fundamental neurocognitive factors that predict return to work or school after outpatient clinical stabilization for schizophrenia (Barder et al., 2015; Nuechterlein et al., 2011). The current research also suggests that improving working memory might also have the added benefit of improving decision-making in situations of ambiguity.

It is possible that the deficits in ambiguous decision-making are having negative impacts on multiple areas of everyday life including social functioning. Social interactions can be particularly challenging for individuals with psychosis (Horan et al., 2009). Forming and maintaining social relationships often require interpretation of ambiguous social rules where individuals are required to respond to the behaviours of other people. Previous research has shown improvements in social skills in individuals

with psychosis who underwent specialized training programs (Horan et al., 2009). It is possible that incorporating social skills training into the PIER programming would be beneficial to the participants. Social skills training may remove some of the ambiguity from social situations that lead to impairments in social functioning. This would be an interesting area of research moving forward.

In summary, a major clinical implication of the current research is the need to reduce ambiguity in the decision-making process where possible. Knowledge coordination would begin with the health professionals at PIER but should also be maintained by family members where possible. Explicit cues and directions would be beneficial for the PIER participants in navigating their world. Additionally, focusing on taking some of the burden off of working memory is warranted. This could be done by utilizing various compensatory strategies as well as possibly engaging in cognitive remediation with a focus on working memory. Finally, the current research also has possible implications in the social functioning of individuals at PIER. The research suggests that social skills training might assist in reducing experiences of ambiguity from everyday life and providing a more explicit framework from which to operate.

Limitations

Some limitations to the current study should be noted. Firstly, the sample size was relatively small. Given the small sample size it is possible there was not sufficient power to determine some significant effects. In addition, there was wide variability within the clinical sample in terms of neurocognitive functioning. In future research it would be

beneficial to utilize a larger sample in order to look at within group differences in neurocognitive functioning as it may relate to ambiguous and risky decision-making. Secondly, testing was completed during a single time point during which the stage of illness, medications, or premorbid status were not controlled for. Second-generation antipsychotic medications act on dopaminergic and serotonergic systems and are known to play a modulatory role in reinforcement learning processes and impact cognition (Murray et al., 2008). As all the PIER participants were prescribed second-generation antipsychotic medication it seems reasonable to conclude the results likely generalize to medicated patients. However, we do not know if the results would be similar in medication naïve or unmedicated patients. Nonetheless, we argue that the current results observed in medicated patients are clinically relevant given almost all patients with early psychosis or schizophrenia are treated with antipsychotics that block dopamine D2 receptors (Waltz, Frank, Robinson, & Gold, 2007).

The current study was conducted in a relatively heterogeneous sample of patients with minimal exclusion criteria. All patients had to be stably medicated, not experiencing any active psychosis, and deemed an appropriate fit for potential inclusion in the study by the psychiatrists at PIER. The testing being conducted at PIER may have led to some degree of social desirability bias. Additionally, it is possible that utilizing a randomly selected community sample for the control participants would have been more representative than the university sample. More specifically, the university undergraduate students may have performed at a higher level on the neurocognitive tasks and decision-making tasks than might be observed in a community sample. Both the PIER and control

groups were relatively evenly matched on gender. However, the majority of participants were Caucasian and while this is fairly representative of the population of Newfoundland and Labrador, it should be born in mind when making generalizations based upon these results.

Laboratory decision-making tasks attempt to model real-world decision-making, and prior research has suggested that participants often respond similarly to real and laboratory rewards (Madden, Begotka, Raiff, & Kastern, 2003). However, it is possible that individuals in the current study might have responded differently on the decision-making tasks if they were playing for real, as opposed to hypothetical rewards.

Future directions

The current research has provided a number of clinical questions that could be explored further. It would be of interest to investigate risky and ambiguous decision-making in individuals enrolled in PIER at an earlier time point within the program. The current study explored decision-making in individuals that had been enrolled for an average of 59 months. To this point, a longitudinal study would allow for an exploration of decision-making over time in individuals receiving treatment for early psychosis. One of the most interesting findings to come out of the current research is the relationship observed between working memory and ambiguous decision-making. Future research exploring cognitive remediation with a focus on working memory could be clinically useful.

A focus of the early psychosis literature is the exploration of comorbid cannabis use. Research exploring prior cannabis use in early psychosis patients and its impact on decision-making is indicated (Sevy et al., 2007). The majority of participants in the present study reported frequent, if not daily, cannabis use for significant periods of time in advance of enrolling in the PIER program. With a larger sample size it might be possible to explore decision-making in a population of PIER patients actively using cannabis. AhnAllen and colleagues, (2012) conducted a study exploring the impact of nicotine on the ability of smokers with schizophrenia to achieve reward-based learning. Given the comorbidity between smoking and early psychosis in the PIER population this might also be an area of interest for further exploration.

Prior research has explored gender differences in decision-making, however, little research has explored gender differences in ambiguous decision-making in individuals with schizophrenia. Furthermore, there has been less research exploring ambiguous decision-making in early psychosis, and to our knowledge, no research has looked at gender differences in risky decision-making within this population. As such, this could be a rewarding area for future research, given the literature which indicates that gender differences do exist within normal populations completing the IGT (Evans & Hampson, 2015).

There is substantial research focused on increased understanding of the links between neurocognition in early psychosis and the presentation of negative symptoms. For example, a study by Raffard and colleagues (2016) explored the impact that working memory deficits have on severe apathy in schizophrenia. More specifically their

longitudinal study demonstrated that working memory deficits were associated with an increased risk of severe overall apathy (Raffard et al., 2016). Subsequently, exploring the impact of motivation and working memory in an early psychosis population would be of clinical interest.

Conclusions

Our data indicate a group of individuals receiving treatment for early psychosis exhibited intact risky decision-making when compared to controls. Conversely, the same participants struggled to make advantageous decisions under ambiguous conditions, and this impairment was positively correlated with working memory deficits. This is the first demonstration of contrasting performance on decision-making tasks by individuals in treatment programs for early psychosis and has potential implications moving forward. These findings are in line with recent research highlighting the importance of neurocognitive deficits in psychosis and would suggest decision-making deficits be better accommodated for by treatment programs. Future research should also explore ways in which cognitive rehabilitation could be utilized to assist individuals in programs such as PIER with the many decisions that are required on a daily basis.

References

- Aas, M., Dazzan, P., Mondelli, V., Melle, I., Murray, R.M., and Pariante, C.M. (2014). A systematic review of cognitive function in first-episode psychosis, including a discussion on childhood trauma, stress, and inflammation. *Frontiers in Psychiatry*, 4(182), 1-13. doi: 10.3389/fpsyt.2013.00182
- Addington, J. and Addington, J. (2002). Cognitive functioning in first-episode schizophrenia. *Journal of Psychiatry and Neuroscience*, 27(3), 188-192.
- Addington, J., Heinssen, R.K., Robinson, D.G., Schooler, N.R., Marcy, P., Brunette, M.F., Correll, C.U., Estroff, S., Mueser, K.T., Penn, D., Robinson, J.A., Rosenheck, R.A., Azrin, S.T., Goldstein, A.B., Severe, J., and Kane, J.M. (2015). Duration of untreated psychosis in community treatment settings in the United States. *Psychiatric Services*, 66(7), 753-756. doi: 10.1176/appi.ps.201400124
- AhnAllen, C.G., Liverant, G.I., Gregor, K.L., Kamholz, B.W., Levitt, J.J., Gulliver, S.B., Pizzagalli, D.A., Koneru, V.K., and Kaplan, G.B. (2012). The relationship between reward-based learning and nicotine dependence in smokers with schizophrenia. *Psychiatry Research*, 196, 9-14. doi: 10.1016/j.psychres.2011.09.011
- Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, 4, 417-423.

- Bagneaux, V., Thomassin, N., Gonthier, C., and Roulin, J.-L. (2013). Working memory in the processing of the Iowa Gambling Task: An individual differences approach. *Plos One*, 8(11), 1-6. doi: 10.1371/journal.pone.0081498
- Barch, D.M. (2008). Emotion, motivation, and reward processing in schizophrenia spectrum disorders: What we know and where we need to go. *Schizophrenia Bulletin*, 34(5), 816-818. doi: 10.1093/schbul/sbn092
- Barch, D.M. and Ceaser, A. (2012). Cognition is schizophrenia: core psychological and neural mechanisms. *Trends in Cognitive Sciences*, 16(1), 27-34. doi: 10.1016/j.tics.2011.11.015
- Barch, D.M. and Dowd, E.C. (2010). Goal representations and motivational drive in schizophrenia: The role of prefrontal-striatal interactions. *Schizophrenia Bulletin*, 36(5), 919-934. doi: 10.1093/schbul/sbq068
- Barder, H.E., Sundet, K., Rund, B.R., Evensen, J., Haahr, U., Hegelstad, W.V., Joa, I., Johannessen, J.O., Langeveld, J., Larsen, T.K., Melle, I., Opjordsmoen, S., Rossberg, J.I., Simonsen, E., Vaglum, P., McGlashan, T., and Friss, S. (2015). 10year course of IQ in first-episode psychosis: Relationship between duration of untreated psychosis and long-term intellectual trajectories. *Psychiatry Research*, 225, 515-521. doi: 10.1016/j.psychres.2014.11.054
- Bechara, A. (2004). The role of emotion in decision-making: Evidence from neurological patients with orbitofrontal damage. *Brain and Cognition*, 55, 30-40. doi: 10.1016/j.bandc.2003.04.001

- Bechara, A., Damasio, A.R., Damasio, H., and Anderson, S.W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, 50, 7-15.
- Bechara, A., Damasio, H., Tranel, D., Damasio, A.R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science*, 275, 1293-1295.
- Bechara, A., Damasio, H., and Damasio, A.R. (2000a). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex*, 10(3), 295-307.
- Bechara, A., Tranel, D., and Damasio, H. (2000b). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain*, 123, 2189-2202.
- Bechara A., Dolan, S., Denburg, A., and Hines, A. (2002). Decision-making and addiction (part II): Myopia for the future or hypersensitivity to reward? *Neuropsychologia*, 40, 1690-1705.
- Bechara, A., Damasio, H., Tranel, D., and Damasio, A.R. (2005). The Iowa Gambling Task and the somatic marker hypothesis: some questions and answers. *Trends in Cognitive Sciences*, 9(4), 159-162. doi: 10.1016/j.tics.2005.02.002
- Birchwood, M., Connor, C., Lester, H., Patterson, P., Freemantle, N., Marshall, M., Fowler, D., Lewis, S., Jones, P., Amos, T., Everard, L., and Singh, S.P. (2013). Reducing duration of untreated psychosis: care pathways to early intervention in

psychosis services. *The British Journal of Psychiatry*, 203, 58-64. doi:
10.1192/bjp.bp.112.125500

Boydell, K.M, Gladstone, B.M., and Volpe, T. (2006). Understanding help seeking delay in the prodrome to first episode psychosis: A secondary analysis of the perspectives of young people. *Psychiatric Rehabilitation Journal*, 30(1), 54-60.

Brambilla, P., Perlini, C., Bellani, M., Tomelleri, L., Ferro, A., Cerruti, S., Marinelli, V., Rambaldelli, G., Christodoulou, T., Jogia, J., Dima, D., Tansella, M., Balestrieri, M., and Frangou, S. (2013). Increased salience of gains versus decreased associative learning differentiate bipolar disorder from schizophrenia during incentive decision-making. *Psychological Medicine*, 43, 571-580. doi:
10.1017/S0033291712001304

Brand, M. (2008). Does the feedback from previous trials influence current decisions? A study on the role of feedback processing in making decisions under explicit risk conditions. *Journal of Neuropsychology*, 2, 431-443. doi:
10.1348/174866407X220607

Brand, M., Labudda, K., Kalbe, E., Hilker, R., Emmans, D., Fuchs, G., Kessler, J., and Markowitsch, H.J. (2004). Decision-making impairments in patients with Parkinson's disease. *Behavioural Neurology*, 15, 77-85.

Brand, M., Fujiwara, E., Borsutzky, S., Kalbe, E., Kessler, J., and Markowitsch, H.J. (2005). Decision-making deficits of Korsakoff patients in a new gambling task

with explicit rules: associations with executive function. *Neuropsychology*, 19(3), 267-277. doi: 10.1037/0894-4105.19.3.267

Brand, M., Kalbe, E., Labudda, K., Fujiwara, E., Kessler, J., and Markowitsch, H.J.

(2005). Decision-making impairments in patients with pathological gambling. *Psychiatry Research*, 133, 91-99. doi: 10.1016/j.psychres.2004.10.003

Brand, M., Labudda, K., and Markowitsch, H.J. (2006). Neuropsychological correlates of

decision-making in ambiguous and risky situations. *Neural Networks*, 19, 1266-1276. doi: 10.1016/j.neunet.2006.03.001

Brand, M., Recknor, E.C., Grabenhorst, F., and Bechara, A. (2007). Decisions under

ambiguity and decisions under risk: Correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules.

Journal of Clinical and Experimental Neuropsychology, 29(1), 86-99. doi: 10.1080/13803390500507196

Brown, E.C., Hack, S.M., Gold, J.M., Carpenter Jr, W.T., Fischer, B.A., Prentice, K.P.,

Waltz, J.A. (2015). Integrating frequency and magnitude information in decision-making in schizophrenia: An account of patient performance on the Iowa

Gambling Task. *Journal of Psychiatric Research*, 66-67, 16-23. doi:

10.1016/j.jpsychires.2015.04.007

Caceda, R., Nemeroff, C.B., and Harvey, P.D. (2014). Toward an understanding of

decision-making in severe mental illness. *Journal of Neuropsychiatry and Clinical Neurosciences*, 26(3), 196-213.

- Cavallaro, R., Cavedini, P., Mistretta, P., Bassi, T., Monica Angelone, S., Ubbiali, A., and Bellodi, L. (2003). Basal-corticofrontal circuits in schizophrenia and obsessive-compulsive disorder: A controlled, double dissociation study. *Biological Psychiatry*, 54, 437-443. doi: 10.1016/S0002-3223(03)01814-0
- Cella, M., Dymond, S., Cooper, A., and Turnbull, O.H. (2012). Cognitive decision modelling of emotion-based learning impairment in schizophrenia: The role of awareness. *Psychiatry Research*, 196, 15-19. doi: 10.1016/j.psychres.2011.08.015
- Chang, W.C., Waltz, J.A., Gold, J.M., Chan, T.C.W., and Chen, E.Y.H. (2016). Mild reinforcement learning deficits in patients with first-episode psychosis. *Schizophrenia Bulletin*, 42(6), 1476-1485. doi: 10.1093/schbul/sbw060
- Chong, H.Y., Teoh, S.L., Wu, D., B.-C., Kotirum, S., Chiou, C.-F., and Chaiyakunapruk, N. (2016). Global economic burden of schizophrenia: a systematic review. *Neuropsychiatric Disease and Treatment*, 12, 357-373. doi: 10.2147/NDT.S96649
- Cicerone, K.D., Langenbahn, D.M., Braden, C., Malec, J.F., Kalmar, K., Fraas, M., Felicetti, T., Laatsch, L., Preston Harley, J., Bergquist, T., Azulay, J., Cantor, J., and Ashman, T. (2011). Evidence-based cognitive rehabilitation: Updated review of the literature from 2003 through 2008. *Archives of Physical Medicine and Rehabilitation*, 92(4), 519-530. doi: 10.1016/j.apmr.2010.11.015
- Collins, A.G.E., Brown, J.K., Gold, J.M., Waltz, J.A., and Frank, M.J. (2014). Working memory contributions to reinforcement learning impairments in schizophrenia.

The Journal of Neuroscience, 34(41), 13747-13756. doi:

10.1523/JNEUROSCI.0989-14.2014

Combs, D.R. and Mueser, K.T. (2007). Schizophrenia. In Hersen, M., Turner, S.M., and Beidel, D.C. (Eds), *Adult Psychopathology and Diagnosis Fifth Edition*, Hoboken, New Jersey: John Wiley and Sons, Inc.

Damasio, A.R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London, B*, 351, 1413-1420.

Delazer, M., Sinz, H., Zamarian, L., Stockner, H., Seppi, K., Wenning, G.K., Benke, T., and Poewe, W. (2009). Decision-making under risk and under ambiguity in Parkinson's disease. *Neuropsychologia*, 47, 1901-1908. doi: 10.1016/j.neuropsychologia.2009.02.034

Derogatis, L.R. (1993). BSI Brief Symptom Inventory: Administration, Scoring, and Procedure Manual (4th ed). Minneapolis, MN, National Computer Systems.

Deserno, L., Boehme, R., Heinz, A., and Schlagenhauf, F. (2013). Reinforcement learning and dopamine in schizophrenia: dimensions of symptoms or specific features of a disease group? *Frontiers in Psychiatry*, 4(172), 1-16. doi: 10.3389/fpsyt.2013.00172

- Deserno, L., Schlagenhauf, F., and Heinz, A. (2016). Striatal dopamine, reward, and decision-making in schizophrenia. *Dialogues in Clinical Neuroscience*, 18(1), 77-89.
- Dixon, L.B., Holoshitz, Y., and Nossel, I. (2016). Treatment engagement of individuals experiencing mental illness: review and update. *World Psychiatry*, 15(1), 13-20. doi: 10.1002/wps.20306
- Dunn, B.D., Dalgleish, T., and Lawrence, A.D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience and Biobehavioral Reviews*, 30, 239-271. doi: 10.1016/j.neubiorev.2005.07.001
- Ernst, M. and Paulus, M.P. (2005). Neurobiology of decision making: A selective review from a neurocognitive and clinical perspective. *Biological Psychiatry*, 58, 597-604. doi: 10.1016/j.biopsych.2005.06.004
- Euteneuer, F., Schaefer, F., Stuermer, R., Boucsein, W., Timmermann, L., Barbe, M.T., Ebersbach, G., Otto, J., Kessler, J., and Kalbe, E. (2009). Dissociation of decision-making under ambiguity and decision-making under risk in patients with Parkinson's disease: A neuropsychological and psychophysiological study. *Neuropsychologia*, 47, 2882-2890. doi: 10.1016/j.neuropsychologia.2009.06.014
- Evans, K.L. and Hampson, E. (2015). Sex differences on prefrontally-dependent cognitive tasks. *Brain and Cognition*, 93, 42-53. doi: 10.1016/j.bandc.2014.11.006

- Fellows, L.K. (2011). Orbitofrontal contributions to value-based decision making: evidence from humans with frontal lobe damage. *Annals of the New York Academy of Sciences*, 1239, 51-58. doi: 10.1111/j.1749-6632.2011.06229.x
- Fellows, L.K. and Farah, M.J. (2005). Different underlying impairments in decision-making following ventromedial and dorsolateral frontal lobe damage in humans. *Cerebral Cortex*, 15(1), 58-63. doi: 10.1093/cercor/bhh108
- Fond, G., Bayard, S., Capdevielle, D., Delmont, J., Mimoun, N., MacGregor, A., and Boulenger, J. (2013). A further evaluation of decision-making under risk and under ambiguity in schizophrenia. *European Archives of Psychiatry and Clinical Neuroscience*, 263(3), 249-257. doi: 10.1007/s00406-012-0330-y
- Frank, M.J. and Claus, E.D. (2006). Anatomy of a decision: Striato-orbitofrontal interactions in reinforcement learning, decision making, and reversal. *Psychological Review*, 113(2), 300-326. doi: 10.1037/0033-295X.113.2.300
- Gleichgerrcht, E., Ibanez, A., Roca, M., Torralva, T., and Manes, F. (2010). Decision-making cognition in neurodegenerative diseases. *Nature Reviews Neurology*, 6, 611-623. doi: 10.1038/nrneurol.2010.148
- Glimcher, P.W., Camerer, C.F., Fehr, E., and Poldrack, R.A. (2009). *Neuroeconomics: Decision Making and the Brain*. London, Academic Free Press.

Gold, J.M., Waltz, J.A., Prentice, K.J., Morris, S.E., and Heerey, E.A. (2008). Reward Processing in Schizophrenia: A Deficit in the Representation of Value.

Schizophrenia Bulletin, 34(5), 835-847. doi: 10.1093/schbul/sbn068

Gold, J.M., Waltz, J.A., Matveeva, T.M., Kasanova, Z., Strauss, G.P., Herbener, E.S., Collins, A.G.E., and Frank, M.J. (2012). Negative symptoms and the failure to represent the expected reward value of actions. *Archives of General Psychiatry*, 69(2), 129-138. doi: 10.1001/archgenpsychiatry.2011.1269

Grant, P.M., Huh, G.A. Perivoliotis, D., Stolar, N.M., and Beck, A.T. (2012).

Randomized trial to evaluate the efficacy of cognitive therapy for low-functioning patients with schizophrenia. *Archives of General Psychiatry*, 69(2), 121-127. doi:

10.1001/archgenpsychiatry.2011.129

Griffiths, K.R., Morris, R.W., and Balleine, B.W. (2014). Translational studies of goal-directed action as a framework for classifying deficits across psychiatric disorders.

Frontiers in Systems Neuroscience, 8(101), 1-16. doi: 10.3389/fnsys.2014.00101

Hargreaves, A., Dillon, R., Anderson-Schmidt, H., Corvin, A., Fitzmaurice, B., Castorina, M., Robertson, I.H., Donohoe, G. (2015). Computerised working-memory focused cognitive remediation therapy for psychosis – A preliminary study. *Schizophrenia Research*, 169, 135-140. doi: 10.1016/j.schres.2015.09.004

Heerey, E.A. and Gold, J.M. (2007). Patients with schizophrenia demonstrate

dissociation between affective experience and motivated behaviour. *Journal of Abnormal Psychology*, 116(2), 268-278. doi: 10.1037/0021-843X.116.2.268

Heerey, E.A., Robinson, B., McMahon, R.P., and Gold, J.M. (2007). Delay discounting in schizophrenia. *Cognitive Neuropsychiatry*, 12(3), 213-221. doi:

10.1080/13546800601005900

Heerey, E.A., Bell-Warren, K.R., and Gold, J.M. (2008). Decision-making impairments in the context of intact reward sensitivity in schizophrenia. *Biological Psychiatry*,

64(1), 62-69. doi: 10.1016/j.biopsych.2008.02.015

Heerey, E.A., Matveeva, T.M., and Gold, J.M. (2011). Imagining the future: Degraded representations of future rewards and events in schizophrenia. *Journal of*

Abnormal Psychology, 120(2), 483-489. doi: 10.1037/a0021810

Homayoun, H and Moghaddam, B. (2008). Orbitofrontal cortex neurons as a common target for classic and glutamatergic antipsychotic drugs. *Proceedings of the*

National Academy of Sciences, 105(46), 18041-18046. doi:

10.1073/pnas.0806669105

Horan, W.P., Kern, R.S., Shokat-Fadai, K., Sergi, M.J., Wynn, J.K., and Green, M.F.

(2009). Social cognitive skills training in schizophrenia: An initial efficacy study of stabilized outpatients. *Schizophrenia Research*, 107(1), 47-54. doi:

10.1016/j.schres.2008.09.006

Insel, T.R. (2010). Rethinking schizophrenia. *Nature*, 468, 187-193. doi:

10.1038/nature09552

Johansen, R., Hestad, K., Iversen, V.C., Agartz, I., Sundet, K., Andreassen, O.A., and Melle, I. (2011). Cognitive and clinical factors are associated with service engagement in early-phase schizophrenia spectrum disorders. *The Journal of Nervous and Mental Disease*, 199(3), 176-182. doi: 10.1097/NMD.0b013e31820bc2f9

Johnson, M.K., McMahon, R.P., Robinson, B.M., Harvey, A.N., Hahn, B., Leonard, C.J., Luck, S.J., and Gold, J.M. (2013). The relationship between working memory capacity and broad measures of cognitive ability in healthy adults and people with schizophrenia. *Neuropsychology*, 27(2), 220-229. doi: 10.1037/a0032060

Kable, J.W. and Glimcher, P.W. (2009). The neurobiology of decision: Consensus and controversy. *Neuron*, 63, 733-745. doi: 10.1016/j.neuron.2009.09.003

Kapur, S. (2003). Psychosis as a state of aberrant salience: A framework linking biology, phenomenology, and pharmacology in schizophrenia. *American Journal of Psychiatry*, 160, 13-23. doi: 10.1176/appi.ajp.160.1.13

Kenney, J., Anderson-Schmidt, H., Scanlon, C., Arndt, S., Scherz, E., McInerney, S., McFarland, J., Byrne, F., Ahmed, M., Donohoe, G., Hallahan, B., McDonald, C., and Cannon, D.M. (2015). Cognitive course in first-episode psychosis and clinical correlates: A 4 year longitudinal study using the MATRICS Consensus Cognitive Battery. *Schizophrenia Research*, 169, 101-108. doi: 10.1016/j.schres.2015.09.007

- Khani, A and Rainer, G. (2016). Neural and neurochemical basis of reinforcement-guided decision making. *Journal of Neurophysiology*, 116(2), 724-741. doi: 10.1152/jn.01113.2015
- Kim, J., Glahn, D.C., Nuechterlein, K.H., and Cannon, T.D. (2004). Maintenance and manipulation of information in schizophrenia: further evidence for impairment in the central executive component of working memory. *Schizophrenia Research*, 68, 173-187. doi: 10.1016/S0920-9964(03)00150-6
- Kim, Y.T., Lee, K.U., and Lee, S.J. (2009). Deficit in decision-making in chronic, stable schizophrenia: From a reward and punishment perspective. *Psychiatry Investigation*, 6(1), 26-33. doi: 10.4306/pi.2009.6.1.26
- Krawczyk, D.C. (2002). Contributions of the prefrontal cortex to the neural basis of human decision making. *Neuroscience and Biobehavioral Reviews*, 26, 631-664.
- Larquet, M., Coricelli, G., Opolczynski, G., and Thibaut, F. (2010). Impaired decision making in schizophrenia and orbitofrontal cortex lesion patients. *Schizophrenia Research*, 116, 266-273. doi: 10.1016/j.schres.2009.11.010
- Lee, D. (2013). Decision making: From neuroscience to psychiatry, *Neuron*, 78, 233-248. doi: 10.1016/j.neuron.2013.04.008
- Lee, D. and Park, S. (2005). Working memory impairments in schizophrenia: A meta-analysis. *Journal of Abnormal Psychology*, 114, 599-611. doi: 10.1037/0021-843x.114.4.599

Lee, D. and Seo, H. (2007). Mechanisms of reinforcement learning and decision making in the primate dorsolateral prefrontal cortex. *Annals of the New York Academy of Sciences*, 1104, 108-122. doi: 10.1196/annals.1390.007

Lee, D., Seo, H., and Jung, M.W. (2012). Neural basis of reinforcement learning and decision making. *Annual Review of Neuroscience*, 35, 287-308. doi: 10.1146/annurev-neuro-062111-150512

Lee, Y., Kim, Y.T., Seo, E., Park, O., Jeong, S.H., Kim, S.H., Lee, S.J. (2007). Dissociation of emotional decision-making from cognitive decision-making in chronic schizophrenia. *Psychiatry Research*, 152, 113-120. doi: 10.1016/j.psychres.2006.02.001

Lezak, M., Howieson, M., and Loring, D. (2004). *Neuropsychological Assessment* (4th ed.). New York, NY, Oxford University Press

Liao, J., Yan, H., Liu, Q., Yan, J., Zhang, L., Jiang, S., Zhang, X., Dong, Z., Yang, W., Cai, L., Guo, H., Wang, Y., Li, Z., Tian, L., Zhang, D., and Wang, F. (2015). Reduced paralimbic system gray matter volume in schizophrenia: Correlations with clinical variables, symptomatology and cognitive function. *Journal of Psychiatric Research*, 65, 80-86. doi: 10.1016/j.psychires.2015.04.008

Madden, G.J., Begotka, A.M., Raiff, B.R., and Kastern, L.L. (2003). Delay discounting of real and hypothetical rewards. *Experimental and Clinical Psychopharmacology*, 11(2), 139-145. doi: 10.1037/1064-1297.11.2.139

Mesholam-Gately, R.I., Giuliano, A.J., Faraone, S.V., Goff, K.P., Seidman, L.J. (2009).

Neurocognition in first-episode schizophrenia: A meta-analytic review.

Neuropsychology, 23(3), 315-336. doi: 10.1037/a0014708

Murray, G.K., Cheng, F., Clark, L., Barnett, J.H., Blackwell, A.D., Fletcher, P.C.,

Robbins, T.W., Bullmore, E.T., and Jones, P.B. (2008). Reinforcement and

reversal learning in first-episode psychosis. *Schizophrenia Bulletin*, 34(5), 848-

855. doi: 10.1093/schbul/sbn078

Nakamura, M., Nestor, P.G., Levitt, J.J., Cohen, A.S., Kawashima, T., Shenton, M.E., and

McCarley, R.W. (2008). Orbitofrontal volume deficit in schizophrenia and

thought disorder. *Brain*, 131, 180-195. doi: 10.1093/brain/awm265

Nelson, H.E. (1976). A modified card sorting test sensitive to frontal lobe defects. *Cortex*,

12, 313-324.

Nieto, R.G. and Castellanos, F.X. (2011). A meta-analysis of neuropsychological

functioning in patients with early onset schizophrenia and pediatric bipolar

disorder. *Journal of Clinical Child & Adolescent Psychology*, 40(2), 266-280. doi:

10.1080/15374416.2011.546049

Norman, R.M.G., Manchanda, R., Harricharan, R., and Northcott, S. (2015). The course

of negative symptoms over the first five years of treatment: Data from an early

intervention program for psychosis. *Schizophrenia Research*, 169, 412-417. doi:

10.1016/j.schres.2015.09.010

- Nuechterlein, K.H., Subotnik, K.L., Green, M.F., Ventura, J., Asarnow, R.F., Gitlin, M.J., Ye, C.M., Gretchen-Doorly, D., and Mintz, J. (2011). Neurocognitive predictors of work outcome in recent-onset schizophrenia. *Schizophrenia Bulletin*, 37(supplement 2), S33-S40. doi: 10.1093/schbul/sbr084
- Pecchinenda, A., Dretsch, M., and Chapman, P. (2006). Working memory involvement in emotion-based processes underlying choosing advantageously. *Experimental Psychology*, 53(3), 191-197. doi: 10.1027/1618-3169.53.3.191
- Raffard, S., Gutierrez, L.-A., Yazbek, H., Larue, A., Boulenger, J.-P., Lancon, C., Benoit, M., Faget, C., Norton, J., and Capdevielle, D. (2016). Working memory deficit as a risk factor for severe apathy in schizophrenia: A 1-year longitudinal study. *Schizophrenia Bulletin*, 42(3), 642-651. doi: 10.1093/schbul/sbw002
- Ritter, L.M., Meador-Woodruff, J.H., and Dalack, G.W. (2004). Neurocognitive measures of prefrontal cortical dysfunction in schizophrenia. *Schizophrenia Research*, 68, 65-73. doi: 10.1016/S0920-9964(03)00086-0
- Rodriguez-Sanchez, J.M., Crespo-Facorro, B., Iglesias, R.P., Bosch, C.G.B., Alvarez, M., Llorca, J., Vazquez-Barquero, J.L. (2005). Prefrontal cognitive functions in stabilized first-episode patients with schizophrenia spectrum disorders: A dissociation between dorsolateral and orbitofrontal functioning. *Schizophrenia Research*, 77, 279-288. doi: 10.1016/j.schres.2005.04.023
- Rund, B.R., Melle, I., Friis, S., Johannessen, J.O., Larsen, T.K., Midboe, L.J., Opjordsmoen, S., Simonsen, E., Vaglum, P., and McGlashan, T. (2007). The

course of neurocognitive functioning in first-episode psychosis and its relation to premorbid adjustment, duration of untreated psychosis, and relapse. *Schizophrenia Research*, 91, 132-140. doi: 10.1016/j.schres.2006.11.030

Schiebener, J. and Brand, M. (2015). Self-reported strategies in decisions under risk: role of feedback, reasoning abilities, executive functions, short-term memory, and working memory. *Cognitive Processing*, 16, 401-416. doi: 10.1007/s10339-015-0665-1

Schultz, W. (1998). Predictive reward signal of dopamine neurons. *Journal of Neurophysiology*, 80, 1-27.

Schultz, W. (2013). Updating dopamine reward signals. *Current Opinion in Neurobiology*, 23, 229-238. doi: 10.1016/j.conb.2012.11.012

Sevy, S., Burdick, K.E., Visweswaraiyah, H., Abdelmessih, S., Lukin M., Yechiam, E., and Bechara, A. (2007). Iowa Gambling Task in Schizophrenia: A review and new data in patients with schizophrenia and co-occurring cannabis use disorders. *Schizophrenia Research*, 92(1-3), 74-84. doi: 10.1016/j.schres.2007.01.005

Shinn, A.K., Bolton, K.W., Karmacharya, R., Lewandowski, K.E., Yuksel, C., Baker, J.T., Chouinard, V.-A., Pingali, S.M., Bye, H., Cederbaum, K., and Ongur, D. (2015). McLean OnTrack: a transdiagnostic program for early intervention in first-episode psychosis. *Early Intervention in Psychiatry*, Nov. 29th [Epub ahead of print]. doi:10.1111/eip.12299

Simonsen, C., Sundet, K., Vaskinn, A., Birkenaes, A.B., Engh, J., Faerden, A., Jonsdottir, H., Andreas Ringen, P., Opjordsmoen, S., Melle, I., Friis, S., and Andreassen, O.A. (2011). Neurocognitive dysfunction in bipolar and schizophrenia spectrum disorders depends on history of psychosis rather than diagnostic group. *Schizophrenia Bulletin*, 37(1), 73-83. doi: 10.1093/schbul/sbp034

Spreeen, O. and Strauss, E. (1998). *A Compendium of Neurological Tests: Administration, Norms, and Commentary*. 2nd edition. Oxford University Press; New York.

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

Stopper, C.M. and Floresco, S.B. (2015). Dopaminergic circuitry and risk/reward decision making: Implications for schizophrenia. *Schizophrenia Bulletin*, 41(1), 9-14. doi: 10.1093/schbul/sbu165

Strauss G.P., Waltz J.A., Gold J.M. (2014). A review of reward processing and motivational impairment in schizophrenia. *Schizophrenia Bulletin*, 40(2), S107-S116. doi: 10.1093/schbul/sbt197

Struglia, F., Stratta, P., Gianfelice, D., Pacifico, R., Riccardi, I., and Rossi, A. (2011). Decision-making impairment in schizophrenia: Relationships with positive symptomatology. *Neuroscience Letters*, 502, 80-83. doi: 10.1016/j.neulet.2011.07.017

Sutton, R.S. and Barto, A.G. (1998). *Reinforcement Learning: An Introduction*.
Cambridge, MA, MIT Press.

Svaldi, J., Philipsen, A., and Matthies, S. (2012). Risky decision-making in borderline
personality disorder. *Psychiatry Research*, 197, 112-118. doi:
10.1016/j.psychres.2012.01.014

Thorndike, E.L. (1911). *Animal Intelligence: Experimental Studies*. New York, NY,
Macmillan.

Tolman, E.C. (1948). Cognitive maps in rats and men. *Psychological Review*, 55(4), 189-
208.

Torgalsboen, A-K., Mohn, C., and Rund, B.R. (2014). Neurocognitive predictors of
remission of symptoms and social role functioning in the early course of first-
episode schizophrenia. *Psychiatry Research*, 216, 1-5. doi:
10.1016/j.psychres.2014.01.031

Tversky, A. and Kahneman, D. (1981). The framing of decisions and the psychology of
choice. *Science*, 211(4481), 453-458.

von Neumann, J and Morgenstern, O. (1944). *Theory of Games and Economic Behavior*.
Princeton, New Jersey, Princeton University Press.

Walker, E., Kestler, E., Bollini, A., and Hochan, K.M. (2004). Schizophrenia: etiology
and course. *Annual Review of Psychology*, 55, 401-430. doi:
10.1146/annurev.psych.55.090902.141950

- Wallis, J.D. (2007). Orbitofrontal cortex and its contribution to decision-making. *Annual Review of Neuroscience*, 30, 31-56. doi: 10.1146/annurev.neuro.30.051606.094334
- Waltz, J.A. and Gold, J.M. (2007). Probabilistic reversal learning impairments in schizophrenia: Further evidence of orbitofrontal dysfunction. *Schizophrenia Research*, 93, 296-303. doi: 10.1016/j.schres.2007.03.010
- Waltz, J.A., Frank, M.J., Robinson, B.M., and Gold, J.M. (2007). Selective reinforcement learning deficits in schizophrenia support predictions from computational models of striatal-cortical dysfunction. *Biological Psychiatry*, 62, 756-764. doi: 10.1016/j.biopsych.2006.09.042
- Wechsler, D. (2008). *Wechsler Adult Intelligence Scale (4th ed.)*. San Antonio, TX, Psychological Corporation.
- Wechsler, D. (2011). *Wechsler Abbreviated Scale of Intelligence (2nd ed.)*. San Antonio, TX, NCS Pearson.
- Weller, J.A., Levin, I.P., and Bechara, A. (2010). Do individual differences in Iowa Gambling Task performance predict adaptive decision-making for risky gains and losses. *Journal of Clinical and Experimental Neuropsychology*, 32(2), 141-150. doi: 10.1080/13803390902881926
- Zhang, L., Tang, J., Dong, Y., Ji, Y., Tao, R., Liang, Z., Chen, J., Wu, Y., and Wang, K. (2015). Similarities and differences in decision-making impairments between

autism spectrum disorder and schizophrenia. *Frontiers in Behavioral Neuroscience*, 9(259), 1-13. doi: 10.3389/fnbeh.2015.00259

Ziauddeen, H. and Murray, G.K. (2010). The relevance of reward pathways for schizophrenia. *Current Opinion in Psychiatry*, 23, 91-96. doi: 10.1097/YCO.0b013e328336661b

Table 1 - Demographics and clinical information for the PIER group

	N (% of total N)	Mean (S.D.)
Age		28.4 (1.4)
Gender		
Male	8 (50%)	
Female	8 (50%)	
Ethnicity		
Caucasian	15 (94%)	
Biracial	1 (6%)	
Diagnosis		
Schizophrenia	10 (64%)	
Schizoaffective disorder	2 (12%)	
Bipolar disorder	2 (12%)	
Psychotic disorder NOS	2 (12%)	
Medication		
<i>Antipsychotics</i>		
Clozapine	5 (31%)	
Olanzapine	3 (19%)	
Risperidone	3 (19%)	
Seroquel	4 (25%)	
Ziprasidone	1 (6%)	
<i>Mood stabilizers</i>		
Lithium	3 (19%)	
Epival	1 (6%)	
Living Arrangements		
Family	7 (44%)	
Spouse	3 (19%)	
Independent	5 (31%)	
Supervised boarding	1 (6%)	
Relationship status		
Single	12 (75%)	
Married	3 (19%)	
Divorced	1 (6%)	
PIER involvement (months)		59.9 (48.3)
GAF score		70 (5.0)

DECISION-MAKING IN EARLY PSYCHOSIS

Table 2 - Demographics, drug-use, and neuropsychological task performance for the PIER and control group

	PIER Patients N = 16 Mean (S.D.)	Healthy Controls N = 20 Mean (S.D.)	Statistic (t or X² where indicated)	P value
Age, in years	28.4 (1.4)	24.1 (5.7)	1.53	0.134
Gender (male/female)	8/8	11/9	X ² = 0.001	0.970
Years of Education	12.6 (1.5)	17.4 (2.8)	-6.543	<0.001
GSI score (BSI)	1.1 (0.2)	0.4 (0.1)	3.249	0.0013
<i>Drug use days within 30 days prior to test</i>				
Cannabis	1.3 (1.3)	0.2 (0.1)	0.843	0.412
Alcohol	3.3 (1.2)	4.9 (0.8)	-1.149	0.259
Cigarettes	15.0 (3.9)	1.5 (1.5)	3.250	0.004
<i>Neuropsychological tasks</i>				
WRAT-4 reading subtest	96.3 (9.4)	105.6 (7.4)	-3.335	0.002
WASI-IV FSIQ	89.9 (15.2)	108.9 (6.8)	-4.625	<0.001
Digit Span	8.6 (3.3)	11.1 (2.7)	-2.461	0.019
Trails A	30.0 (9.9)	22.3 (6.3)	2.801	0.008
Trails B	80.0 (23.0)	49.9 (8.1)	5.071	<0.001
m-WCST				
Categories correct	5.62 (0.9)	6.0 (0)	-1.695	0.111
Total errors	6.5 (5.5)	3.1 (2.3)	2.344	0.030
Perseverative errors	1.63 (2.5)	0.7 (0.9)	1.629	0.113

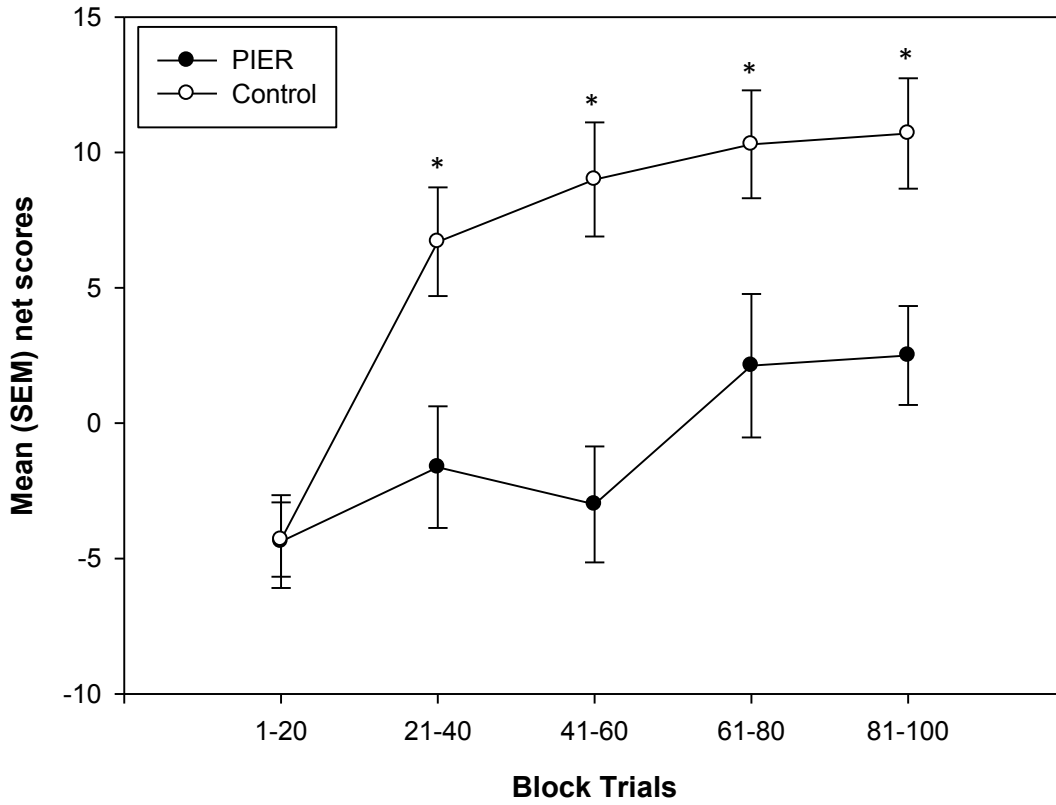


Figure 1 – Mean (SEM) IGT performance by PIER and control participants during the five block trials.

* = significant within-block group difference (p < 0.05)

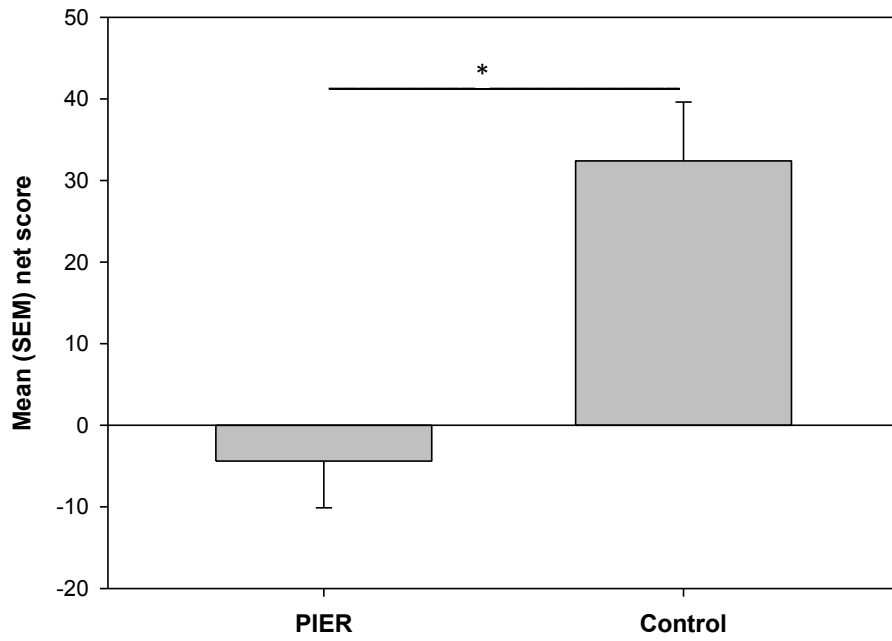


Figure 2 - Mean (SEM) IGT performance by PIER and control participants.

* = significant group difference ($p < 0.05$)

DECISION-MAKING IN EARLY PSYCHOSIS

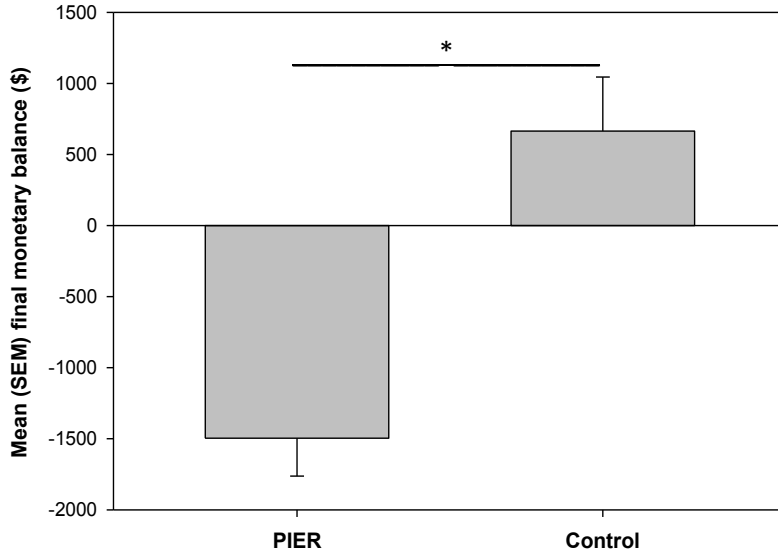


Figure 3 – Mean (SEM) total IGT monetary balance for PIER and control participants.

* = significant group difference ($p < 0.05$)

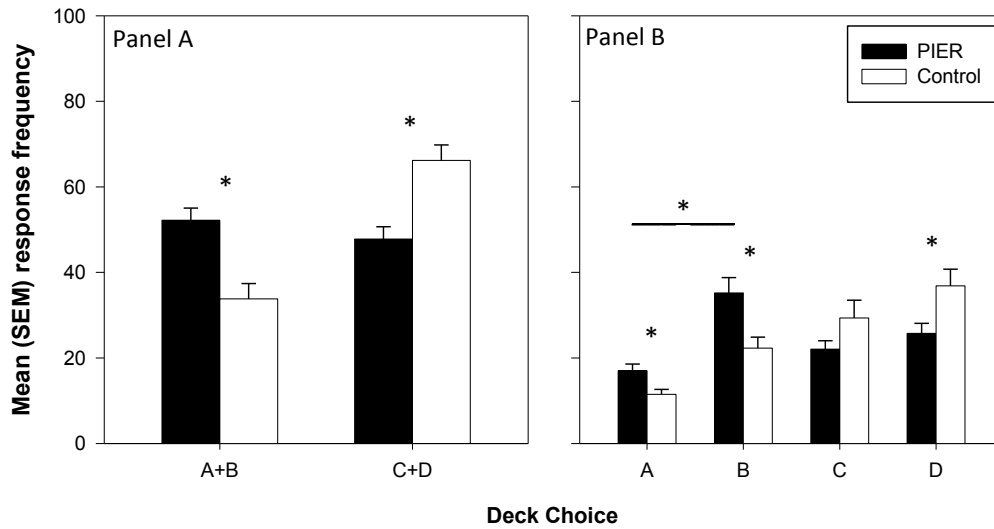


Figure 4 – Panel A: Mean (SEM) IGT response frequency for combined decks A+B and C+D by the PIER and control groups. Panel B: Mean (SEM) IGT response frequency across all decks by the PIER and control groups.

* = significant between group differences ($p < 0.05$)

—* = significant within group differences ($p < 0.05$)

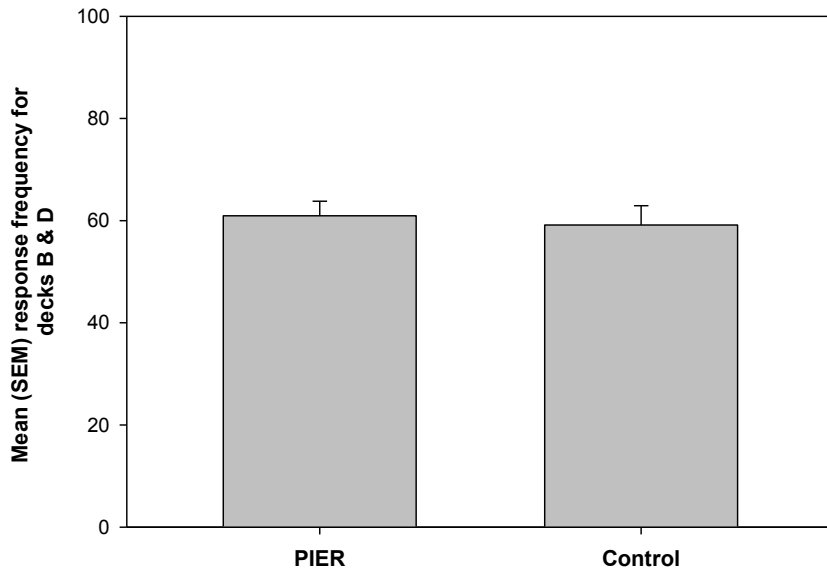


Figure 5 – Mean (SEM) IGT response frequency for the infrequent loss decks (B & D) by the PIER and control groups.

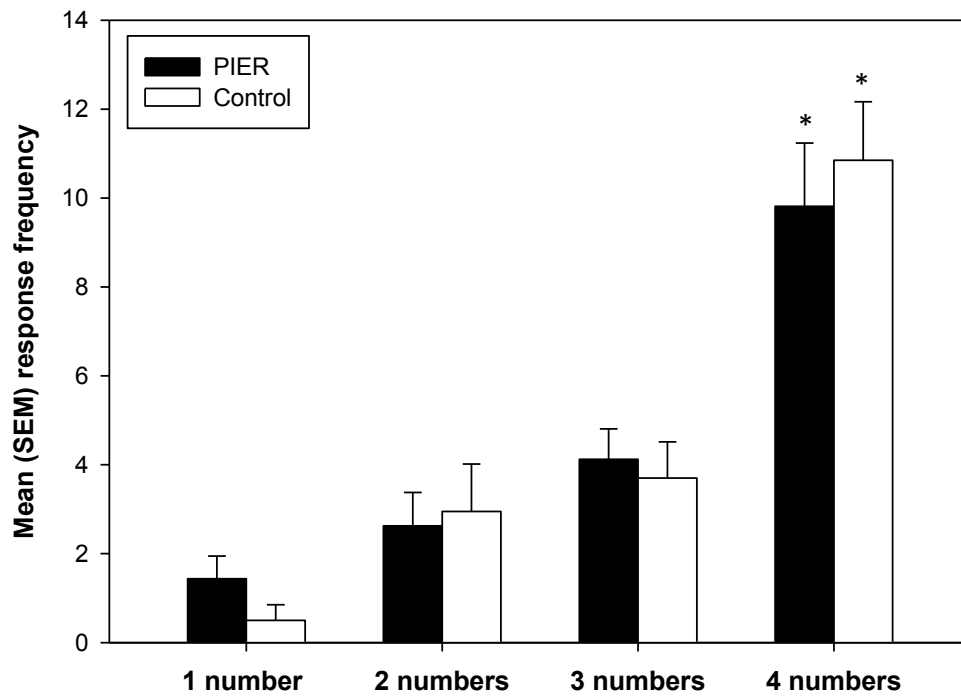


Figure 6 - Mean (SEM) GDT frequency of deck choice selection by the PIER and control groups.

* = significant within group differences ($p < 0.05$). Both groups selected the 4 numbers option significantly more than all other available choices

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Table 3 – Correlations between performance on the neuropsychological test battery and the decision-making tests for the PIER group.
 * = p < 0.01

	Years of Educ.	WRAT- 4	FSIQ	GSI (BSI)	Trails A	Trails B	Digit Span	Total Errors mWCST	Pers. Errors mWCST	Net Total IGT	Decks A&B IGT	Decks C&D IGT	Total \$ IGT	Adv. Choice GDT	Dis. Choice GDT
Age	0.35	-0.14	-0.30	0.03	0.23	-0.01	0.34	0.10	0.05	0.30	-0.30	0.30	0.24	-0.22	0.22
Years of Educ.		0.46	0.51	-0.27	-0.35	-0.35	0.71*	-0.21	-0.20	0.31	-0.31	0.31	0.30	0.04	-0.04
WRAT-4			0.76*	0.02	-0.55	-0.51	0.53	-0.35	-0.29	0.10	-0.10	0.10	0.14	0.46	-0.46
FSIQ				0.19	-0.31	-0.21	0.52	-0.39	-0.31	0.29	-0.29	0.29	0.20	0.23	-0.23
GSI (BSI)					0.39	0.17	-0.30	-0.42	-0.46	-0.15	0.15	-0.15	-0.45	-0.40	0.40
Trails A						0.70*	-0.33	0.18	-0.02	0.03	-0.03	0.03	-0.15	-0.61	0.61
Trails B							-0.17	0.37	0.12	0.29	-0.29	0.29	0.26	-0.45	0.45
Digit Span								-0.12	-0.16	0.63*	-0.63*	0.63*	0.65*	0.11	-0.11
Total Errors mWCST									0.86*	0.07	-0.07	0.07	0.28	-0.07	0.07
Pers. Errors mWCST										0.15	-0.15	0.15	0.32	0.18	-0.18
Net Total IGT											-1.00*	1.00*	0.91*	0.14	-0.14
Decks A&B IGT												-1.00*	-0.91*	-0.14	0.32
Decks C&D IGT													0.91*	0.14	-0.14
Total \$ IGT														0.27	-0.27
Adv. Choice GDT															-1.00*

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Table 4 – Correlations between performance on the neuropsychological test battery and the decision-making tests for the control group.
 * = p < 0.01

	Years of Educ.	WRAT- 4	FSIQ	GSI (BSI)	Trails A	Trails B	Digit Span	Total Errors mWCST	Pers. Errors mWCST	Net Total IGT	Decks A&B IGT	Decks C&D IGT	Total \$ IGT	Adv. Choice GDT	Dis. Choice GDT
Age	0.76*	0.14	0.02	-0.20	-0.29	-0.07	0.02	0.14	0.45	-0.24	0.24	-0.24	-0.31	0.28	-0.28
Years of Educ.		0.20	0.19	-0.23	-0.29	-0.35	0.23	0.17	0.49	-0.23	0.23	-0.23	-0.26	0.30	-0.30
WRAT-4			0.46	-0.13	0.23	0.17	0.36	-0.05	0.18	0.13	-0.13	0.13	0.10	-0.03	0.03
FSIQ				-0.33	-0.23	0.01	0.47	0.11	0.28	0.38	-0.38	0.38	0.33	-0.04	0.04
GSI (BSI)					0.26	0.09	-0.08	-0.16	-0.27	-0.31	0.31	-0.31	-0.27	-0.22	0.22
Trails A						-0.05	0.10	-0.21	-0.28	-0.07	0.07	-0.07	-0.02	-0.04	0.04
Trails B							-0.50	-0.09	-0.14	-0.10	0.10	-0.10	-0.03	-0.13	0.13
Digit Span								-0.14	0.26	0.22	-0.22	0.22	0.12	-0.46	0.46
Total Errors mWCST									0.64*	-0.12	0.12	-0.12	-0.07	0.15	-0.15
Pers. Errors mWCST										-0.17	0.17	-0.17	-0.19	0.14	-0.14
Net Total IGT											-1.00*	1.00*	0.96*	-0.17	0.17
Decks A&B IGT												-1.00*	-0.96*	0.17	-0.17
Decks C&D IGT													0.96*	-0.17	0.17
Total \$ IGT														-0.14	0.14
Adv. Choice GDT															-1.00*

Appendices

Appendix A – Information Letter for PIER participants



Dear Participant,

We are researchers from the Waterford Hospital (Dr. LeDrew, Dr. Thomas, Dr. Hogan) and the Department of Psychology at Memorial University (Ben Goddard and Dr. Hadden). We are conducting a study to learn about how people who have experienced psychosis make decisions after their symptoms have been treated. When people are involved in treatment programs such as PIER, they are required to make many decisions about appointment times, medication, and how the treatment is working. These decisions have a big impact on how you experience the program and if it works for you. In order to improve treatment for people suffering from challenges similar to those you face, we need to understand how you make decisions. This study will take approximately 2-hours of your time.

We will be studying decision-making in people who have experienced early psychosis and people who have not had this experience. Our hope is to develop a model of decision-making in people who have had a psychotic episode. We are also interested in comparing the decision-making strategies of people with experience(s) of psychosis and those who have not had these experiences. In addition, we are interested in examining how drug use might impact the way in which people make decisions.

We have two tasks that examine how people make decisions. The first is called the Iowa Gambling Task and it requires you to pick cards from different decks on a computer screen. The second task involves selecting a number based on how many dice you choose to roll and this is called the Game of Dice Task.

Along with doing these two tasks, we will also ask you questions related to your age, mental health history, drug use, and education. There are also several other tasks that involve answering questions about definitions of words, memory tasks, and sorting cards.

It is important that you know that your treatment will not be affected by whether you choose to participate in this study. You can withdraw from the study at any time.

DECISION-MAKING IN EARLY PSYCHOSIS

This research project has been reviewed and approved by the Health Research Ethics Board (HREB). All information collected from your participation will be stored in a locked filing cabinet. Your name or identifying information will not appear on any forms.

Sincerely,

Ben Goddard
PsyD Candidate

Kellie Hadden, PhD., R. Psych
Supervisor

Appendix B – Consent form for PIER participants



Consent to Take Part in Research

TITLE: An exploration of decision-making by individuals enrolled in the PIER program and students at Memorial University of Newfoundland

INVESTIGATOR(S): Ben Goddard, Kellie Hadden, Ph.D., Kellie LeDrew, M.D., K Hogan, M.D., Barbara Thomas, Ph.D., Jackie Hesson, Ph.D.

You have been invited to take part in a research study. Taking part in this study is voluntary. It is up to you to decide whether to be in the study or not. You can decide not to take part in the study. If you decide to take part, you are free to leave at any time. This will not affect your normal treatment provided by the PIER program.

Before you decide, you need to understand what the study is for, what risks you might take and what benefits you might receive. This consent form explains the study.

Please read this carefully. Take as much time as you like. If you like, take it home to think about for a while. Mark anything you do not understand, or want explained better. After you have read it, please ask questions about anything that is not clear.

The researchers will:

- discuss the study with you
- answer your questions
- keep confidential any information which could identify you personally
- be available during the study to deal with problems and answer questions

1. Introduction/Background:

This study has been designed to look at how people make decisions. We make decisions every day in our lives. When people are involved in treatment programs such as PIER, they are required to make many decisions about appointment times, medication, and how the treatment is working and these can have a big impact on the progression of their treatment. In order to improve treatment for people experiencing

challenges similar to those you face, we hope to better understand how people make decisions. In addition, we are also interested in examining how drug use might impact the way in which people make decisions. We will also be collecting similar information (study tasks and measures) from a group of undergraduate students at Memorial University.

2. Purpose of study:

The purpose of the study is to explore how people who have experienced early psychosis make decisions compared to a university undergraduate group of students.

3. Description of the study procedures:

Participation in this study will involve one study visit that includes a number of different tasks. The study will involve answering some questions, completing paper and pencil tasks as well as computer tasks specific to decision-making.

4. Length of time:

You will be expected to participate in one appointment at the Waterford hospital. The appointment will last for approximately 2 hours.

5. Possible risks and discomforts:

It is possible that while participating in this study you might feel some frustrations around some of the tasks you are performing. This may happen because of

- The time required
- The repetitive nature of some of the tasks
- Uncertainty around their answers

6. Benefits:

It is not known whether this study will benefit you. Our goal is to begin to understand how people who suffer early episodes of psychosis make decisions, which will hopefully help us with improving our understanding of treatment decisions.

7. Liability statement:

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. Every effort to protect your privacy will be made. However it cannot be guaranteed. For example we may be required by law to allow access to research records.

When you sign this consent form you give us permission to

- Collect information from you
- Collect information from your health record
- Share information with the people conducting the study
- Share information with the people responsible for protecting your safety

Access to records

The members of the research team will see health and study records that identify you by name.

Other people may need to look at your health records and the study records that identify you by name. This might include the research ethics board. You may ask to see the list of these people. They can look at your records only when supervised by a member of the research team.

Use of your study information

The research team will collect and use only the information they need for this research study.

This information will include your

- date of birth
- sex
- education
- medical conditions
- medications
- drug use
- the results of psychological tests you had before the study
- the results of tests you completed during the study
- information from study interviews and questionnaires

Your name and contact information will be kept secure by the research team in Newfoundland and Labrador. It will not be shared with others without your permission. Your name will not appear in any report or article published as a result of this study.

Information collected for this study will be kept for seven years.

If you decide to withdraw from the study, the information collected up to that time will continue to be used by the research team. It may not be removed. This information will only be used for the purposes of this study.

After your part in this study ends, we may continue to review your health records to check that the information we collected is correct.

Information collected and used by the research team will be stored at the Department Psychology at Memorial University. Dr. Kellie Hadden is the person responsible for keeping it secure.

Your access to records

You may ask the study researcher to see the information that has been collected about you.

9. Questions or problems:

If you have any questions about taking part in this study, you can meet with the investigator who is in charge of the study at this institution. That person is: Ben Goddard

Principal Investigator's Name and Phone Number

Ben Goddard, PsyD Candidate, Department of Psychology, Memorial University
864-7675

Dr. Kellie Hadden, Department of Psychology, Memorial University 864-7675

Or you can talk to someone who is not involved with the study at all, but can advise you on your rights as a participant in a research study. This person can be reached through:

Ethics Office

Health Research Ethics Authority

709-777-6974 or by email at info@hrea.ca

After signing this consent you will be given a copy.

Signature Page

Study title: An exploration of decision-making by individuals enrolled in the PIER program and students at Memorial University of Newfoundland.

Name of principal investigator: Ben Goddard

To be filled out and signed by the participant:

Please check as appropriate:

I have read the consent and information sheet.	Yes { }	No { }
I have had the opportunity to ask questions/to discuss this study.	Yes { }	No { }
I have received satisfactory answers to all of my questions.	Yes { }	No { }
I have received enough information about the study.	Yes { }	No { }
I have spoken to Ben Goddard (Research Coordinator) has answered my questions	Yes { }	No { }
I understand that I am free to withdraw from the study	Yes { }	No { }
• at any time		
• without having to give a reason		
• without affecting my future care at PIER Program.		
I understand that it is my choice to be in the study and that I may not benefit.	Yes { }	No { }
I understand how my privacy is protected and my records kept confidential	Yes { }	No { }
I agree that the study doctor or investigator may read the parts of my hospital records which are relevant to the study	Yes { }	No { }
I agree to take part in this study.	Yes { }	No { }

Signature of participant

Name printed

Year/Month/Day

To be signed by the investigator or person obtaining consent

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of investigator

Name printed

Year/Month/Day

Telephone number: _____

Appendix C - Demographics and Drug Use Questionnaire

Date of Interview (day/month/year)	
Subject Number	
Date of Birth (day/month/year)	
DEMOGRAPHICS	
Gender	Female Male
Preferred Language	English French Other - Specify: _____ Unknown
Highest Education Completed (circle):	Some Elementary: specify _____ Junior High (Grade 9) Some High School: specify _____ High School (Grade 12) Post-Secondary: specify _____
Do you have any mental health diagnosis (that you know of): Yes / No	If yes, please specify
Do you take medication as a result: Yes / No	If yes, please specify
Do you have any past history of traumatic head injury where there was a loss of consciousness: Yes / No	If yes, please specify
DRUG USE HISTORY	

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Cannabis	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>
Crack/Cocaine	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>
Heroin/Opium	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>
Methadone	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>
Tobacco	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>
Alcohol	<p>Number of days last 30 days prior:</p> <p>How many years in your life have you regularly used (3+ times/week):</p> <p>Route of administration</p>