

**The Role of Cognitive Biases in the Development, Maintenance and  
Treatment of Delusional Belief across the Psychosis Continuum**

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## SUMMARY

Cognitive approaches to the study of delusional beliefs have been the focus of much research over the last decade. The present thesis builds on this research output through six manuscripts. These manuscripts incorporate three distinct pieces of research, which collectively represent an investigation into the role that cognitive biases have in the development, maintenance and treatment of delusions.

The first aim of the thesis was to observe the validity of the Jumping to Conclusions (JTC) bias, and particularly the “over-adjustment” component of this bias, which holds that people with delusions over-react to disconfirmatory evidence. Paper 1 investigated the possibility that “over-adjustment” is an artefact of the “beads task”, which is the most commonly used task to elucidate the effect. Importantly, Paper 1 offered qualitative evidence that “over-adjustment” is likely to be due to a miscomprehension of this task’s instructional set. Paper 2 was an extension of these findings and included an intervention designed to improve comprehension during the beads task. The intervention successfully improved comprehension and simultaneously reduced the “over-adjustment” effect, further suggesting that this effect was driven by miscomprehension.

The second aim of the thesis was to investigate the validity of the “hypersalience of evidence-hypothesis matches” mechanism. “Hypersalience” has recently been put forward as the underlying mechanism responsible for cognitive reasoning biases that affect people with delusions, such as the JTC. The ensuing three papers tested whether people with delusions, and those identified as delusion-prone, were hypersalient to evidence-hypothesis

matches by observing whether these groups were more susceptible to confirmation biases (Paper 3), reasoning heuristics (Paper 4), and illusory correlations and illusions of control (Paper 5) relative to non-delusion-prone controls. Collectively, these papers offered empirical support for the “hypersalience” mechanism and demonstrated that delusional beliefs may be caused and maintained by a heightened propensity to confirmation biases, reasoning heuristics, and illusory associations via this mechanism.

The third and final aim of this thesis was to investigate the efficacy of a targeted metacognitive training (MCT) program, incorporating a single module which focussed on the “hypersalience of evidence-hypothesis matches” mechanism (Paper 6). MCT represents a novel approach for the treatment of delusions in people with schizophrenia, as it targets the cognitive biases thought to underlie the development and maintenance of delusional belief; in this case, the hypersalience mechanism. Relative to controls, participants in the targeted MCT treatment group exhibited significant decreases in delusions, significant increases in perceived quality of life and insight, and significant improvements in performance on two cognitive bias tasks.

The findings presented within this thesis contribute to our understanding of the cognitive processes underlying the formation and maintenance of delusional beliefs, and offer new treatment possibilities for people with psychotic illnesses, such as schizophrenia.

## DECLARATION

I, Ryan Balzan, certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Ryan Balzan \_\_\_\_\_

Date \_\_\_\_\_

## PUBLISHED WORKS

### **Chapter Three: Paper 1**

**Balzan, R. P.**, Delfabbro, P. H., & Galletly, C. (in press). Delusion-proneness or miscomprehension? A re-examination of the jumping-to-conclusions bias. *Australian Journal of Psychology*. DOI: 10.1111/j.1742-9536.2011.00032.x

### **Chapter Four: Paper 2**

**Balzan, R. P.**, Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press). Over-adjustment or miscomprehension? A re-examination of the jumping to conclusions bias. *Australian and New Zealand Journal of Psychiatry*. DOI: 10.1177/0004867411435291

### **Chapter Five: Paper 3**

**Balzan, R. P.**, Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press). Confirmation biases across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches. *British Journal of Clinical Psychology*. [accepted for publication 24 February 2012]

### **Chapter Six: Paper 4**

**Balzan, R. P.**, Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press). Reasoning heuristics across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches. *Cognitive Neuropsychiatry*. DOI: 10.1080/13546805.2012.663901

## UNPUBLISHED WORKS

### **Chapter Seven: Paper 5**

**Balzan, R. P.**, Delfabbro, P. H., Galletly, C., & Woodward, T. S. (submitted).  
Illusory correlations and control across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches.

### **Chapter Eight: Paper 6**

**Balzan, R. P.**, Delfabbro, P. H., Galletly, C., & Woodward, T. S. (submitted).  
Metacognitive training for patients with schizophrenia: Preliminary evidence for a targeted single-module program.

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## **CHAPTER 1: Overview and Literature Review**

### **Overview**

The present thesis examines the role of cognitive biases in the development, maintenance and treatment of delusions across the “psychosis continuum”. This concept proposes that the symptoms of dichotomous psychotic diagnoses (such as schizophrenia) occur to varying degrees along a continuum within the general population. The research program incorporated three distinct research aims presented in six papers, all of which have been either published in or submitted to peer-reviewed journals. This thesis is centred on these six papers, which have been presented in manuscript typeset. These papers have been book-ended with chapters providing the broader context and discussion relevant to the research program as a whole.

Chapter One, the present chapter, provides a brief summary of the research literature on delusional beliefs, introduces a working definition of delusions, compares delusional themes and subtypes, and discusses the frequency of delusions across the psychosis continuum. This chapter also summarises research on cognitive approaches to understanding delusion formation and maintenance, focussing particularly on the contribution that cognitive biases may make to this process. This chapter will conclude with a summary of the efficacy of psychotherapeutic methods in treating delusions, especially novel treatments such as metacognitive training (MCT) for people with schizophrenia. MCT targets the cognitive biases assumed to underlie the

development and maintenance of delusions. This review chapter is not intended to be exhaustive, but rather aims to offer a summary of the most important research on cognitive approaches to delusional belief carried out over the last three decades.

Chapter Two provides an exegesis for each of the six manuscripts included within the thesis. The chapter begins with a discussion of some of the limitations facing cognitive approaches to the study and treatment of delusional beliefs, and introduces three sets of studies intended to address each of these limitations. These studies go on to form the framework of the current thesis. Each of these research components is followed by a summary of the relevant manuscripts that pertain to that study, including the reasoning that links each paper to the next.

Chapters Three to Eight contain the six manuscripts. These chapters have been presented in three sections, Section A titled “Validity of the Over-adjustment Bias”, Section B titled “Validity of the „Hypersalience of Evidence-hypothesis Matches” Account of Delusion Formation and Maintenance”, and Section C titled “Towards a Targeted Metacognitive Training Program”. These three sections correspond to the three research aims mentioned above. The manuscripts have been reformatted to match the typeset for the thesis.

Chapter Nine, the final chapter, provides a general conclusion and summarises the main findings, overall significance, and methodological limitations of the current thesis and proposes a number of directions for future research.

Before proceeding with a review of the literature, it should be noted that each of the subsequent papers presented in Chapters Three through Eight begins with a short summary of the literature relevant to the topic of study within that particular paper. Therefore, this review will avoid repeating such information, and where applicable will direct the reader to the appropriate chapter for further reading.

### **Delusions: Defining Characteristics, Frequency and Themes**

The purpose of this section is to provide a “working” definition of delusions, report their frequency across the psychosis continuum, and describe some of the delusional themes that have been observed by both clinicians and researchers.

#### *Delusions: A Working Definition*

The American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders (*DSM-IV-TR*) defines a delusion as:

A false belief based on incorrect inference about external reality that is firmly sustained despite what almost everyone else believes and despite what constitutes incontrovertible and obvious proof or evidence to the contrary. The belief is not one ordinarily accepted by other members of the person’s culture or subculture (e.g., is not an article of religious faith). When a false belief involves a value judgement, it is regarded as a delusion only when the judgement is

so extreme as to defy credibility. Delusional conviction occurs on a continuum and can sometimes be inferred from an individual's behavior. (American Psychiatric Association, 2000, p. 821)

For these reasons, delusions have been described as phenomena that reflect cognitive processes and *(i)* are maintained despite counter-evidence and rational counter-argument; *(ii)* held with great conviction; and *(iii)* would be dismissed by members of the same social-cultural environment (Gilleen & David, 2005; Langdon & Coltheart, 2000; Miller & Karoni, 1996). The *DSM-IV-TR* also distinguishes between bizarre delusions (e.g., a belief that one is pregnant with a Border Collie puppy) from mundane or ordinary delusions (e.g., delusional jealousy or Othello syndrome, characterised by unfounded beliefs that one's sexual partner is unfaithful). This distinction is of diagnostic importance, as bizarre delusions may allow for a diagnosis of schizophrenia, yet preclude a diagnosis of delusional disorder (Coltheart, Langdon, & McKay, 2011).

Despite this clinical convention of what defines delusional belief, it should be noted that this approach to defining delusions is not without its problems, at least at a theoretical level. One such problem is that delusions may not necessarily be "false beliefs", in that they may be unfalsifiable (e.g., it is difficult to mount counter-evidence against the belief that someone is being controlled by an invisible entity). Mundane or non-bizarre delusions, such as delusional jealousy, may be based on a true situation, although the person's

explanations as to how they know about the infidelity may be delusional (Bell, Halligan, & Ellis, 2006).

Other issues include the fact that some delusional beliefs are not “firmly sustained”, but wax and wane over time. In addition, delusions may represent an incorrect inference from an “internal reality” (e.g., thought insertion) rather than an “external reality” (for an expanded review of these and other theoretical inconsistencies relating to this definition of delusional belief see Coltheart, et al., 2011). Despite these theoretical inconsistencies, the current thesis acknowledges the practicality of the existing conventional definition of delusional belief, and all future references to delusions should be interpreted as being consistent with the *DSM-IV-TR*.

### *Frequency of Delusions*

Delusions are one of the defining characteristics of psychosis, which along with hallucinations, disorganised thoughts, and acute agitation and aggression, may lead to a disturbance in the perception of reality (Jibson, 2010). The *DSM-IV-TR* lists many psychotic disorders and medical conditions that may be associated with the experience of delusions, including major depression, bipolar disorder, delusional disorder, Alzheimer’s disease, delirium, brief psychotic disorder, substance induced psychotic disorder, schizoaffective disorder, and perhaps most notably, schizophrenia. Schizophrenia affects around 0.3–0.7% of people at some point in their life (Freeman, 2006; van Os & Kapur, 2009) or 24 million people worldwide as of 2011 (World Health Organization, 2011). It occurs 1.4 times more frequently

in males than females and typically appears earlier in men (Picchioni & Murray, 2007). While delusions are not required for a diagnosis of schizophrenia (i.e., other “positive” symptoms include hallucinations and grossly disorganised speech and thinking, while “negative” symptoms include apathy, asociality, anhedonia, and avolition), they do represent a “core” symptom of the disorder. It has been estimated that up to 74% of all people diagnosed with schizophrenia experience delusions (e.g., Landa, Silverstein, Schwartz, & Savitz, 2006).

Psychotic disorders have traditionally been conceptualised as dichotomous „all or none“ phenomena, which are qualitatively different from the experiences in the general population. However, in recent years there has been a shift in the way the symptoms of psychosis are viewed. The “psychosis continuum” view challenges the “clinical practice” perspective, arguing that psychotic symptoms (note *not* disorders) are continuously distributed in the general population (e.g., Freeman, 2006; Johns & van Os, 2001; McKay, Langdon, & Coltheart, 2006; Smith, Riley, & Peters, 2009; Van Dael, et al., 2006; Warman, Lysaker, Martin, Davis, & Haudenschild, 2007; Woodward, Buchy, Moritz, & Liotti, 2007). Hence, “delusion-proneness” can be thought of as a continuously distributed characteristic in a similar way to glucose tolerance or blood pressure, with diagnosed conditions such as schizophrenia, diabetes and hypertension occurring at the *extremes* of these continuous characteristics (van Os, 2003).

While the idea of a continuum of psychotic experiences within the population is certainly not a new one (e.g., Meehl, 1962; Strauss, 1969), it is

only in the last two decades that it has been studied with any rigour. The most common approach has been to measure the prevalence of symptoms seen in psychotic patients in the general population, the assumption being that, while the prevalence of the clinical disorder may be low, the frequency of low grade psychotic symptoms is much higher (Johns & van Os, 2001). This is evident from several studies which have observed that delusions are much more prevalent than the traditional „dichotomous“ view would allow. As mentioned above, only 0.3% to 0.7% of the population have schizophrenia, but approximately 3% of the non-clinical population experience delusions to a level of severity comparable to that observed in psychoses; that is, clinically significant delusions are up to six times more frequent than schizophrenia in the general population (Freeman, 2006, 2007). Freeman (2006) also notes that a further 5% to 6% of the non-clinical population have delusions of less severity (which nevertheless still cause emotional and social problems), and an additional 10-15% have fairly moderate delusional ideation. Similar findings have been put forward by Eaton and colleagues, who found that bizarre, paranoid, and grandiose delusions were observed in 2-8% of a general population sample (Eaton, Romanoski, Anthony, & Nestadt, 1991). Other studies propose even higher prevalence rates. For example, a longitudinal New Zealand birth cohort study revealed that about 20% of non-clinical participants had experienced delusions at some time (Poulton, et al., 2000). Although these studies demonstrate that the prevalence of subclinical psychotic experiences is higher than the incidence of clinical psychotic disorders, it should be noted that most of these experiences are transitory,



and only a small proportion of those affected go on to develop a psychotic disorder (van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009).

A recent meta-analysis of the risk factors associated with the development of subclinical psychotic experiences included child and adult social adversity, trauma, psychoactive drug use (e.g., cannabis), male sex, migrant status, urbanisation, developmental stage (i.e., age of exposure to these factors) and genetic predisposition (van Os, et al., 2009). The “psychosis proneness-persistence-impairment” model of psychotic disorder posits that a transitory developmental expression of psychosis (psychosis proneness) may become abnormally persistent (persistence) and subsequently clinically relevant (impairment), depending on the degree of genetic/environmental factors the person is exposed to (van Os, et al., 2009).

In light of these and other findings, Peters and colleagues developed the Peters et al. Delusions Inventory (PDI) to measure delusion-proneness in the general population. Other delusional measures, such as the Foulds Delusions-Symptoms-State-Inventory (DSSI, Foulds & Bedford, 1975) or the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen & Olsen, 1982), are not well suited for assessment of the general population as they typically consist of items depicting very specific florid symptoms, and they also do not account for the full range of delusional sub-types, or the multidimensionality of delusions (e.g., distress, conviction, preoccupation). Both the original 40-item and the more recently revised 21-item Peters et al. Delusions Inventory were designed to overcome these shortcomings, by toning down the questions to a format suitable for the normal population (e.g.,

“Is anyone deliberately trying to harm you?” would become “Do you ever feel as if someone is deliberately trying to harm you?”), and measures of distress, belief strength, and preoccupation were included. Both versions of the inventory have retained concurrent validity with other measures (e.g., DSSI), as well as good internal consistency, criterion validity and test-retest reliability (Peters, Joseph, Day, & Garety, 2004; Peters, Joseph, & Garety, 1999). The initial findings from both measures, which compared PDI scores of clinically diagnosed psychotic patients with the normal population, revealed that the ranges of scores significantly overlapped with the normal population, with over ten percent of healthy participants scoring higher than the mean of the patient group, despite failing to meet the other diagnostic criteria for a psychotic disorder (Peters, et al., 2004; Peters, et al., 1999). This confirms the findings described earlier that a small percentage of the general population experience delusions at levels experienced in patient samples, and that delusion-proneness occurs across a continuum of severity. It was also found that that the patient group experienced higher levels of conviction, preoccupation and particularly distress, suggesting that the multidimensional nature of delusions differs across the continuum.

Furthermore, studies that have included samples assumed to be more susceptible to delusion-proneness – for example, members of Spiritualist churches (Colbert & Peters, 2002) and relatives of people with schizophrenia (Van Dael, et al., 2006) – have found that these groups do score higher on the PDI, reaffirming its ability to adequately test the psychosis continuum.

### *Delusional Themes*

Although the prevalence of delusional beliefs varies across many different conditions and sub-groups there are some common themes. Delusions of reference and persecutory delusions are among the most commonly reported delusional themes, particularly in schizophrenia, where they commonly co-occur and represent approximately 60% to 70% of all delusions experienced by people with this illness (Gilleen & David, 2005). Persecutory delusions are characterised by beliefs that one is being harmed (either currently or in the near future) and that the persecutor has the intention to cause harm (Freeman & Garety, 2000). Delusions of reference are beliefs that innocuous or unrelated phenomena (e.g., television programs, billboards, newspaper articles, other people) have special personal significance or are referring specifically to oneself (Startup & Startup, 2005). Delusions of reference may supplement persecutory beliefs, whereby affected individuals may believe that others are subtly communicating with them by dropping hints or using inconspicuous gestures, or that they are being monitored or gossiped about (Coltheart, et al., 2011). Delusions of control include beliefs that thoughts are broadcast into other people's minds or are inserted into or withdrawn from one's own mind; that other people can read one's mind; or that one no longer has control over their physical actions or mental thoughts (Frith, 1992, in press). Finally, grandiose delusions are characterised by beliefs that one has a special ability, is omnipotent or famous, has great wealth, or is part of a special mission (Smith, Freeman, & Kuipers, 2005).

Despite the practice of classifying delusions into one or more of these delusional themes, it should be noted that even within a particular theme, there is a considerable amount of heterogeneity (Coltheart, et al., 2011).

In addition to the delusional themes outlined above, delusions have also been categorised as either monothematic (i.e., tightly circumscribed single delusional belief or theme) or polythematic (i.e., wide variety of delusional beliefs or themes covering many different and possibly unrelated topics) (Coltheart, Langdon, & McKay, 2007; Davies, Coltheart, Langdon, & Breen, 2001; Langdon & Coltheart, 2000). A commonly cited example of a monothematic delusion is the Capgras delusion, whereby an individual believes that a highly familiar person (such as a spouse) has been replaced with an impostor or stranger (Davies, et al., 2001). Mathematician and Nobel laureate John Nash maintained a polythematic delusional system, where he simultaneously believed he was the Emperor of Antarctica, that he was the left foot of God on Earth, and that his name was really Johann von Nassau (Capps, 2004, as cited in Coltheart, et al., 2007). While monothematic delusions are usually associated with patients with brain injury and polythematic florid delusional systems are usually linked to schizophrenia and other related psychoses, it should be noted that this is not always the case. For instance, some Capgras patients expand on their initial delusional belief that their loved ones have been replaced by imposters, and some patients with schizophrenia maintain tightly circumscribed beliefs (Langdon & Coltheart, 2000).

This section of the literature review has considered a working definition of delusional belief (whilst acknowledging the limitations of such a definition), observed the frequency of delusions across the psychosis continuum, and identified a number of common delusional themes. It is worth noting that this thesis will focus on individuals diagnosed with schizophrenia with an active history of delusional beliefs and on individuals identified as “delusion-prone”. While some studies have focussed their research on specific delusional themes (e.g., persecutory delusions: Bentall, Corcoran, Howard, Blackwood, & Kinderman, 2001; Freeman, 2007; McKay, Langdon, & Coltheart, 2007b) or on monothematic delusions (e.g., Coltheart, et al., 2007; McKay & Cipolotti, 2007), this thesis takes a more general approach to the content of delusions; this approach is more commonly adopted in the relevant research literature (e.g., Garety, et al., 2005; Huq, Garety, & Hemsley, 1988; Moritz & Woodward, 2005; Peters & Garety, 2006; Speechley, Whitman, & Woodward, 2010; Woodward, Moritz, Menon, & Klinge, 2008). It is therefore assumed that the delusions observed in this thesis will cover many different delusional themes and could either be polythematic or monothematic. However, given that the studies within this thesis gauge delusional ideation using the PDI (which totals delusion-proneness scores across a range of themes), the findings will most likely relate to polythematic than monothematic delusions.

The next section of the literature review will critically review some of the cognitive approaches and models that have attempted to account for delusion formation and maintenance, with a particular focus on the role of cognitive biases.

### **Cognitive Approaches to Delusions**

There are many different theoretical approaches to studying the origins and maintenance of delusions. Corvin (2011) summarises the genome research which suggests that many of the symptoms of schizophrenia, including delusions, have a genetic basis. Neurological evidence suggests that delusions in schizophrenia arise from a dysregulated dopamine transmission in the ventral striatal dopamine pathway (e.g., Kapur, 2003). Dopamine release tends to occur when events of personal significance occur, and it is hypothesised that when abnormal bursts of dopamine release occur, the person begins to attribute salience to events that do not have specific personal relevance.

Neuropsychological accounts have been offered for monothematic delusions. For example, the Capgras delusion has been linked to a disconnection between an intact face recognition system and an intact autonomic nervous system, whereby familiar faces are perceived to be strangers (Coltheart, et al., 2007; Coltheart, Menzies, & Sutton, 2010). The role of affective processes (e.g., anxiety, stress, depression, mania, self-esteem) have also been linked to delusional onset (for a detailed review see Freeman, 2007), as have social factors like social-economic-status, migration and urbanisation (van Os, Hanssen, Bijl, & Vollebergh, 2001). Other approaches offer more holistic models of delusion formation and maintenance by incorporating particular aspects of these different theoretical accounts (e.g., Freeman, Garety, Kuipers, Fowler, & Bebbington, 2002).

Whilst acknowledging the importance of a multi-factorial approach to understanding delusional beliefs, the remainder of this literature review will

focus specifically on the role that cognitive processes may play in the development and maintenance of delusions. As outlined above, delusions have been defined as phenomena that reflect cognitive processes, and they represent the way people with delusions view the world and themselves. Consequently, as noted by Miller and Karoni (1996), it is important to investigate the cognitive processes giving rise to delusions, and the reasons why delusions are so resistant to change once they have become established.

### *Intact Cognitive Functioning and Anomalous Experiences*

Brendan Maher was arguably the first to acknowledge the role of cognitive processes in delusion formation, putting forward the notion that delusions arise from normal or intact cognitive mechanisms attempting to explain abnormal perceptual experiences (e.g., hallucinations) (Maher, 1974, 1988). Maher claimed that, when faced with such aberrant perceptual experiences, the individual searches for an explanation using normal reasoning processes, and this gives rise to “delusional belief”.

Evidence in support of Maher’s model largely comes from studying individuals with schizophrenia who have been found to experience abnormalities in attention and the processing of incoming information, which in turn generates abnormal perceptual experiences (e.g., Maher & Spitzer, 1993). For example, delusions of control (“someone else is in control of my actions”) may arise when internal monitoring of self-initiated action is lost but visual and kinaesthetic feedback of movement is intact, resulting in the

experience that one has lost control over one's actions (Frith, 1992). Maher's account is also consistent with monothematic delusions, such as the Capgras delusion ("my spouse has been replaced by an impostor"). The model suggests that this delusion arises from the patient attempting to explain the anomalous experience of recognising a familiar face in the absence of the usual affective response associated to that face (Davies, et al., 2001). Moreover, Miller and Karoni (1996) summarise work which suggests that sensory deficits (such as deafness in older people) have been associated with anomalous sensory experiences, which, in turn, can foster delusional beliefs. In essence then, Maher's model predicts that the presence of an abnormal experience is necessary and sufficient to explain the presence of delusional beliefs (Langdon & Coltheart, 2000).

However, there are some conceptual difficulties with Maher's approach. First, the model predicts that the mere presence of an anomalous experience is sufficient to produce a delusion. Therefore, anyone with neuropsychological damage that results in reduced affective responses to familiar faces should experience the Capgras delusion. Likewise, impaired monitoring of self-initiated actions should lead to delusions of control. However, these assumptions are not validated in the neuropsychological literature. For example, people with damage to the ventromedial frontal cortex experience the same automatic under-reactivity to familiar faces, yet these people do not go on to develop the Capgras delusion (Coltheart, et al., 2007; Langdon & Coltheart, 2000). Similarly, patients with depersonalisation disorder feel *as if* someone else was controlling their actions, yet these patients maintain intact reality testing, whereas people with delusions of



control do not (Davies, et al., 2001). Therefore the “loss of control” experience is insufficient to produce delusions of control. Langdon and Coltheart (2000) also comment on individuals who have phantom limb experiences, where an amputated limb is still perceived to be present and may even cause pain, yet these individuals do not develop delusions. Rather than believing that a “conspiring” doctor has made the limb invisible, they instead accept that some neurological dysfunction is responsible for their aberrant experience. People with persecutory delusions do not so readily accept that dysfunctional neurochemistry might be causing their senses to become unreliable sources of information.

Other problems with Maher’s account include the fact that there are many delusions that occur in the absence of any specific anomalous experience, particularly polythematic grandiose delusions or delusions of reference (Garety & Freeman, 1999). There is also the issue that people with delusions maintain their beliefs despite the availability of evidence to suggest that their beliefs are false (Coltheart, et al., 2007). That is, people with delusions often fail to consider alternative explanations for their experiences and beliefs (Freeman, et al., 2004). Finally, and perhaps most importantly, Maher’s account contrasts with a growing body of research which suggests that people with delusions, and even individuals identified as “delusion-prone”, do not retain intact cognitive functioning, but that their cognitive processing may be systematically biased relative to the general population (e.g., Bentall, et al., 2009; Fine, Gardner, Craigie, & Gold, 2007; Garety & Freeman, 1999; Moritz & Woodward, 2005; Speechley, et al., 2010; Woodward, Buchy, Moritz, & Liotti, 2007).

In essence then, Maher's account may go some way in explaining the *thematic content* of delusions (particularly bizarre monothematic delusions), but it fails to adequately explain the *presence* and *maintenance* of a delusional belief (Langdon & Coltheart, 2000), or account for the possibility that delusional belief may be associated with cognitive biases rather than intact cognitive functioning. Therefore, a one-factor theory of delusion formation and maintenance, such as Maher's, is not sufficient. The next section will briefly review the theoretical approach that a second factor is also required to account for why a delusional belief is adopted, and why it might be so resistant to disconfirmatory evidence.

### *The Two-Factor Theory*

The two-factor account of delusion development and maintenance posits that a first factor accounts for the content of a delusion, and may include the perceptual aberrations discussed above, which can lead to the development of delusional hypotheses. Due to the varied content of delusions, it is assumed that this first factor varies from delusion to delusion. The second factor accounts for why this delusional hypothesis, once formulated, is adopted and maintained despite the availability of potentially overwhelming counter-evidence (Coltheart, et al., 2007, 2011; Davies, et al., 2001; Langdon & Coltheart, 2000; McKay, Langdon, & Coltheart, 2005b). The nature of this second factor has been modified gradually over time; early attempts to conceptualise it maintained that it was an "all-or-none" deficit present in delusional people but absent in healthy individuals (Langdon & Coltheart, 2000). It is now considered to be a neurocognitive impairment at

the extreme end of a belief evaluation continuum (McKay, et al., 2005b). This impairment in belief evaluation may account for why delusional beliefs are adopted and why they are so resistant to rational counter-argument (Coltheart, et al., 2011). Moreover, unlike the first factor which varies according to delusional content, it is assumed that this second factor remains constant and will be present regardless of the specific delusional theme (Coltheart, et al., 2011). There is also preliminary neurological evidence to suggest that this second factor is associated with damage to the right lateral prefrontal cortex (Coltheart, et al., 2007).

Nevertheless, there are a couple of issues with the two-factor account as it currently stands. First, the theory has mainly been applied to monothematic delusions, and it does not easily extend to some polythematic delusions of reference or grandiose delusions, which may lack a clear first factor that accounts for the content of the delusion (this was also one of the problems for Maher's one-factor account). There is also debate regarding the theoretical nature of the second factor; one account suggests that the second factor represents a failure to adequately incorporate relevant evidence in belief revision, or a bias towards "doxastic conservatism", whereby existing beliefs are maintained (Coltheart, et al., 2010). Another account suggests the second factor represents a systematic deviation from Bayesian updating and is instead a bias toward "explanatory adequacy", whereby one updates beliefs as if ignoring the relevant prior probabilities of candidate hypotheses (McKay, submitted). Therefore, the precise theoretical nature of the second factor remains unclear.

Despite these issues, the second factor theory represents an important departure from Maher's one-factor "anomalous experience – intact cognitive processing" approach. By contrast, the two-factor theory of delusion formation and maintenance assumes that the cognitive processes of people with delusions are impaired or biased. This explains why people with the Capgras delusion perceive familiar faces as "imposters" yet people with damage to the ventromedial frontal cortex do not. It also offers an explanation for why delusions may be maintained in the face of over-whelming disconfirmatory evidence (i.e., impaired belief evaluation), and the theory is consistent with a growing body of literature suggesting that people with delusions exhibit "cognitive biases".

It is not the contention of this thesis to suggest that any particular cognitive bias represents the precise underlying cognitive mechanism responsible for the second factor. However, it is assumed that at least some of these biases may be associated with this proposed mechanism. The next section will review some of the current empirical evidence regarding the hypothesised link between cognitive biases and delusional ideation in patients with schizophrenia, and in some circumstances, individuals identified as delusion-prone.

### *The Role of Cognitive Biases in the Onset and Maintenance of Delusions*

Humans often make errors in their thinking, judgement and memory. When these errors reliably and systematically deviate from "reality", they are referred to as cognitive illusions or cognitive biases (Pohl, 2004). Cognitive

biases appear involuntarily (people are often unaware that they have exhibited the bias); they are assumed to be an innate characteristic of cognition (although some people may be more susceptible to particular biases than others, e.g., problem gamblers may exhibit a stronger “illusion of control” over non-contingent outcomes); and they are difficult to avoid (Pohl, 2004). The defining characteristics of a cognitive bias are therefore similar to those of delusional belief, and it has even been suggested that delusions are the “pathological twin” of cognitive biases (Pohl, 2004). Similar to the conceptualisation of mundane and bizarre delusions, cognitive biases have been conceptualised as “trivial” in the sense that a bias may actually be justified by the evidence (e.g., a roving male in a singles bar over-estimating his success over his rejection rate), or “interesting”, by which they systematically violate rational standards of reasoning (e.g., believing one has control over a non-contingent outcome) (McKay & Efferson, 2010).

Delusions and cognitive biases have also been compared in terms of whether either may serve an adaptive purpose. While the default evolutionary assumption would hold that true beliefs are adaptive and misbeliefs maladaptive, there is evidence to suggest that cognitive biases, and even delusions, may be at least *psychologically* adaptive in particular contexts and scenarios (for a more in-depth discussion on this issue, see McKay & Dennett, 2009; McKay & Efferson, 2010). For example, positive illusions (e.g., unrealistic optimism about the future, exaggerated positive self-appraisals) and illusions of control (i.e., the perception of control where none objectively exists) may protect against depressed states and low self-esteem (e.g., Alloy & Abramson, 1979; Matlin, 2004). Similarly, it has been postulated that

persecutory delusions are constructed defensively for the maintenance of self-esteem, where negative self-representations are projected onto others (Kinderman & Bentall, 1996; Kinderman & Bentall, 1997; McKay, Langdon, & Coltheart, 2007a).

Given the relative similarity of the two constructs, researchers have become increasingly interested in the possibility that cognitive biases, which have been studied in healthy populations for decades (e.g., Kahneman & Tversky, 1972; Langer, 1975; Tversky & Kahneman, 1973; Wason, 1960; Wright, 1962), may contribute to delusion onset and maintenance. The basic premise of this line of research is that as one moves further along the psychosis continuum, from a non-delusional state to a delusion-prone or psychotic state, one becomes ever more susceptible to a particular set of cognitive biases, relative to healthy non-delusional individuals. Importantly, the cognitive biases referred to in this context are not to be confused with the neurocognitive deficits associated with psychosis (e.g., deficits in memory, attention, verbal processing, and executive function; Jibson, 2010), which represent a separate vulnerability in psychosis (van Hooren, et al., 2008).

The study of cognitive bias within the context of delusional belief clusters around two general domains; biases in social cognition (e.g., theory of mind deficits, attribution bias) and biases in cognitive reasoning (e.g., jumping to conclusions, bias against disconfirmatory evidence). Empirical evidence for the biases within each of these clusters will now be briefly reviewed.

### *Biases in Social Cognition*

Research investigating biases in social cognition within psychosis has focussed on whether people with delusions exhibit “theory of mind” deficits, or might be more susceptible to an attribution bias. Theory of mind refers to the ability to understand the mental states (e.g., beliefs, desires, feelings, intentions) of other people or oneself. Delusions, and particularly persecutory delusions, may involve the misreading of the intentions of other people (Freeman, 2007). Therefore, there has been considerable research into the possibility people with delusions demonstrate theory of mind deficits, whereby impairments in understanding the mental states of others may lead to the misinterpretation of social cues which, in turn, may result in paranoia and other delusions (e.g., Frith, 1992, 1994). The research regarding the attribution bias in psychosis suggests that people with delusions (and again, particularly individuals with persecutory delusions) demonstrate an externalising bias for negative events, such as blaming other people or events when things go wrong, rather than internalising these events (e.g., Bentall, Kinderman, & Kaney, 1994; Kaney & Bentall, 1992).

While this body of research has at times demonstrated that people with schizophrenia, relative to non-symptomatic controls, do perform more poorly on theory of mind tasks (e.g., Corcoran, Mercer, & Frith, 1995; Langdon, Ward, & Coltheart, 2008) or exhibit an externalising bias for negative events (e.g., Fear & Healy, 1997), overall the evidence in support of these biases is mixed (for in-depth reviews see Freeman, 2007; Garety & Freeman, 1999; Woodward, Mizrahi, Menon, & Christensen, 2009). For example, there is limited evidence that these deficits are associated with the positive symptoms

of schizophrenia (e.g., delusions and hallucinations); rather, they appear to be more associated with the negative symptoms (e.g., apathy, affective blunting) (e.g., Kelemen, et al., 2005; Langdon, Coltheart, Ward, & Catts, 2001; So, Garety, Peters, & Kapur, 2010). Other studies have shown that an externalising attribution bias is more closely related to overall psychopathology than delusion severity (So, et al., 2010), and there are also a number of studies that do not offer any evidence of an externalising attribution bias among individuals with delusions (e.g., Kinderman & Bentall, 1996; Martin & Penn, 2002; McKay, Langdon, & Coltheart, 2005a; Randall, Corcoran, Day, & Bentall, 2003). These findings limit the possibility that either theory of mind deficits or attribution biases are causally sufficient to the development and maintenance of delusions.

### *Biases in Cognitive Reasoning*

While the evidence that delusional belief is related to biases in social cognition is mixed, there is generally more support for the proposition that biases in cognitive reasoning may play a role in the development and maintenance of delusions. Two of the most robust cognitive reasoning biases that have been investigated are the jumping to conclusions (JTC) bias and the bias against disconfirmatory evidence (BADE).

Studies observing the JTC bias have consistently shown that individuals with delusions demonstrate a hasty decision-making style, where decisions are made on limited evidence (e.g., Fine, et al., 2007; Garety, Hemsley, & Wessely, 1991; Huq, et al., 1988; Menon, Mizrahi, & Kapur, 2008;



Moritz & Woodward, 2005). Many of these JTC studies have also demonstrated that people with delusions exhibit an “over-adjustment” bias, whereby decisions are also hastily modified when presented with disconfirmatory evidence (e.g., Fear & Healy, 1997; Garety, et al., 1991; Langdon, et al., 2008; Peters, Day, & Garety, 1997; Young & Bentall, 1997).

Contrastingly, studies that have used alternative tasks to those employed in the JTC literature have consistently demonstrated that people with delusions instead demonstrate a bias against disconfirmatory evidence (BADE); that is, people with delusions are actually less likely to attend to disconfirmatory evidence and are less flexible in their beliefs than healthy non-delusional controls (e.g., Moritz & Woodward, 2006; Speechley, Moritz, Ngan, & Woodward, in press; Woodward, Moritz, & Chen, 2006a; Woodward, Moritz, Cuttler, & Whitman, 2006b; Woodward, Moritz, Cuttler, & Whitman, 2004).

The next chapter (i.e., the exegesis), as well as Chapters Three and Four, will explore the JTC and BADE cognitive biases in more detail, including a discussion on the tasks used to elucidate them, as well as some of the theoretical inconsistencies and shortcomings surrounding this research (e.g., the conflict between the BADE and the “over-adjustment” effects or the lack of an underlying cognitive mechanism that might unite the effects). Despite these shortcomings, both the JTC and BADE biases are the most closely associated with delusional severity (So, et al., 2010), and both have also been found in non-clinical participants identified as delusion-prone (e.g., Buchy, Woodward, & Liotti, 2007; Colbert & Peters, 2002; Freeman, Pugh, &

Garety, 2008; Rodier, et al., in press; Woodward, et al., 2007). This last point is particularly noteworthy, as it suggests that the biases are independent of a diagnosis of a psychosis and may be present prior to delusion development. Perhaps most intriguingly, the JTC and BADE biases, when considered together, offer empirical evidence for the proposed second factor; that is, the JTC bias accounts for why a delusional hypothesis might be *adopted* as a belief, while the BADE effect accounts for why this belief is *maintained* despite the availability of counter-evidence.

The final section of the literature review will briefly examine the efficacy of a newly developed psychotherapy that attempts to treat delusions within schizophrenia by targeting the cognitive biases thought to underlie their onset and maintenance.

### *Cognitive Biases and the Treatment of Delusions: Metacognitive Training*

While psychopharmacological treatments remain the dominant approach in the treatment of delusions and other positive and negative symptoms associated with psychosis, there is a growing body of evidence that psychotherapies, such as cognitive-behavioural therapy (CBT), may be a useful and effective adjunct therapy (e.g., Barrowclough, et al., 2006; Bechdolf, et al., 2010; Garety, Kuipers, Fowler, Chamberlain, & Dunn, 1994; Granholm, Auslander, Gottlieb, McQuaid, & McClure, 2006; Landa, et al., 2006; Lecomte, et al., 2008; Lecomte, Leclerc, Wykes, & Lecomte, 2003; Spidel, Lecomte, & LeClerc, 2006). CBT has been labelled a “front door” psychotherapeutic approach as it focuses directly on the symptoms of

psychosis (Aghotor, Pfueller, Moritz, Weisbrod, & Roesch-Ely, 2010). However, a new “back door” psychotherapeutic training program has been developed that indirectly targets psychotic symptoms by focussing on the underlying cognitive biases rather than the idiosyncratic delusions of the individual patient. Developed by Moritz and Woodward (see Moritz & Woodward, 2007b for a review), “metacognitive training for patients with schizophrenia” (MCT) aims to bring to the attention of patients the cognitive dysfunctions that may be causing and/or maintaining their delusional symptoms (i.e., “metacognitive” implies “thinking about one’s thinking”). The program presently covers jumping to conclusions (JTC), belief inflexibility (BADE), social cognition deficits (i.e., theory of mind and the attribution bias), overconfidence in memory errors, and low self-esteem. Preliminary research into the efficacy of the MCT program has thus far yielded promising results. Relative to controls, patients with delusions who were randomised into the MCT intervention group exhibited significant improvements in delusion distress, memory, social quality of life, illness insight, and a diminished JTC bias (Aghotor, et al., 2010; Moritz, et al., 2011). For a full review and discussion of the program, see Chapter Eight.

### *Summary*

This literature review has introduced some of the core concepts covered within this thesis, including a working definition of delusions, the concept of the psychosis continuum and the frequency of delusions in psychotic disorders (such as schizophrenia) and in non-clinical populations, and a summary of the main delusional themes. It has also reviewed some of

the cognitive approaches to the study of delusions, including the shortcomings of a one-factor theory of delusional belief; the theoretical advantages of a two-factor theory of delusion development and maintenance; and a summary of the cognitive biases which might contribute to this proposed second factor.

The subsequent chapter, the exegesis, will present in greater detail the broad aims of the thesis, including the specific research questions and underlying rationale for each of the six manuscripts.

## **CHAPTER 2: Exegesis**

Cognitive approaches to understanding how delusional beliefs are formed and maintained are relatively recent, which is interesting given that delusions are, fundamentally, disorders of belief or thought. The last decade in particular has seen an almost exponential increase in research in this domain, which has led to the advancement and refinement of our theoretical understanding of delusions (e.g., a shift from a one-factor to a two-factor account of delusions); the discovery of new cognitive biases affecting people with delusions (e.g., bias against disconfirmatory evidence or BADE); and the implementation of novel treatment approaches (e.g., metacognitive training). However, like all novel approaches to complex issues, there are inconsistencies and limitations within the cognitive approach to delusional beliefs. My research candidature focussed on three distinct, but intrinsically linked, issues within the literature. These issues concern (1) the theoretical conflicts surrounding the “over-adjustment” bias and the BADE effect; (2) the lack of an underlying cognitive mechanism which might unify the cognitive reasoning biases associated with delusional beliefs; and (3) a need to investigate further, and possibly enhance, the efficacy of the metacognitive training program for individuals with delusions. This chapter reviews each of these research themes in more detail, and will include a discussion on each of the six manuscripts with regard to their contribution to each relevant theme, as well as how they contribute to the overall thesis.

## Section A:

### Validity of the Over-adjustment Bias

There are two conflicting accounts of how people with delusions treat evidence that contradicts a pre-existing belief or hypothesis. As briefly discussed in the previous chapter, the “over-adjustment” bias, commonly elicited alongside the jumping to conclusions (JTC) “premature decisions” bias, suggests that people with delusions will over-adjust for conflicting disconfirmatory evidence and will readily jump to a *different* conclusion (e.g., Garety, et al., 1991; Moritz & Woodward, 2005; Peters, et al., 1997; Young & Bentall, 1997). This effect is in contrast to a characteristic of delusional belief as outlined by the *DSM-IV-TR* (i.e., “[delusions are] firmly sustained despite what almost everyone else believes and despite what constitutes incontrovertible and obvious proof or evidence to the contrary”, p. 821). Proponents of the two-factor theory of delusional belief have also argued that the “over-adjustment bias” weakens the interpretation that cognitive reasoning biases, such as the JTC, may represent the second factor, as “jumping to *new* conclusions” does not explain how delusional beliefs are *maintained* (Davies, et al., 2001). Moreover, and perhaps most troubling, the “over-adjustment” effect also stands in contrast to other studies that have observed that people with delusions actually exhibit a bias against disconfirmatory evidence (BADE), where disconfirmatory evidence and alternative explanations of events are ignored, downplayed or resisted (e.g., Moritz & Woodward, 2006; Speechley, et al., in press; Woodward, et al., 2004). The BADE task usually presents participants with sets of three delusion-neutral pictures. For each picture, participants must rate the plausibility of four

interpretations of the event that was occurring in the picture. The three pictures are sequentially presented so that the “true” interpretation of the scenario is eventually unfolded. In this way, two of the interpretations serve as “lures” that seem plausible at first, but by the last picture are unlikely. Another represents the “true” interpretation, which is questionable at first, but becomes likely by the third picture in the sequence, whereas the last interpretation is implausible throughout the three trials. Non-delusional controls will usually down-rate the likelihood of the “lures” on presentation of the second and third pictures and simultaneously up-rate the “true” interpretation. However, people with delusions usually fail to down-rate the “lures”, despite the disconfirmatory evidence that these interpretations are no longer valid.

Due to the inconsistencies regarding the “over-adjustment” bias, there have been a number of theoretical accounts put forward which attempt to explain its occurrence. For example, Young and Bentall (1997) put forward a “recency account”, which states that deluded individuals put undue weight on recently encountered information when making decisions. Hence, irrespective of whether the evidence is confirmatory or disconfirmatory, events occurring in the “here and now” will sway judgements one way or another. However, this explanation does not reconcile “over-adjustment” with the BADE effect or definitional characteristic that delusional belief is *resistant* to counter-evidence. Langdon and Coltheart (2000) proposed a model that places importance on the *nature* of the counter-evidence. They state that the normal belief system is able to evaluate, with equal weight, explanations that derive from first-person information (accessed directly from the senses), second-

person information (derived from what others say or do), and third-person information (knowledge about the world acquired through learning and past experience). Although there is a natural tendency to favour explanations that are derived from first-person experiences, the normal belief system is able to suspend this automatic preference so that all explanations are considered equally. Langdon and Coltheart (2000) argue that this system is damaged in deluded individuals, because they are unable to suspend this automatic preference, and are thus unable to critically evaluate different hypotheses based on *indirect* second- or third-person sources of information. This explanation accounts for both JTC effects (i.e., “premature decisions” and “over-adjustment”), in which beliefs are thought to be formed on the basis of first-person information, and also maintains that beliefs can still be resistant to counter-evidence if this evidence is indirect, such as a doctor telling a patient their delusional experience is due to neuro-physiological impairments. However, the model does not easily account for the BADE studies, where the nature of the disconfirmatory evidence is usually acquired directly (i.e., “first-person”), but is still ignored and downplayed by participants with delusions.

Recently, a more parsimonious explanation for the “over-adjustment bias” has been offered. Rather than attempt to account for the bias at a theoretical level, the approach suggests that the effect is an artefact of the “beads task”, which is the most frequently used task to elucidate the JTC bias (Moritz & Woodward, 2005). The nature of the task will be covered in more detail in the subsequent two chapters, but to summarise briefly, the task presents two containers to participants, each filled with coloured beads (e.g.,



one container may have green [G] and red [R] beads to the proportion of 85:15, while the other has the reverse proportion of beads). The containers are then removed from sight, and beads are drawn with replacement from one of the containers one bead at a time, and participants are asked to guess which container the bead *sequence* was drawn from. Importantly, participants are instructed that only one container is selected throughout the task. Moreover, the sequence of beads presented to participants is pre-determined (e.g., R-R-R-R-G-R-R-R-R). Typically, participants with delusions will choose one container over the other with full confidence on the first or second bead (i.e., “premature decisions”), and when presented with potentially disconfirmatory evidence (e.g., a green bead when the majority have been red) they will modify their decision from the mostly red container to the mostly green container, and back again (i.e., “over-adjustment”). Specifically, the “artefact” approach suggests that “over-adjustment” may not be a genuine cognitive bias, but may instead represent *miscomprehension* of the instructions of the beads task (Moritz & Woodward, 2005). That is, rather than “jumping to new conclusions” given disconfirming evidence, people may simply have misinterpreted the basic principle of the task, which was that beads were only coming from *one* container and not both. Consequently, participants may incorrectly assume that containers swap throughout the task (e.g., “red beads must always come from the mostly red container, while all green beads must come from the mostly green container”).

This was the approach adopted by my first two papers (Chapter 3 and 4, respectively), which were among the first studies to empirically investigate the possibility that the beads task may be confounded by miscomprehension.

## *Paper 1*

The purpose of the first paper was to evaluate the possible influence of task miscomprehension on the elucidation of the JTC bias (i.e., “premature decisions” and “over-adjustment”). As with the original Moritz and Woodward (2005) study, upon which the current study was based, “miscomprehension” was defined as “extreme over-adjustment” or “illogical responses”, characterised by selecting the opposite container to the one which was expected (e.g., judging beads were coming from the container with mostly green beads when the sequence of ten beads only contained one green bead and nine red beads). Due to the definitional overlap “miscomprehension” and “over-adjustment” share, the study also included a qualitative measure of miscomprehension. Essentially, after each decision per bead, participants would be asked why they made their response for each bead (e.g., “based on a hunch” or “probability”) and what was influencing a change in confidence. Participants were also asked at the end of the experiment to reveal their strategies throughout both tasks, or to state what rules they thought governed the tasks. It was hoped that the inclusion of these qualitative measures would determine if any “illogical responses” made by participants were really being driven by a misunderstanding of task instructions.

Unlike the other five papers presented in this thesis, which utilise clinical samples, the sample in this paper consisted only of non-delusional and healthy participants, who were split into delusion-prone and non-delusion-prone groups based on their scores on the Peters et al. Delusions Inventory (Peters, et al., 1999). This was because the study intended to extend the research suggesting that the JTC bias can be elucidated even

within non-clinical delusion-prone samples (e.g., Broome, et al., 2007; Colbert & Peters, 2002; Ellett, Freeman, & Garety, 2008; Van Dael, et al., 2006); more importantly, a demonstration that even non-clinical and healthy participants were miscomprehending the beads task would strengthen the argument that the task may not be optimally assessing cognitive biases. The study was also a preliminary investigation into the potential influence of the way the beads task was administered. The original Moritz and Woodward (2005) study, which included a measure of miscomprehension, employed a computerised version of the beads task (i.e., using digital containers and beads). Therefore, it remained untested whether the original non-computerised versions of the beads task (i.e., using actual containers and beads) also prompted miscomprehension; indeed, it was conceivable that comprehension for this version may be easier considering there is more interaction between the participant and experimenter.

### *Paper 2*

Paper 1 had provided qualitative evidence that the “over-adjustment” effect was being driven by a miscomprehension of the instructions of the beads task. The aim of Paper 2 was to extend these findings to a clinical sample of people with schizophrenia who were experiencing delusions, in addition to non-clinical delusion-prone and non-delusion-prone groups. Importantly, this paper included two versions of the beads task; one version presented the beads task in its original form as it had appeared in Paper 1; the other version modified the task’s instructional set so as to improve comprehension. The aim of this intervention was to determine whether

improving comprehension would simultaneously remove or reduce the “over-adjustment” effect, which would strengthen the argument that “over-adjustment” may be driven by “miscomprehension”. Furthermore, Paper 2 introduced the possibility that “premature decisions” may be driven by a hypersalience of evidence-hypothesis matches (e.g., hypersalience between evidence of a “red bead” and the hypothesis or belief that “beads are coming from the mostly red container”). This cognitive mechanism, which forms the basis for the next section of the thesis, may also be driving the “over-adjustment” effect *when instructions are misunderstood* (i.e., miscomprehension that containers swapping). In this context, hypersalience and miscomprehension are inextricably linked, whereby a miscomprehension that “containers are swapping” may lead to a hypersalience between this belief and the “disconfirming bead” (e.g., green bead in sequence of red beads), which results in “over-adjustment” (Speechley, et al., 2010).

### Section B:

#### Validity of the “Hypersalience of Evidence-hypothesis Matches” Account of Delusion Formation and Maintenance

Despite our advancements in the development and refinement of the cognitive biases that have been linked to delusional belief (i.e., the JTC bias and BADE effects), there has not been as much progress in the development of an underlying cognitive mechanism that might link and unify the cognitive processes responsible for these biases. One line of research has investigated the possibility that the “hypersalience of evidence-hypothesis matches”

mechanism, which was introduced in the previous section, may account not only for the JTC bias, but also the BADE effect; that is, hypersalient and strengthened evidence-hypothesis matches may ensure that disconfirmatory evidence is no longer integrated into belief evaluation (Speechley, et al., in press). The hypersalience construct may also more accurately represent the cognitive nature of the second factor within the two-factor theory of delusional belief, as it accounts for *both* delusion formation (e.g., leads to premature decisions) and delusion maintenance (e.g., leads to a resistance towards disconfirmatory evidence).

Notwithstanding the potential theoretical and clinical importance of hypersalience, I noticed there was a lack of substantial empirical support for this cognitive mechanism. Although Speechley, et al. (2010) offered tentative evidence for the hypersalience account using a “beads task” paradigm (see Papers 1 and 2 for a thorough overview of this task), I wanted to investigate other cognitive biases in addition to the JTC and BADE effects. Using a variety of cognitive tasks would help establish the validity and reliability of the “hypersalience” mechanism, and reduce the likelihood that this effect is just an artefact of task specifications. While I acknowledge the importance to continue research on the JTC and BADE effects, I felt that other cognitive biases were being overlooked.

Therefore, I selected a number of established cognitive reasoning biases, all of which have been widely investigated within the cognitive literature, based on their suitability to test the hypersalience construct within delusions. I was interested in testing the premise that, if people with delusions were hypersalient to evidence-hypothesis matches, they would exhibit a

heightened sensitivity to the biases that I had selected, relative to individuals without delusions. This investigation formed the basis for the next three papers of the thesis, each of which observed a unique cluster of cognitive biases, but all of which were designed to test whether people with delusions were hypersalient to evidence-hypothesis matches. All three papers utilised the same sample consisting of people diagnosed with schizophrenia who were experiencing active delusions ( $n = 25$ ), and a non-clinical sample of people who were identified as delusion-prone ( $n = 25$ ) or non-delusion-prone ( $n = 25$ ). These papers are summarised below.

### *Paper 3 – Confirmation Bias*

The confirmation bias has been defined as a cognitive mechanism that ensures the immunity of a hypothesis to counter-evidence or falsification. In this sense, it is conceptually very similar to the “hypersalience” mechanism. It has also been studied extensively and continually refined since the 1960s (e.g., Wason, 1960), and a number of different tasks have been optimised to test for the bias over the years. Therefore, the confirmation bias was an ideal place to begin my investigation into the validity of the “hypersalience” mechanism among people with delusions. Consistent with the cognitive literature that distinguishes between two facets of the confirmation bias, I selected two different confirmation bias tasks: (1) a biased search for evidence, and (2) a biased filtering and utilisation of evidence. The first task investigated whether patients with delusions and those identified as “delusion-prone” would be more likely to employ biased search strategies relative to non-delusion-prone controls. Specifically, I was interested in whether

delusional belief was associated with a preference for positive-tests (i.e., a hypothesis test that seeks to confirm a belief) over diagnostic-tests (i.e., a search for evidence that will support the hypothesis at hand *or* its alternative). Studies have shown people generally prefer to employ diagnostic strategies over non-diagnostic strategies (Samuels & McDonald, 2002), but it remained untested whether individuals with delusions may be biasing their search strategies for positive tests over diagnostic tests if they were hypersalient to evidence-hypothesis matches.

The second confirmation task investigated whether people with delusions would: (a) *selectively encode* and *recall* information that conforms to a hypothesis; and/or (b) bias the *interpretation* of confirming information such that disconfirmatory evidence is systemically re-interpreted to confirm a hypothesis or is attributed less importance than hypothesis-congruent information, which is what one would expect if this evidence is “hypersalient” to those with delusions.

#### *Paper 4 – Reasoning Heuristics*

Paper 4 investigated the possibility that people with delusions, and those identified as delusion-prone, would be particularly susceptible to the representativeness and availability reasoning heuristics due to the “hypersalience” mechanism. Representativeness is defined as a procedure for estimating probabilities by means of similarity or typicality judgements, and the availability heuristic is defined as the ease with which the probability of events come to mind when assessing the frequency of such events (Tversky

& Kahneman, 1973, 1974). I noticed the potential that both heuristics may be enhanced by hypersalient evidence-hypothesis matches (i.e., hypersalient evidence-hypothesis matches might be particularly representative and easier to recall). Moreover, there was preliminary evidence that the heuristics were indeed linked to delusional belief (e.g., Corcoran, et al., 2006). Nevertheless, these studies used tasks which employed delusion-specific stimuli (e.g., threatening words which people with paranoia might react differently to), and the tasks differed significantly from the original Tversky and Kahneman studies. Therefore I felt that these results needed to be replicated using the original and more thoroughly investigated Tversky and Kahneman tasks, which might reduce the chances of introducing confounds, such as miscomprehension, into the results. Moreover, the established battery of representativeness tasks seemed especially well suited to testing the validity of the hypersalience mechanism because they present participants with particularly strong confirmatory evidence (i.e., strong evidence-hypothesis matches), which I hypothesised may further distinguish delusional from non-delusional styles of responding.

#### *Paper 5 – Illusory Correlation and Control*

The final paper in this series of “hypersalience” papers observed the illusory correlation (i.e., perception of a correlation where none actually exists) and the illusion of control (i.e., overestimation of one’s personal influence over an outcome) cognitive biases. One of the factors responsible for the illusory correlation is an unequal weighting of information, which has important implications for hypothesis testing paradigms and, more particularly, the



hypersalience of evidence-hypothesis matches. Previous studies (e.g., Kao & Wasserman, 1993) have shown that information which conveys and combines a present “cause” (e.g., a fertiliser to promote the growth of a plant) with a present “effect” (e.g., evidence this plant has grown) is assigned more *importance* than information that conveys an absent cause/effect combination (e.g., no fertiliser/no growth). This may bias ratings to favour information which suggests a cause-effect relationship, even when this relationship does not objectively exist (i.e., an “illusory correlation”). The “fertiliser” task developed by Kao and Wasserman (1993), which asks people to rate the likelihood of a plant blooming given different combinations of present/absent cause (fertiliser)/effect (blooming), therefore represented a unique way to test the “hypersalience” mechanism, whereby present cause/effect combinations represent particularly strong “evidence-hypothesis” matches.

The research concerning the illusion of control over an outcome suggests that judgements of control are governed by (a) one’s *intention* to achieve an outcome and (b) the perceived *connection between responses and outcomes* (Thompson, Armstrong, & Thomas, 1998). Thus, perceptions of control will be more likely where one desires an outcome, and where one can see a connection between one’s own action and the outcome. I saw the second component of the bias (“perceived connection”) as another interesting way to test the validity of the “hypersalience” mechanism. For example, if people with delusions are asked to assess the amount of control they have over an outcome (which equates to testing the hypothesis that they have control), their level of perceived connection between their responses and outcomes (i.e., evidence-hypothesis matches) will be higher and will also

result in higher estimates of control (even in non-contingent situations), if they are hypersalient to these matches.

In sum, the three papers presented in this section were designed to test the validity of the “hypersalience of evidence-hypothesis matches” mechanism, which I have argued may underlie the cognitive processes responsible for delusion formation and maintenance. The next section of the thesis intended to extend this work to the novel approaches in the treatment of delusions within schizophrenia, which focus on addressing the cognitive biases rather than the psychotic symptoms themselves.

### Section C:

#### *Towards a Targeted Metacognitive Training Program*

##### *Paper 6*

The third and final aim of the thesis was to continue the ongoing investigation into the efficacy of the newly developed metacognitive training (MCT) for people with schizophrenia. As mentioned in the previous chapter, this training program is a unique psychotherapeutic approach to the treatment of delusions, in that it does not target the delusions directly, as other psychotherapies do (e.g., cognitive-behavioural therapy). Rather it targets cognitive reasoning biases such as the JTC and BADE, social cognitive biases (i.e., attribution bias; theory of mind deficits), overconfidence, and low self-esteem. The therapy could also be a useful adjunct to

psychopharmacological treatment approaches, particularly when used in conjunction with other psychotherapies.

However, studies into the efficacy of MCT have only just begun (Aghotor, et al., 2010; Moritz, et al., 2011), and more work is required before the program's potential can be fully realised. One of the issues surrounding the program in its current form is the length of time it takes to administer; there are currently eight modules across two different cycles, and administering the complete program can take up to sixteen weeks. Given that some of the biases covered may not even be associated with delusional belief (e.g., theory of mind deficits), I wanted to test the efficacy of a shorter and more targeted metacognitive training module. This condensed version would take the "hypersalience" mechanism as its central theme, and would utilise the existing JTC and BADE modules to instruct patients how this mechanism can lead to the formation and maintenance of delusions.

The JTC and BADE effects are more closely associated with delusional severity than the other cognitive biases commonly investigated within delusional populations (So, et al., 2010). Thus, I maintained that, even a single session of this targeted MCT program, might be effective in reducing a delusional patient's susceptibility to the cognitive biases I had been investigating (e.g., representativeness, illusory control). This could therefore also lower their delusional severity, conviction, preoccupation and distress, which might also improve insight and perceived quality of life.

**SECTION A:**

**Validity of the Over-adjustment Bias**

## **CHAPTER 3: Paper 1**

### **Delusion-proneness or Miscomprehension?**

#### **A Re-examination of the Jumping to Conclusions Bias**

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#### *Statement of Contributors*

##### Ryan Balzan (Candidate)

I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

Date: 20/04/2012

Assoc Prof Paul Delfabbro and Prof Cherrie Galletly (Co-authors)

We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We also provided advice on responding to comments by the journal reviewers and editor. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

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## Abstract

Previous research has consistently shown that individuals with delusions typically exhibit a *jumping to conclusions* (JTC) bias when administered the probabilistic reasoning “beads task” (i.e., decisions made on limited evidence and/or decisions over-adjusted in light of disconfirming evidence). However, recent work in this area has indicated that a lack of comprehension of the task may be confounding this finding. The purpose of the present study was to evaluate the influence of task administration, delusion-proneness, and miscomprehension on the elucidation of the JTC bias. A total of 92 undergraduate university students were divided into one of two task conditions (i.e., non-computerised and computerised) and were further identified as either delusion-prone or non-delusion-prone and as comprehending or miscomprehending the task. Overall, 25% of the sample demonstrated a JTC bias, and just over half made illogical responses consistent with a failure to comprehend the task. Qualitative evidence of comprehension revealed that these “illogical responses” were being driven by a misunderstanding of task instructions. The way the task was administered and levels of delusion-proneness did not significantly influence JTC. However, miscomprehending participants were significantly more likely to exhibit the bias than those who did comprehend. These results suggest that miscomprehension rather than delusion-proneness may be driving the JTC bias, and that future research should include measures of miscomprehension.

The role that cognitive reasoning biases may play in the development and maintenance of delusions has been the focus of much research in recent years. The biases described in people with delusions include: *attribution biases*, where individuals are prone to exhibiting an externalising bias for negative events, with a particular inclination to blame others, rather than the situation or chance (Bentall, et al., 1994; Garety & Freeman, 1999); *attentional biases*, in which individuals are more selectively attentive towards threat-related stimuli than neutral stimuli (e.g., Bentall & Kaney, 1989); high *need for closure*, which is a bias to seek definite answers to avoid ambiguity but at the cost of accuracy (e.g., McKay, et al., 2007b); and a *theory of mind* impairment, which leads to biases in assessing the intentions of others (e.g., Frith, 1994).

However, perhaps the most documented and robust cognitive bias identified by researchers in this area is the *jumping to conclusions* (JTC) bias. The JTC bias occurs when decisions are made on the basis of limited evidence. The task most commonly used to elicit the JTC bias is the “beads task”, first adapted by Huq, Garety, and Hemsley (1988). This task requires two containers each filled with coloured beads. Participants are shown that one jar has, for example, green and red beads in the proportion of 85:15, while the other has the reverse proportion of beads. The containers are then removed from sight, and the experimenter randomly draws out a bead and asks the participant which container a particular bead was drawn from, before placing the bead back and removing another, supposedly from the same container. However, the sequence of beads presented to participants is pre-determined. The experiment is normally administered in one of two ways: the



“draws to decision” procedure, where participants take as many trials as needed to reach a definite decision (i.e., which container the bead sequence is coming from); or the “graded estimates” procedure, where the number of trials is fixed, and for each trial, participants must provide a probability estimate that a particular bead is from one of the two containers (Garety & Freeman, 1999; Moritz & Woodward, 2005).

The most commonly reported finding is that participants with delusions typically reach a decision and are more confident about that decision on *less* evidence than controls, whether the task is administered in its original non-computerised form (e.g., Garety, et al., 1991; Huq, et al., 1988; Peters & Garety, 2006; Peters, Thornton, Siksou, Linney, & MacCabe, 2008; So, Freeman, & Garety, 2008) or as a computerised version (e.g., Dudley, John, Young, & Over, 1997; Ellett, et al., 2008; Fear & Healy, 1997; Moritz & Woodward, 2005).

At the same time, graded-estimates beads task experiments have repeatedly revealed that when deluded individuals are faced with potentially disconfirmatory evidence (e.g., a green bead when the majority have been red), they are *more likely* and *quicker* than controls to change their hypothesis in regards to which container a bead came from (e.g., Garety, et al., 1991; Moritz & Woodward, 2005; Peters, et al., 1997; Young & Bentall, 1997). In other words, deluded participants over-adjust for conflicting disconfirmatory evidence and readily jump to a different conclusion. This aspect of the JTC bias has been dubbed as a “bias towards disconfirmatory evidence” or an “over-adjustment” bias.

Researchers employing the task have also found that the JTC bias can be elucidated in deluded patients using bead ratios as low as 60:40 (Garety & Freeman, 1999); is stable over time (Menon, et al., 2008; Peters & Garety, 2006); and is related to other cognitive biases such as the “theory of mind” impairment (Langdon, et al., 2008). There is also growing evidence that the JTC bias can be found in non-clinical individuals identified as “delusion-prone” (e.g., Broome, et al., 2007; Colbert & Peters, 2002; Ellett, et al., 2008; Van Dael, et al., 2006), but not non-delusional patients with schizophrenia (Peters, et al., 2008), which suggests the bias is specific to delusions rather than to a diagnosis of schizophrenia.

Despite the apparent robustness of the beads task at elucidating the JTC bias, recent work has exposed a potential confounding factor. In a computerised replication of the graded estimates procedure, Moritz and Woodward (2005) included a measure of non-comprehension (referred to hereafter as *miscomprehension*), defined as “extreme over-adjustment” by selecting the opposite container to the one which was expected (e.g., judging beads were coming from the container with 90% green beads/10% red beads, when the sequence of ten beads only contained one green bead and nine red beads). It was proposed that participants may simply have misinterpreted or forgotten the basic principle of the task, which was that beads were only coming from *one* container and not both. Consequently, participants may incorrectly assume that containers swap throughout the task (e.g., “red beads must always come from the mostly red container, while all green beads must come from the mostly green container”). Although the “*miscomprehension*”

construct most directly relates to the “over-adjustment” aspect of the JTC bias, it may also potentially account for “premature decisions”, as participants may simply be responding to the *current* bead (“red beads = red container”) and not the bead *sequence*.

The results of this study indicated that 52% of the schizophrenia sample and 23% of the healthy controls made illogical responses congruent with the miscomprehension style of responding described above. Moreover, participants exhibiting a JTC bias were significantly more likely to apparently fail to comprehend the task. Once the miscomprehending participants were removed, the deluded group still exhibited a stronger JTC “premature decisions” bias than controls, but these results nonetheless highlight the confounding nature of miscomprehension.

With the exception of Warman, Lysaker, Martin, Davis, and Haudenschild (2007), no other study using the beads task to assess the JTC bias in participants with delusions has formally observed or even recognised miscomprehension as a possible confound, despite the common finding that participants with a JTC style of responding usually have a lower IQ (e.g., Garety, et al., 1991; Van Dael, et al., 2006), and consequently might be finding it more difficult to grasp the task instructions. Furthermore, there is an extensive literature demonstrating cognitive deficits in clinical populations, such as people with schizophrenia (see Szöke et al. (2008) for a meta-analytic review); hence if participants are diagnosed with these conditions then it would be expected that they would have more difficulty understanding and remembering instructions, compared to healthy controls. The original non-computerised versions of the beads task have yet to be tested for levels

of miscomprehension, but it is conceivable that comprehension for this version may be easier considering there is more interaction between the participant and experimenter.

Consequently, the present study pursued three major aims. The first aim was to determine if the style of *task administration* (i.e., non-computerised / computerised) and/or *delusion-proneness* (see “Participants” in Methods) affected JTC (i.e., premature decisions and over-adjustment), and/or comprehension levels. The second aim was to examine the specific influence of *miscomprehension* itself on JTC. Finally, the study assessed qualitative evidence of comprehension to determine if the “illogical responses” made by participants were really being driven by a misunderstanding of task instructions.

## **Methods**

### ***Participants***

Undergraduate students given the beads task have been shown to display styles of responding consistent with the JTC bias (Warman, et al., 2007; Warman & Martin, 2006). For this reason, a sample of 72 first year undergraduate psychology students (60 female; 12 male; mean age = 21.15, SD = 7.01) was employed for the study on the assumption that their higher-than-average IQ might negate the influence of miscomprehension. The two “task administration” groups (i.e., non-computerised and computerised) revealed no significant differences in age ( $t(70) = .65, p > .05$ ) nor gender ( $p = .75$ , Fisher’s exact test (2-sided)).

All participants were administered the Peters et al. Delusions Inventory (or PDI; Peters, et al., 1999) at the beginning of the experiment. The PDI is designed to assess “delusion-proneness” (or delusional ideation in the absence of active delusions) in the general population. The total score (including an affirmation of the unusual belief as well as the Distress, Preoccupation, and Conviction subscales, each with subtotal of 200) can range from 0 to 640. In line with other research (e.g., Linney, Peters, & Ayton, 1998; Warman, et al., 2007), participants were classified as delusion-prone if their PDI score fell above the median (median = 75.5) and non-delusion-prone if their score fell below the median. The PDI scores of the current sample were consistent with other studies using the scale, and are summarised in the Table 1. Delusion-proneness revealed no significant differences in age ( $t(70) = .92, p > .05$ ) nor gender ( $p = .75$ , Fisher’s exact test (2-sided)).

A further 20 undergraduate participants (12 female; 8 male; mean age = 20.85, SD = 6.29) were recruited separately for the qualitative analyses (see Table 1 for PDI scores). As with the former sample, no differences arose between groups or delusion-proneness for age ( $t(18) = 1.59, p > .05$ ;  $t(18) = .67, p > .05$ , respectively) or gender ( $p = .17$ , Fisher’s exact test (2-sided);  $p = 1.00$ , Fisher’s exact test (2-sided), respectively).

## **Materials and Procedure**

Apart from the nature of administration, both the computerised and non-computerised versions of the task were kept exactly the same, each consisting of two “graded-estimates” beads tasks, in replication of the Moritz

and Woodward (2005) experimental procedure. In Task 1 participants were presented with two containers (or a picture of two containers for the computerised version) full of red and green beads (90% red [R] and 10% green [G] for one, and vice versa for the other), and were told that the experimenter/computer will randomly select beads from the same container for the duration of the task (i.e., only one container). The sequence of ten beads, however, was predetermined, and was presented in the following order:

R-R-R-R-G-R-R-R-R-R.

After each trial, participants were asked to select from one of the following seven options (by pressing keys 1-7 for the computerised version or stating aloud their response for the non-computerised version): 1 = beads are definitely from container A; 2 = beads very likely from Container A; 3 = beads probably from Container A; 4 = no estimate possible yet; 5 = beads probably from Container B; 6 = beads very likely from Container B; 7 = beads definitely from Container B. This rating scale was displayed for the duration of the experiment, as was the explicit instruction that estimates/decisions should be carried out while considering all beads being drawn. To ensure participants remembered the proportion of beads in each container, the containers themselves (non-computerised version) or pictures of the containers (computerised version) also remained displayed for the duration of the task. Participants were then shown a demonstration of a trial, and were given the opportunity to clarify any questions before the task began (only for Task 1). Participants were said to have demonstrated a JTC bias if they gave a definite rating (i.e., 1 or 7) when presented with only one bead.

Task 2 followed a similar procedure with exactly the same instructions using blue and yellow beads; however, this task increased the number of trials which represented potentially disconfirmatory evidence (i.e., a change from yellow-to-blue beads, and vice-versa). Consequently, 20 beads were presented as coming from two containers (80% yellow [Y], 20% blue [B] and vice versa) to the following order:

Y-Y-Y-B-Y-Y-Y-Y-B-Y-B-B-B-Y-B-B-B-B-Y-B.

Participants were informed there was no time limit to complete the tasks, and that they had as long as they wished before making a decision. This instruction was included to reduce the chances of participants making rash decisions on the basis of a perceived time limit.

### ***Measures***

The various measures that were employed in the study included:

- a) *JTC-Premature Decisions* – a participant was identified as displaying this aspect of the JTC bias if they made a *definite* decision after only one bead on at least *one task*.
  
- b) *JTC-Over-adjustment* – represented the amount of change in the judgement-ratings between trials with potentially disconfirmatory evidence (i.e., when beads changed from red to green/*vice-versa* in Task 1 and from yellow to blue/*vice-versa* for Task 2).

c) *Miscomprehension* – or “extreme over-adjustment”, was defined as selecting the opposite container to the one which was being suggested; that is, if participants made an estimate that beads were coming from Container B (i.e., ratings 5-7) within the first 10 trials for Task 1 where the sequence was clearly indicating Container A; and/or made an estimate that beads were coming from Container A (i.e., ratings 1-3) within the first 10 trials for Task 2 where the sequence was clearly indicating Container B (Moritz & Woodward, 2005). Participants were identified as miscomprehending based on “illogical responses” on at least *one task*.

### ***Qualitative Measures***

Twenty participants were randomly selected for a qualitative analysis of the miscomprehension measure. They completed the experiment as described above, but were asked to state aloud why they made their response for each bead (e.g., based on a hunch or probability) and, if applicable, what was influencing a change in confidence. This was recorded for the duration of the experiment. Additionally, all participants were asked at the end of the experiment to reveal their strategies throughout both tasks, or to state what rules they thought governed the tasks. Due to the slightly different methods used within this group of participants, they were not included in the quantitative analysis.



**Table 1:** Mean (SD) PDI scores, including subtotal PDI and subscales of Distress, Preoccupation and Conviction, across both samples

	<b>PDI (SD)</b>	<b>Distress (SD)</b>	<b>Preoccupation (SD)</b>	<b>Conviction (SD)</b>	<b>Total PDI (SD)</b>	<b>Median Total PDI</b>
Quantitative Sample	10.49 (5.74)	21.82 (15.08)	22.36 (15.88)	27.88 (17.55)	82.65 (52.48)	75.5
Qualitative Sample	11.90 (6.47)	26.50 (21.03)	23.85 (16.59)	29.20 (17.64)	90.35 (60.32)	84.5

N: Quantitative = 72; Qualitative = 20

## Results

The results are divided into three sections. The first examines the influence of *task administration* and *delusion-proneness* on JTC and miscomprehension. The second examines the association *miscomprehension* has on the JTC bias. A third section presents the qualitative evidence relating to *miscomprehending* behaviour.

### ***Task Administration and Delusion-Proneness***

#### *JTC-Premature Decisions*

As indicated in Table 2, “JTC-premature decisions” (i.e., a definite rating after only one bead on at least one task) was relatively high considering the sample consisted of healthy undergraduate students. Levels of this measure of JTC were identical for both the computerised and non-computerised versions of the task (i.e., 25% for each version).

Although not significant ( $\chi^2 (1, N = 72) = 2.68, p > .05$ ), participants identified as delusion-prone exhibited higher “JTC-premature decisions” levels than non-delusion-prone individuals, with around a third of the delusion-prone participants displaying the bias (Table 2). This trend is consistent with previous findings which have shown that individuals higher in delusion-proneness demonstrate significantly higher JTC-premature

decisions compared to non-delusion-prone individuals (e.g., Warman & Martin, 2006).

### *JTC-Over-adjustment*

There were no significant differences for task type ( $t(70) = .58, p > .05$ ) nor delusion-proneness ( $t(70) = .34, p > .05$ ) in relation to over-adjustment across either Task 1 or 2, although there was a slight trend for the non-computerised group and the delusion-prone participants to display slightly higher levels of over-adjustment (Table 2).

### *Miscomprehension*

As seen in Table 2, just over half of the sample appeared to lack comprehension of the task as evidenced by responses which indicated that beads were coming from Container B (i.e., ratings 5-7) within the first 10 trials for Task 1, even though the sequence was clearly indicating Container A and/or an estimate that beads were coming from Container A (i.e., ratings 1-3) within the first 10 trials for Task 2, where the sequence was clearly indicating Container B. Although the non-computerised condition appeared to show higher levels of miscomprehension (Table 2), the results were not significant,  $\chi^2(1, N = 72) = 1.39, p > .05$ . Delusion-prone individuals had a greater tendency to not comprehend (Table 2), but this was likewise non-significant,  $\chi^2(1, N = 72) = 1.39, p > .05$ .

## **Task Comprehension**

### *JTC-Premature Decisions*

As seen in Table 3, miscomprehending participants were more likely to demonstrate premature decisions compared to comprehending participants (37.8% and 11.4%, respectively). These proportional differences were found to be significant,  $\chi^2(1, N = 72) = 6.69, p < 0.05$ .

### *JTC-Over-adjustment*

Miscomprehending participants were significantly more likely to over-adjust their responses in the face of potentially disconfirmatory evidence across both Task 1 and Task 2,  $t(70) = 9.77, p < .001$ , as can be clearly seen in Table 3.

*Note: all analyses were repeated with Task 2 removed from the Miscomprehension variable. This more conservative approach ensured that the variable was not contaminated from the fact that “miscomprehending behaviour” in Task 2 (i.e., selecting a bead from a non-suggestive container) may have arisen as a result of the proportions being more balanced (i.e., 80% vs. 20% instead of 90% vs. 10% in Task 1). However, the results as presented above remained unaltered.*

**Table 2:** JTC-premature decisions (%), JTC-over-adjustment, and Miscomprehension (%) by Task administration and Delusion-proneness (across tasks)

	JTC-premature decisions ( <i>n</i> )	JTC-over-adjustment (SD)	Miscomprehension ( <i>n</i> )
<b>Overall</b>	25.0 (18)	1.33 (1.18)	51.4 (37)
<b>Task administration</b>			
Non-computerised	25.0 (9)	1.41 (1.06)	58.3 (21)
Computerised	25.0 (9)	1.25 (1.30)	44.4 (16)
<b>Delusion-proneness</b>			
Delusion-prone	33.3 (12)	1.37 (1.20)	58.3 (21)
Non-delusion-prone	16.7 (6)	1.28 (1.18)	44.4 (16)

*Notes:* JTC-premature decisions: relative percentage of participants who gave a definite rating after only one bead (for at least one task).  
 JTC-over-adjustment: mean difference in judgement-ratings between trials with potentially disconfirmatory evidence.  
 Miscomprehension: relative percentage of participants displaying miscomprehension of at least one task.  
*N* for all conditions = 72 (Task Administration: *n* = 36 per group; Delusion-proneness: *n* = 36 per group).

**Table 3:** JTC-premature decisions (%) and JTC-over-adjustment by Comprehension (across tasks)

	JTC- premature decisions ( <i>n</i> )	JTC- over-adjustment (SD)
<b><i>Task comprehension</i></b>		
Miscomprehension	37.8 (14)*	2.19 (1.03)*
Comprehension	11.4 (4)	0.41 (0.32)

*N*: Miscomprehension = 37; Comprehension = 35

\*  $p < .001$

### ***Qualitative Measures of Miscomprehension***

A further twenty participants were randomised into the computerised/non-computerised conditions in an effort to qualitatively assess whether participants who demonstrated “miscomprehending behaviour” actually failed to understand the task instructions. They were asked to state throughout each task what was influencing their decisions/confidence and what strategies they used and/or what rules governed each task. In line with the previous sample, 55% of all participants displayed “miscomprehending” behaviour and 20% demonstrated both forms of the JTC bias, all of whom were miscomprehending.

The most interesting observation was that over 90% of all miscomprehending participants thought containers were swapping throughout the task (i.e., beads were coming from both rather than one container). This is despite being explicitly told that beads are only coming from the one container throughout the task. Examples of what these participants said include: “I think that this is probably from Container B because it has been Container A for a

while now, so it's got to switch over.”; “I thought that if there was a series of red [beads] and then it suddenly swapped to a green [bead], it could be picking a green bead out of Container A [mostly red], but I thought it would be more likely that it would be switching it up.”; “I assumed the program was designed to randomly select containers throughout the task.” This left some participants rather confused and unconfident in their decisions, even by the end of Task 1 which was clearly indicating Container A, “My confidence is decreasing, I don't know where beads are coming from now, there doesn't seem to be a system. So I think I'll choose 4 [no estimate possible]”.

Additionally, just under half of these miscomprehending participants revealed a misunderstanding of the laws of probability that governed the tasks,

“My strategy was based on the probability that beads would come from the other container eventually. They could not have come from one container.”; “I thought if [a bead] had been drawn a few times it would have to eventually come from another container, so I just tried to use my knowledge of probability more than hunches.”; “If there are too many red beads coming up, I would say that eventually the computer is going to choose a red bead from Container B, with mostly green beads.”; “Since there has been so many red beads, and its only a 90% chance that it would be Container A, the likelihood of it being from Container B is becoming ever increasing”.

Finally, some miscomprehending participants in the non-computerised conditions claimed they actually tried to listen to where beads were picked from, and stated the task involved some level of deception, for instance, “In

Task 1, at first I was thinking you've picked beads from Container A, then you pick a green bead to try and trick me".

In contrast to the comments made by miscomprehending participants, those who comprehended the task generally confirmed the task rules that only one container was used throughout, with one participant going so far as to say "it made it easier knowing that only one container was being used for the whole task, otherwise it would have been confusing".

## **Discussion**

The present study aimed to investigate the potentially confounding influences of task administration, delusion-proneness and miscomprehension on the JTC bias using the "beads" task. Neither task administration nor delusion-proneness could account for the bias, although there was a non-significant trend for delusion-prone individuals to display higher levels of JTC and miscomprehension. The results suggest instead that illogical responses due to miscomprehension of the task instructions may be driving the effect.

Overall, levels of both JTC and miscomprehension were relatively high compared to previous findings. Most studies report JTC in healthy controls to be around 10-20% (Freeman, 2007). Interestingly, the Moritz and Woodward (2005) study did not detect the JTC bias at all among healthy controls, whereas the present findings revealed that up to 25% of all participants demonstrated a JTC bias on at least one task (this was also using a conservative threshold of making a definite decision after only one bead). Furthermore, the Moritz and Woodward (2005) study found that only 23% of



healthy controls made at least one illogical response consistent with miscomprehension, compared with the present findings where just over half the total healthy sample made at least one illogical response, which is actually more consistent with Moritz and Woodward's finding that 52% of the schizophrenia sample did not comprehend.

### ***Task Administration and Delusion-Proneness***

When the sample was analysed for task administration type (i.e., computerised; non-computerised), levels of "JTC-premature decisions" were identical, yet there was a non-significant trend for the computerised condition to display lower rates of "JTC-over-adjustment" and miscomprehension. These findings may help explain why the Moritz and Woodward study, which only employed the computerised condition, found lower levels of JTC and miscomprehension among the healthy controls. This also has implications for much of the "beads task" literature, both past and present, which have and continue to employ non-computerised versions of the task (e.g., Peters, et al., 2008; So, et al., 2008). It is highly conceivable that clinical samples may have even higher rates of miscomprehension than the present findings, based on the fact that 52% of Moritz and Woodward's (2005) schizophrenia sample were in a computerised condition. While the exact mechanisms behind this task type trend are not fully understood, and any suggestion here remains speculative, it is possible that computerised versions allow participants to work at their own pace, and re-read instructions, without having to consult the experimenter.

Delusion-proneness similarly yielded some interesting trends in concordance with the previous literature, with individuals identified as delusion-prone consistently scoring higher levels of JTC and miscomprehension. However, these trends failed to reach significance, making it difficult to draw any conclusions about the role delusion-proneness plays in explaining the bias. It is also worth pointing out here that although the study had low power due to the sample size, the magnitude of the effect was quite small.

### ***Task Comprehension***

As stated above, levels of miscomprehension were particularly high, and these results suggest that they may be at least partially responsible for the “premature decisions” and “over-adjustment” findings. Nearly 40% of miscomprehending participants exhibited “JTC-premature decisions”, or alternatively, nearly 80% of all participants to show the bias were miscomprehending. Similarly, miscomprehending participants were also significantly more likely to “over-adjust” in the face of potentially disconfirmatory information, which in part confirms the definition of miscomprehension as “extreme over-adjustment”. The qualitative comments made by participants confirm that “miscomprehension” is a valid measure, as the majority of the miscomprehending participants stated that the containers swapped throughout the tasks. The notion that containers were swapping is of theoretical importance, as it can alternatively explain both aspects of the bias (i.e., premature decisions and over-adjustment), as participants may have been responding to the current bead (e.g., “red beads come from the

red container; green beads come from the green container”) rather than the bead sequence (cf. Young and Bentall’s (1997) “recency effect”, which claims that people with delusions may simply be responding to the most recent information being presented). This style of reasoning was not simply due to the nature of Task 2 (first ten trials indicate Container B and second ten indicate Container A), as these participants implied containers swapped every time the beads changed colour, and the comments were also observed for Task 1, where the entire sequence was strongly indicating one container. Such a belief may have been generated simply because these participants somehow missed or had forgotten the crucial instruction that only one container is picked. This could also explain why some of these participants demonstrated a misunderstanding of the probabilities that governed the tasks; yet it is equally conceivable that their knowledge of probabilities was limited from the outset.

Taken together, the results suggest that at least for healthy controls, task administration and delusion-proneness contribute little towards the bias, while there is a somewhat greater association between JTC and miscomprehension, which may undermine the validity of the effect.

Nonetheless, it can be pointed out that the “JTC-premature decisions” effect has been shown to be significantly higher among participants with delusions even when those who did not comprehend were removed from the analysis (Moritz & Woodward, 2005). A recent study by Speechley, Whitman, and Woodward (2010) further explored this issue by attempting to reduce the risk of participants not comprehending the task. This was done by employing

a more realistic “fish/lakes” stimuli set rather than the typical abstract beads/containers set. Additionally, four of the six series of tasks incorporated ten fish of the same colour (“uniform” condition) rather than the usual alternating pattern (“alternate” condition), which helped participants understand that only one lake was being drawn from. Moreover, in contrast to previous designs, the study included two ten-point rating scales (very unlikely to very likely) for each of the two “lakes”. It was argued that a single rating scale results in a loss of information, such that it is impossible to know whether a movement in one direction implies a downward rating adjustment for one option with a simultaneous upward rating adjustment for the other, or vice-versa. The results were hence able to show how people reacted to “matching lakes” (i.e., a lake with a ratio of fish consistent with the colour of the current fish) and “non-matching lakes” at the same time.

The results showed that even within the four “uniform colour” lakes, where miscomprehension could effectively be ruled out, participants with active delusions rated “matching lakes” significantly higher (i.e., more likely) than all non-delusion groups, consistent with the JTC “premature decisions” effect. Moreover, participants with delusions seemingly over-adjusted to the „disconfirmatory evidence” in the “alternating lakes” conditions, suggesting they still misunderstood the instructions for these “lakes” despite efforts to reduce miscomprehension.

However, the most interesting finding was there were no differences between delusional and non-delusional groups for “non-matching lakes”, whether the trials of fish were of “uniform” colour or were “alternating”. Hence, the authors concluded that in the absence of miscomprehension, “JTC-

premature decisions” is better thought of as a hypersalience of positive matches between the evidence and hypothesis, as the non-matching lakes were not rated any lower by the delusional participants compared to controls. This finding also affirms the notion that “JTC-over-adjustment” findings are not over-reactions to disconfirming evidence in the “alternating” condition, as ratings for the “original” matching lake were not any lower than those reported by the healthy controls, as would be expected if decisions were ultimately changed. Rather, the “over-adjustment” may represent a hypersalience of positive matches between the evidence and hypothesis when instructions are misunderstood (i.e., containers/lakes “swapping”).

The present study is not without some limitations. Most notably, delusion-proneness is conceptually different from clinical delusions, thus a replication would benefit from the inclusion of a clinical sub-sample of individuals with a diagnosis of active psychosis. Replications of the study might also include a qualitative analysis of miscomprehension for all participants, rather than a sub-sample, to better account for any potential variability. To determine the potential influence of IQ on miscomprehension, future research should also include a measure of IQ, particularly verbal IQ. An additional experimental condition could also be added, whereby participants are explicitly instructed that “beads always come from the same container” and that “containers do not swap at any point”, outlining that it is more logical to down-rate confidence for a particular container in the face of “disconfirming evidence” rather than jump between containers. This instruction could effectively remove miscomprehension entirely (even for “alternating”

containers/lakes), and if miscomprehension and “over-adjustment” are indeed the same construct as suggested by the current study, this should likewise remove any evidence of over-adjustment.

Despite these caveats, the present study has nonetheless demonstrated the confounding nature of miscomprehension in the beads task. The findings question the validity of the JTC bias previous “beads” studies have revealed, and further question its unmodified use in future research. In sum, the present study highlights the importance for experimenters in this area to check that participants actually understand the task before proceeding to “jump to conclusions” about the potential influence a bias may have on the formation and/or maintenance of delusions.

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## **CHAPTER 4: Paper 2**

### **Over-adjustment or Miscomprehension?**

#### **A Re-examination of the Jumping to Conclusions Bias**

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##### Ryan Balzan (Candidate)

I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

Date: 20/04/2012

Assoc Prof Paul Delfabbro, Prof Cherrie Galletly and Assoc Prof Todd Woodward (Co-authors)

We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We also provided advice on responding to comments by the journal reviewers and editor. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

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## Abstract

Previous research has consistently shown that individuals with delusions typically exhibit a jumping to conclusions (JTC) bias when administered the probabilistic reasoning “beads task” (i.e., decisions made with limited evidence or “premature decisions” and decisions over-adjusted in light of disconfirming evidence or “over-adjustment”). More recent work, however, also suggests that these effects may also be influenced by miscomprehension of the task. The current paper is an investigation into the contributing effects of miscomprehension on the JTC bias. In this study, 75 participants (25 diagnosed with schizophrenia with a history of delusions; 25 non-clinical delusion-prone; 25 non-delusion-prone controls) completed two identical versions of the beads task, distinct only by the inclusion of an extra instructional set designed to increase comprehension. Qualitative data confirmed that miscomprehension is a valid construct, and the results showed that the addition of an instructional set to the second version of the task led to greater comprehension and a statistically significant drop in “over-adjustment”. Nevertheless, both tasks showed that “premature decisions” were significantly more prevalent in the schizophrenia group and were unaffected by the intervention. It was concluded that the “premature decisions” component of the JTC bias remains a feature of decision-making in schizophrenia, but that previously reported “over-adjustment” effects are likely to be influenced by miscomprehension of the beads task instructional set. These findings are discussed in light of the recently proposed “hypersalience of evidence-hypothesis matches” account of the JTC bias.

Delusions have been described as phenomena that reflect cognitive processes. Such beliefs are often held despite counter-evidence and rational counter-argument, are often held with great conviction and are usually not accepted by others living in the social-cultural environment (Gilleen & David, 2005; Langdon & Coltheart, 2000; Miller & Karoni, 1996). In earlier research, delusions were generally not attributed to abnormal reasoning processes (Maher, 1974) and were instead considered to reflect broader pathologies of the mind and brain. However, in more recent research, there is now growing acceptance of the view that inadequacies in reasoning and susceptibilities to information processing biases may also be associated with delusion formation and maintenance (e.g., Garety & Freeman, 1999; McKay, et al., 2007b; Moritz & Woodward, 2006).

One of the most documented of these is the jumping to conclusions (JTC) bias that involves inadequate or selective consideration of information in making judgments about outcomes or the status of events. The JTC bias is typically considered to have two components. The first relates to what are termed “premature decisions” in which decisions are made based on limited evidence. The second is referred to as “over-adjustment” and involves situations where decisions are radically altered in the face of modest accumulations of disconfirming evidence (Garety, et al., 1991). The most commonly employed task to elucidate the JTC bias is the “beads task”. First adapted to samples with psychosis by Huq, Garety, and Hemsley (1988), this task typically consists of two containers each filled with coloured beads. Participants are shown that one jar has, for example, green and red beads in

the proportion of 85:15, while the other has the reverse proportion of beads. Participants are instructed that the containers will be removed from sight and that one of the two containers will be selected by the experimenter. Beads will be drawn from this unseen container one at a time and subsequently placed back, upon which another bead is withdrawn. From this sequence of withdrawn beads, participants are asked to decide which container the experimenter had picked, and to make decisions on a bead-per-bead basis. The sequence of beads presented to participants is pre-determined and usually has a fixed order for all participants. For example, participants might be presented with nine red beads (R) and one green bead (G) out of a sequence of ten beads (i.e., R-R-R-R-G-R-R-R-R). The experiment is normally administered in one of two ways: the “draws to decision” procedure, where participants take as many trials as needed to reach a definite decision (i.e., which container the bead sequence is coming from); or the “graded estimates” procedure, where the number of trials is fixed, and for each trial, participants must provide a probability estimate that a particular bead is from one of the two containers (Garety & Freeman, 1999; Moritz & Woodward, 2005).

Careful decision-making is usually withheld until sufficient evidence is obtained. However, participants with delusions typically do not respond in this way. Instead, up to 70% of patients with delusions will often reach a definite decision on which container beads are coming from on the first or second bead (i.e., they make premature decisions). They will also be more likely to over-adjust their hypothesis when faced with potentially disconfirmatory

evidence. For example, a person presented with containers consisting of red and green beads (i.e., 90:10 red/green and 10:90 red/green) might witness a long string of red beads and then change his or her opinion when faced with a single green bead (e.g., Garety, et al., 1991; Langdon, et al., 2008; Moritz & Woodward, 2005; Rodier, et al., in press; Young & Bentall, 1997). These findings have also been replicated using “delusion-prone” samples (e.g., Colbert & Peters, 2002; Van Dael, et al., 2006; Warman, et al., 2007), providing evidence that the JTC bias may be a precursor to delusion formation.

Although these findings have been accepted as providing evidence of an association between delusion-proneness and suboptimal reasoning strategies, there are a number of concerns that have emerged relating to the interpretation of these findings, particularly in relation to the “over-adjustment” phenomenon. The first concern is that this component of the bias could be considered inconsistent with one of the defining characteristics of delusions; namely, that they are resistant to counter-evidence. The “over-adjustment” effect instead predicts that individuals with delusions are particularly responsive to disconfirmatory evidence. “Over-adjustment” also appears to be an effect limited to the beads task itself, as it contrasts with another set of findings which suggest that individuals with delusions are actually more likely to ignore or downplay the importance of disconfirmatory evidence when compared with healthy controls (i.e., “bias against disconfirmatory evidence”, BADE) (Buchy, et al., 2007; Woodward, et al., 2006b). Furthermore, a recent meta-analysis suggested that the “over-adjustment” bias is not always

replicated within the literature, and may not even be associated with delusions (Fine, et al., 2007).

As a result of these conceptual difficulties, some suspicion has arisen as to whether another factor may account for the over-adjustment effect. One suggestion, for example, is that it may be due to an artefact of the beads task (e.g., Balzan, Delfabbro, & Galletly, in press-a; Moritz & Woodward, 2005), in particular, the possibility that participants may have misinterpreted or forgotten the basic principle of the task, which was that beads were only coming from one container rather than both. Consequently, participants in these studies may have incorrectly assumed that containers swap throughout the task (e.g., “red beads must always come from the mostly red container, while all green beads must come from the mostly green container”), or equivalently, that they were expected to consider each bead separately rather than all information in the entire series of beads. Such “miscomprehension” of the task instructions may therefore account for the erratic decision-changing behaviour traditionally labelled as “over-adjustment”, as participants may simply be responding to the current bead (“red beads = red container”) and not the bead sequence. In sum, miscomprehension rather than delusional ideation may be driving the over-adjustment effect.

This possibility of miscomprehension was first proposed by Moritz and Woodward (2005) and was defined by a participant selecting the opposite container to the one which was expected (e.g., judging beads were coming

from the container with 90% green beads-10% red beads, when the sequence of ten beads only contained one green bead and nine red beads). The results of this study indicated that 52% of the schizophrenia sample and 23% of the healthy controls made illogical responses congruent with the miscomprehension style of responding. Moreover, participants exhibiting a JTC bias were significantly more likely to apparently fail to comprehend the task.

Speechley, Whitman, and Woodward (2010) further explored this issue by attempting to reduce the risk of participants not comprehending the task. This was done by devising a presumably more realistic “fish/lakes” stimuli set rather than the typical abstract beads/containers set. Additionally, four of the six series of tasks incorporated ten fish of the same colour (“uniform” condition) rather than the usual alternating pattern of coloured beads/fish (“alternate” condition), which may have helped participants understand that only one lake was being drawn from and not both lakes (i.e., one colour implies one lake). Finally, the task included two ten-point rating scales (very unlikely to very likely) for each of the two “lakes”, as it was argued that a single rating scale results in a loss of information, such that it is impossible to know whether a movement in one direction (e.g., a downward rating adjustment) for one option is accompanied by a simultaneous and reciprocal rating in the opposite direction for the other option. The results were therefore able to show how people reacted to both “matching lakes” (i.e., a lake with a higher ratio of fish the same colour as the current fish) and “non-matching lakes” (i.e., a lake with a low ratio of fish the same colour as the current fish).

One aspect of the results showed that participants appeared to be considering each fish separately rather than using all information in the entire series of beads and using Bayesian reasoning strategies (see Speechley et al., (2010), Figure 6). Other aspects of the results showed that, within the “uniform colour” condition, where miscomprehension could effectively be ruled out, participants with active delusions still rated “matching lakes” significantly higher earlier in the sequence than all non-delusion groups, thereby validating the “premature decisions” effect. However, there were no differences between delusional and non-delusional groups for “non-matching lakes”, whether the trials of fish were of “uniform” colour or were “alternating”. Accordingly, the authors concluded that JTC-premature decisions are better thought of as a hypersalience of positive matches between the evidence and hypothesis, as the non-matching lakes were not rated any lower by the delusional participants compared to controls. This finding also suggests that the “JTC-over-adjustment” findings are not over-reactions to disconfirming evidence in the “alternating” condition. Rather, the “over-adjustment” may represent a hypersalience of positive matches between the evidence and hypothesis when instructions are misunderstood (i.e., containers/lakes are “swapping”).

However, neither of these studies provided any direct qualitative evidence to suggest that “miscomprehension” was actually occurring during the task. Moreover, “miscomprehension” was removed only from the “uniform sequence” condition in the above study, yet to fully determine any influence it has over “over-adjustment”, it would also need to be removed from an

“alternating sequence” condition. Indeed, if miscomprehension is driving JTC-over-adjustment, the absence of miscomprehension should lead to significant reductions in levels of this phenomenon.

In an attempt to gather qualitative evidence of miscomprehension, a recent replication of the Moritz and Woodward (2005) study asked a sample of non-clinical participants (identified as either delusion-prone or non-delusion-prone, as determined by the Peters et al. Delusions Inventory, Peters, et al., 1999) to justify their response upon presentation of the “disconfirmatory bead” in the sequence (Balzan, et al., in press-a). It was hoped that this would determine if miscomprehending participants actually thought the containers had been swapped at this point in the sequence. Overall, 25% of the sample demonstrated a JTC bias, and just over half made illogical responses consistent with a failure to comprehend the task. Importantly, qualitative evidence of miscomprehension revealed that these “illogical responses” were being driven by a misunderstanding of task instructions (i.e., non-comprehending participants thought the containers had swapped at the contrasting bead colour). The lack of a clinical sample within this study however limits the interpretability of these results. Moreover, to date no studies have successfully removed miscomprehension from an “alternating sequence”.

To determine the validity of the “over-adjustment” component therefore, miscomprehension would need to be removed from an “alternating”



sequence, and this would need to be confirmed by qualitative evidence that containers were not perceived to be exchanged during the presentation of disconfirming evidence. These issues were addressed in the present study which utilised two versions of the traditional beads task and three participant groups: (1) a clinical schizophrenia group, (2) a non-clinical delusion-prone group, and (3) a group of healthy controls. The first task was an unaltered replication of the task used in the Moritz and Woodward (2005) study. The second version was modified such that participants were explicitly instructed that “beads always come from the same container” and that “containers do not swap at any point”. Participants were also instructed that it is more logical, considering the available evidence, to down-rate confidence for a particular container in the face of “disconfirming evidence” rather than jump between containers.

Based on previous evidence, it was hypothesised that the schizophrenia and delusion-prone groups would show higher levels of “premature decisions” and “over-adjustment” relative to controls, and if these phenomena represent a genuine characteristic of decision-making in these populations, the effect should persist following clearer instructions during the second task. Conversely, it was hypothesised that, if miscomprehension is indeed a major explanation for “over-adjustment”, then one would observe significant decreases in responding consistent with this effect in the second task, where comprehension is expected to improve.

## **Methods**

### ***Participants***

A total of 75 participants were recruited consisting of 50 non-clinical participants (23 males; 27 females), who were further divided into delusion-prone and non-delusion-prone groups as determined by the PDI-21 (Peters, et al., 2004), and 25 clinical participants (15 males and 10 females; 23 outpatients and 2 inpatients) with a diagnosis of schizophrenia and a history of delusions. The diagnosis of schizophrenia was confirmed with the Mini-International Neuropsychiatric Interview (MINI), and the Positive and Negative Symptoms Scale (PANSS; Kay, Fiszbein, & Opler, 1987) was employed to determine the severity of current positive symptoms. Both of these instruments were assessed by a trained and experienced research nurse. All clinical participants were being treated with atypical antipsychotic medications at the time of testing.

Non-clinical participants were drawn from hospital staff and the general population via advertisement and word-of-mouth. These participants were screened with the MINI to rule out brain damage and mental illness as confounding factors.

All participants were fluent in English and were able to complete both tasks. Premorbid intelligence estimates were made with the NART (Nelson & Willison, 1991), and working memory was assessed with the Wechsler Adult Intelligence Scale-Revised Digits Forward and Backward subtests (Wechsler,

1997). All attempts were made to ensure clinical and non-clinical groups were matched on social and educational grounds, and socio-economic status was estimated using the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957) using highest parental occupation and education level. Scores for these measures and all other demographic information for each group is summarised in Table 1. As indicated in Table 1, the three samples were generally well matched in relation to their age, educational attainment and scores on standardised measures of cognitive and intellectual functioning.

**Table 1:** Socio-demographic and psychopathological characteristics of participants (mean; SD)

	<b>Schizophrenia <i>n</i> = 25</b>	<b>Delusion-prone <i>n</i> = 25</b>	<b>Non-delusion-prone <i>n</i> = 25</b>
Age	39.96 (10.04)	43.68 (15.93)	41.92 (14.98)
Gender – M:F	15:10	9:16	14:11
Education (no. years)	11.20 (1.41)	11.16 (0.99)	11.72 (1.43)
Index of Social Position <sup>1</sup>	51.96 (10.93)	52.52 (7.87)	48.48 (8.47)
IQ Estimate(NART)	108.27 (5.90)	108.01 (6.08)	111.31 (4.07)
Memory (total)	17.00 (2.92)*	18.36 (3.93)	20.44 (3.65)
PDI-21 (total, median)	82.00	60.00	13.00
PANSS (P1-P7 total)	11.08 (3.12)	N/A	N/A
PANSS-Delusions	2.08 (1.04)	N/A	N/A
Length of illness (years)	14.22 (8.51)	N/A	N/A

<sup>1</sup>Higher scores indicate lower social-economic status

\**p* < .05, between schizophrenia and non-delusion-prone group

### ***Materials and Procedure***

Participants were presented with two computerised versions of the beads task, both adapted from the Moritz and Woodward (2005) “graded estimates” procedure. In Task 1 participants were presented with a picture of two containers full of red and green beads (90% red [R] and 10% green [G] for Container A, and vice versa for Container B). They were told that the computer would randomly select beads from the same container for the duration of the task (i.e., only one container). The sequence of ten beads was, however, predetermined, and was presented in the following order: R-R-R-R-G-R-R-R-R-R.

After each trial, participants were asked to select from one of the following seven options (by pressing keys 1-7 on the keyboard): 1 = Beads are definitely from container A; 2 = beads very likely from Container A; 3 = Beads probably from Container A; 4 = No estimate possible yet; 5 = Beads probably from Container B; 6 = Beads very likely from Container B; 7 = Beads definitely from Container B. This rating scale was displayed for the duration of the experiment, as was the explicit instruction that estimates/decisions should be carried out when considering each bead drawn in turn. To ensure participants remembered the proportion of beads in each container, pictures of the containers also remained displayed for the duration of the task. Participants were then shown a demonstration of a trial, and were given the opportunity to clarify any questions before the task began. Participants were said to have demonstrated a JTC bias if they gave a definite rating (i.e., 1 or 7) when presented with the first bead that was drawn.

Task 2 followed a similar procedure using blue and yellow beads with a 90:10 ratio, and a bead sequence of nine yellow beads and one blue bead in the middle of the sequence (i.e., implicating the yellow container). However, this task included extra instructions which were intended to make it clearer that containers did not swap during the task, even if participants had thought containers swapped during the first task. To solidify this concept, participants were reminded that, in addition to changing containers completely upon presentation of a contrasting bead colour, they also had the option of changing their confidence within the same container (e.g., from “very likely” to “probably”). Participants were also informed that they were free to change their minds about which container the bead sequence was coming from (e.g., A to B), but that this should be done only if presented with sufficient evidence to warrant this (e.g., a string of yellow beads followed by a larger string of blue beads). This intervention was expected to improve levels of comprehension.

### ***Measures***

The various measures that were employed in the study included:

- a) *JTC-Premature Decisions* – a participant was identified as displaying this aspect of the JTC bias if they made a *definite* decision after only one bead.

- b) *JTC-Over-adjustment* – represented the amount of change in the judgement-ratings between trials with potentially disconfirmatory evidence (i.e., when beads changed from red to green/*vice-versa* in Task 1 and from yellow to blue/*vice-versa* for Task 2).
- c) *Miscomprehension* – or “extreme over-adjustment”, was defined as selecting the opposite container to the one which was being suggested, that is, if participants made an estimate that beads were coming from Container B (i.e., ratings 5-7), where the sequence was clearly indicating Container A (Moritz & Woodward, 2005).
- d) *Qualitative measure of miscomprehension* – to confirm that “miscomprehension” was a valid measure, participants were informed that should they alter their confidence ratings and/or change containers throughout the task, they were to state aloud why they had done so. Responses consistent with the notion that containers were swapping or had swapped at the contrasting bead were recorded.

## **Results**

The results are divided into two main sections. The first examines the influence of delusional ideation (i.e., schizophrenia; delusion-prone; non-delusion-prone groups) on “JTC-premature decisions”, “JTC-over-adjustment” and miscomprehension during Task 1. The impact miscomprehension itself had on both components of the JTC bias is also assessed for Task 1. The second section examines the effectiveness of the Task 2 intervention at

reducing the JTC bias and/or miscomprehension while also testing for group differences in JTC bias components.

Qualitative data were analysed by examining the explanations provided by participants displaying evidence of miscomprehension. As anticipated, this analysis showed that all of these participants incorrectly assumed that containers “swapped” when the contrasting bead was displayed (for both tasks). In contrast, no such statements were reported by comprehending participants.

### **Task 1 – Pre-intervention**

#### *(a) Delusional Ideation: JTC-Premature Decisions*

As indicated in Table 2, “JTC-premature decisions” (i.e., a definite rating after only one bead) was relatively high for the schizophrenia group, with nearly 70% of this group responding in this way, compared to 32% and 12% of the delusion-prone and non-delusion-prone groups, respectively. A chi-squared analysis confirmed that there was a significant association between group membership and this phenomenon ( $\chi^2 (2, N = 75) = 17.21, p < .001$ ). Further 2 x 2 analyses confirmed associations between the schizophrenia and delusion-prone group ( $\chi^2 (1, N = 50) = 6.48, p < .05$ ) and the schizophrenia and non-delusion-prone group ( $\chi^2 (1, N = 50) = 16.33, p < .001$ ). On the other hand, there was no significant association between group and premature decision-making when the delusion-prone and non-delusion prone groups were compared ( $\chi^2 (1, N = 50) = 2.91, p > .05$ ).

*(b) Delusional Ideation: JTC-Over-adjustment<sup>1</sup> and Miscomprehension*

In line with previous findings, a planned comparisons *t*-test between schizophrenia and non-delusion-prone groups revealed that over-adjustment was significantly higher within the schizophrenia sample ( $t(48) = 1.90, p < .05$  (1-tailed)). Schizophrenia/delusion-prone and delusion-prone/non-delusion-prone planned comparisons did not yield significant differences ( $t(48) = 1.01, p > .05$  (1-tailed);  $t(48) = .84, p > .05$  (1-tailed)). Furthermore, there was no significant association between group membership and miscomprehension ( $\chi^2(2, N = 75) = 2.99, p > .05$ ), although there was a trend for the schizophrenia and delusion-prone groups to exhibit higher proportions of miscomprehension (Table 2). These findings are not, however, necessarily inconsistent with the view that the JTC-over-adjustment effect is influenced by miscomprehension. In fact, they are consistent with the view that although all groups display high levels of miscomprehension, patients with schizophrenia display higher levels of “over-adjustment” due to a hypersalience of evidence-hypothesis matches. That is, when it is assumed that “containers have swapped”, the same evidence-hypothesis hypersalience that caused the initial “premature decision” (e.g., red bead = red container) now leads to a “premature decision” in the other container (i.e., green bead = green container). This issue is explored in more detail below.

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<sup>1</sup> An anonymous reviewer suggested that these data could also have been combined in a 3 (Group) x 2 (Task) ANOVA with repeated measures on task for JTC-Over-adjustment to test for a possible interaction effect. However, the results from this analysis did not yield a significant interaction for Group x Task ( $F(2, 72) = .88, p > .05$ ).



*(c) Task Comprehension: JTC-Premature Decisions*

Table 3 indicates that participants who miscomprehended the task were more likely to make “premature decisions” as compared with comprehending participants (52.6% and 21.6%, respectively),  $\chi^2(1, N = 75) = 7.71, p < 0.05$ . In fact, over 70% of those who displayed this component of the bias misunderstood the instruction that containers do not swap.

*(d) Task Comprehension: JTC-Over-adjustment*

As shown in Table 3, miscomprehending participants in Task 1 were significantly more likely to over-adjust their responses in the face of potentially disconfirmatory evidence,  $t(73) = 14.74, p < .001$ . Thus, there was evidence that over-adjustment as well as premature decision-making may be influenced by miscomprehension of the task.

**Task 2 – Post-intervention**

As indicated above, the aim of the second part of the study was to examine whether the inclusion of an intervention, designed to improve comprehension, would influence the levels of the JTC bias.

*(a) JTC-Over-adjustment and Miscomprehension*

A Wilcoxon Signed Ranks Test showed that the inclusion of extra instructions highlighting the fact that containers do not swap at any time during the task significantly reduced the levels of task miscomprehension ( $Z = -5.66, p < .001$ ). A paired samples  $t$ -test further revealed significant decreases

in the amount of “over-adjustment” from Task 1 to Task 2,  $t(74) = 6.40$ ,  $p < .001$  (Table 2).

*(b) JTC-Premature Decisions*

The observed decrease in premature decision-making due to the intervention was not, however, found to be statistically significant (Wilcoxon Signed Ranks Test,  $Z = -1.16$ ,  $p > .05$ ), which suggests that this phenomenon still remains despite the provision of additional information.

*(c) Delusional Ideation: JTC-Premature Decisions*

As in Task 1, a significant association was found between group membership and premature decision-making ( $\chi^2(2, N = 75) = 14.34$ ,  $p < .001$ ). Once again, participants with schizophrenia were more likely to display this component of the JTC bias than the other two groups (delusion-prone:  $\chi^2(1, N = 50) = 6.65$ ,  $p < .05$ ; non-delusion-prone:  $\chi^2(1, N = 50) = 12.50$ ,  $p < .001$ ), despite the intervention. No statistically significant association was found between group membership and premature decision-making when the analysis was confined to the two non-clinical groups ( $\chi^2(1, N = 50) = 1.22$ ,  $p > .05$ ).

*(d) Delusional Ideation: JTC-Over-adjustment and Miscomprehension*

As with Task 1, the planned comparisons for Task 2 showed significant group differences between the schizophrenia and non-delusion-prone groups

( $t(48) = 2.39, p < .05$  (1-tailed)) and the delusion-prone and non-delusion-prone groups ( $t(48) = 2.40, p < .05$  (1-tailed)). It is worth noting however that the “over-adjustment” levels for the schizophrenia group during Task 2 were much lower than even the non-delusion-prone group during Task 1. No differences in “over-adjustment” were found between the schizophrenia and delusion-prone group ( $t(48) < 1$ ), or between groups in the likelihood of miscomprehending the task ( $\chi^2(2, N = 75) = 3.26, p > .05$ ).

**Table 2:** JTC-premature decisions ( $n$ ), JTC-over-adjustment, and miscomprehension ( $n$ ) by delusional ideation for Task 1 and Task 2

		JTC-premature decisions, $n$ (%)	JTC-over-adjustment (SD)	Miscomprehension $n$ (%)
<b>Task 1</b>				
	<b><i>N</i></b>			
Schizophrenia	25	17 (68%)*	2.74 (2.35)^	16 (64%)
Delusion-prone	25	8 (32%)	2.08 (2.26)	12 (48%)
Non-delusion-prone	25	3 (12%)	1.58 (1.95)	10 (40%)
<b>Total (sample)</b>	<b>75</b>	<b>28 (37.33%)</b>	<b>2.13 (2.22)#</b>	<b>38 (50.67%)#</b>
<b>Task 2</b>				
	<b><i>N</i></b>			
Schizophrenia	25	15 (60%)*	0.94 (1.28)^	3 (12%)
Delusion-prone	25	6 (24%)	0.96 (1.33)^	3 (12%)
Non-delusion-prone	25	3 (12%)	0.30 (0.38)	0 (0%)
<b>Total (sample)</b>	<b>75</b>	<b>24 (32%)</b>	<b>0.73 (1.12)</b>	<b>6 (8%)</b>

JTC-premature decisions: percentage of participants (per group) who gave a definite rating after only one bead.

JTC-over-adjustment: mean difference in judgement-ratings between trials with disconfirmatory evidence.

Miscomprehension: percentage of participants displaying miscomprehension and stating “containers swapped”.

\*  $p < .05$ , between all groups

^  $p < .05$ , between schizophrenia/non-delusion-prone (Task 1 & Task 2); delusion-prone/non-delusion-prone (Task 2)

#  $p < .001$ , repeated measures (Task 1 – Task 2)

**Table 3:** JTC-premature decisions (%) and JTC-over-estimation by miscomprehension for Task 1

	<i>N</i>	JTC- premature decisions <i>n</i> (%)	JTC- over-adjustment (SD)
Miscomprehending participants	38	20 (52.6%)*	4.01 (1.54) <sup>#</sup>
Comprehending participants	37	8 (21.6%)	0.20 (0.32)

\*  $p < .05$ , between groups

<sup>#</sup>  $p < .001$ , between groups

## Discussion

The aim of the present study was to determine the validity of the miscomprehension construct, and to examine the extent to which people’s susceptibility to the “over-adjustment” component of the JTC bias are influenced by miscomprehension of the task. The results indeed lend support to the notion that miscomprehension is a valid construct and that it appears to be driving the JTC-over-adjustment effect. From qualitative evidence it was clear that all miscomprehending participants (across both tasks) had believed that the containers had been swapped during the course of the task. Levels of miscomprehension were high, even amongst healthy controls, questioning the continued use of the task in its unmodified form.

Moreover, as hypothesised, the intervention was shown to be effective at reducing levels of miscomprehension during Task 2, despite the fact that this task consisted of an “alternating” sequence. In Task 2, the level of “over-adjustment” dropped significantly which suggests that, in the absence of miscomprehension (or the notion that containers are swapping), participants no longer “over-correct” their judgements in response to the “disconfirmatory

evidence". Although the schizophrenia group did exhibit significantly higher levels of "over-adjustment" relative to the non-delusion-prone group during Task 1, this does not imply patients with schizophrenia over-react to disconfirming evidence in the "alternating" condition, as has been previously suggested.

As the present findings confirm the validity of miscomprehension, the "hypersalience of evidence-hypothesis matches" account put forward by Speechley et al. (2010) may offer a better explanation of the effect. When instructions are misunderstood at the contrasting bead (i.e., containers "swapping"), it would appear that patients with schizophrenia are particularly hypersalient to the apparent "match" between the "new bead" (i.e., the "evidence") and the notion that they are now coming from the "other container" (i.e., the "hypothesis"), such that "a green bead must imply the green container". As will be explained in more detail below, this account of the JTC bias may also represent the cognitive mechanism underlying the "premature decisions" phenomenon. Furthermore, the finding that both the schizophrenia and delusion-prone groups exhibited significantly higher levels of "over-adjustment" at Task 2 should not be taken as evidence of "over-adjustment" in absence of miscomprehension. The levels of "over-adjustment" were substantially lower at Task 2 (i.e., the schizophrenia group had levels lower at Task 2 than those exhibited by the non-delusion-group during Task 1), which can be explained by the significant improvement in task comprehension. The significant proportional differences observed here do not so much represent "over-adjustment" per se, but rather "modest adjustment", which itself may be a reflection of "modest miscomprehension" which

prevailed for a minority of the schizophrenia and delusion-prone groups (Table 2).

JTC-over-adjustment has been considered a valid construct and a factor in the development and maintenance of delusions since it was first reported in Garety, et al. (1991). The present findings, which equate the construct to a misinterpretation of the beads task's instructional set, challenge this view. The JTC-over-adjustment finding was not originally expected; participants with delusions were instead hypothesised to downplay the importance of the disconfirmatory evidence (Garety, et al., 1991), in line with the definition of delusions that they are maintained with great conviction despite counterevidence or counterargument. It would seem that in light of the present findings, this discrepancy between the "over-adjustment" effect and a defining characteristic of delusions is now consistent. Moreover, the findings are consistent with the BADE literature (e.g., Woodward, et al., 2006b), which states that disconfirmatory evidence is ignored or its importance is downplayed in individuals with active delusions and those who are identified as delusion-prone.

Although the findings challenge the interpretation of the JTC-over-adjustment construct, they nonetheless lend further support to the validity of the "premature decisions" component. JTC-premature decisions were significantly higher in the schizophrenia group and there was a non-significant trend of higher levels of the construct within the delusion-prone group compared to non-delusion-prone participants, consistent with the theory that the construct may play a role in the development and maintenance of

delusions across the psychosis continuum (van Os, 2003). Furthermore, despite a significant relationship between miscomprehension and “premature decisions” during Task 1, which has been interpreted as a confound in previous studies (Balzan, et al., in press-a; Moritz & Woodward, 2005), levels of “premature decisions” remained stable across groups in Task 2, where miscomprehension was effectively removed. This offers further evidence that significant differences in levels of JTC-premature decisions can be demonstrated between groups differing in delusional ideation in the absence of miscomprehension (Speechley, et al., 2010). Finally, as has already been highlighted, these findings are also consistent with the interpretation that “premature decisions” may represent a hypersalience of hypothesis (e.g., “beads coming from red container”) to evidence (“red bead”) matches. Such hypersalience in turn generates higher confidence, and the “premature decisions” phenomenon is observed.

While the current study included a number of features to investigate the issue of miscomprehension in different ways (group comparisons and an intervention task), it is important to be mindful of some of the study’s limitations. First, due to the nature of the study it was not feasible to counterbalance the order of tasks, so that is unclear how much of the change in responding across tasks was due to practice effects as opposed to a genuine decrease in JTC responding. A replication of the study could, for example, include a control group to determine whether a repeat of the task leads to changes in performance. Practice effects would not, however, explain why premature decision-making continued to persist in the

schizophrenia group whereas the over-correction effect strongly declined following the introduction of additional instructions. Moreover, typical beads task studies have included multiple versions of the task without any indication that either “premature decisions” or “over-adjustment” improve in subsequent tasks. Rather, they appear to remain stable, thereby limiting the influence “practice effects” potentially had on these findings.

Second, in line with more recent studies (e.g., Speechley, et al., 2010), a replication would benefit from collecting a larger sample of highly delusional participants within a schizophrenia sample to disambiguate the contributing effect of active delusions or the schizophrenia diagnosis itself. Moreover, PDI scores for the delusion-prone sample were not as high as other studies (e.g., Warman, et al., 2007), which may have contributed to the non-significant differences in “premature decisions” within the non-clinical sample, despite a trend for the delusion-prone subsample to demonstrate higher levels of “premature decisions”. A more targeted “delusion-prone” sample could be collected in future research (e.g., spiritualist churches, conspiracy theory groups). Such research should also attempt to gather more evidence for the “hypersaliency of positive matches between the evidence and hypothesis” and BADE constructs. Such studies could include “confirmation bias” tasks where the importance of confirmatory and disconfirmatory evidence is simultaneously rated; participants with delusions would be expected to pay particular attention to confirmatory “matches” whilst downplaying disconfirmatory evidence.



In conclusion, the present study has demonstrated the confounding nature of miscomprehension in the beads task, and confirmed the presence of the JTC bias in schizophrenia. The findings question the validity of the JTC-over-adjustment construct, and further question the use of an unmodified version of the beads task in future research. In sum, the present study highlights the importance for experimenters in this area to check that participants actually understand the task before proceeding to “jump to conclusions” about the potential influence a bias may have on the formation and/or maintenance of delusions.

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**SECTION B:**

**Validity of the “Hypersalience of Evidence-hypothesis Matches”**

**Account of Delusion Formation and Maintenance**

## **CHAPTER 5: Paper 3**

### **Confirmation biases across the psychosis continuum:**

### **The contribution of hypersalient evidence-hypothesis matches**

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#### Ryan Balzan (Candidate)

I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

Date: 20/04/2012

Assoc Prof Paul Delfabbro, Prof Cherrie Galletly and Assoc Prof Todd Woodward (Co-authors)

We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We also provided advice on responding to comments by the journal reviewers and editor. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

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## **Abstract**

Hypersalience of evidence-hypothesis matches has recently been proposed as the cognitive mechanism responsible for the cognitive biases which, in turn, may contribute to the formation and maintenance of delusions. However, supporting evidence for this construct is still required. Using two tasks designed to elicit three core facets of the confirmation bias (i.e., biased search of confirming evidence; biased interpretation of confirming evidence; and biased recall of confirming evidence), the present paper investigated the possibility that individuals with delusions and those identified as delusion-prone are hypersalient to evidence-hypothesis matches. A total of 75 participants (25 diagnosed with schizophrenia with a history of delusions; 25 non-clinical delusion-prone; 25 non-delusion-prone controls) completed both tasks. The results across both tasks showed that participants with schizophrenia and delusion-prone participants prefer: non-diagnostic or non-specific positive tests over diagnostic negative tests (biased search); rate confirming evidence as more important than disconfirming evidence (biased interpretation); and remember confirming evidence with greater ease than disconfirming evidence (biased recall). Participants with higher delusional ideation also failed to integrate disconfirmatory evidence to modify prior hypotheses. These results suggest that delusional ideation is linked to a hypersalience of evidence-hypothesis matches. The theoretical implications of this cognitive mechanism on the formation and maintenance of delusions are discussed.

The contention that delusion formation and maintenance in schizophrenia may in part be attributable to biased cognitive processing, or “cognitive biases”, has gathered momentum in recent years (e.g., Garety & Freeman, 1999; McKay, et al., 2007b; Moritz & Woodward, 2006). These biases include the Jumping to Conclusions (JTC) bias, which involves inadequate or selective consideration of information in making judgments about outcomes or the status of events, and the Bias Against Disconfirmatory Evidence (BADE), where the importance of disconfirmatory evidence is downplayed or ignored (Fine, et al., 2007; Garety, et al., 1991; Moritz & Woodward, 2006; Woodward, et al., 2006b). However, the underlying cognitive mechanism giving rise to these biases has been unclear.

One line of research suggests that cognitive biases, such as the JTC and BADE, are a result of a *hypersalience of positive matches* between a hypothesis and the available evidence (Speechley, et al., 2010). For example, hypersalient evidence hypothesis matches can lead to an early cessation of data gathering and encourage hasty decisions based on limited evidence (i.e., JTC), and can also strengthen otherwise weak evidence-hypothesis connections, making them more resistant to counter evidence (i.e., BADE).

To date there is little direct empirical evidence for an underlying “hypersalience” mechanism, although there is an emerging body of research that has begun to investigate the phenomenon by drawing upon established biases studied more widely in the cognitive literature, such as the

representativeness and availability reasoning heuristics. For example, one recent study showed that people with delusions were more prone to make judgements by representativeness when judging the likelihood of “evidence-hypothesis” matches, and were more susceptible to the availability heuristic when assessing the frequency of these matches (Balzan, Delfabbro, Galletly, & Woodward, in press-d).

The current paper aims to extend this line of research by examining the propensity of the confirmation bias across the assumed “psychosis continuum”, which incorporates both people with active delusions and those identified as “delusion-prone” (van Os, 2003). The confirmation bias is defined as a cognitive mechanism that ensures the immunity of a hypothesis to counter-evidence or falsification (for a recent overview see Oswald & Grosjean, 2004). This bias is particularly well suited to investigating the validity of the “hypersalience of evidence-hypothesis matches” construct, as the tasks which have been designed to elucidate this bias typically measure how individuals react to strong confirming and disconfirming evidence.

The confirmation bias is conceptually different from a “positive test strategy”, as this strategy still allows for the falsification of a hypothesis whilst reducing the number of instances in which the hypothesised event is expected to occur. Thus, a positive test strategy may actually represent a near-optimal hypothesis test heuristic (Klayman & Ha, 1987; Navarro & Perfors, 2011; Oswald & Grosjean, 2004). However, there are a number of

conditions under which a positive test strategy *becomes* a confirmation bias; that is, a strategy which systemically impedes the possible rejection of a hypothesis. Trope and Bassok (1982) noted that if the questions asked to test hypotheses are *non-diagnostic* (i.e., non-specific) they will likely be answered in the affirmative, irrespective of the actual truth of the hypothesis. The information is searched for in such a way that captures both the hypothesised event and its *alternative*. This leads to spurious confirmation of a hypothesis and immunises it against falsification. Conversely, a diagnostic strategy implies a search for evidence that will support the hypothesis *or* its alternative. Studies have shown people generally prefer to employ diagnostic strategies over non-diagnostic strategies, even if they are given the choice between a negative-diagnostic test strategy and a positive-non-diagnostic test strategy (Samuels & McDonald, 2002). However, it is unknown whether individuals with delusions may be biasing their search strategies for positive tests over diagnostic tests due to a hypersalience of evidence-hypothesis matches.

In addition to biased search strategies, research has revealed two other avenues by which hypotheses can be immunised against rejection. People may: (a) *selectively encode* and *recall* information that conforms to a hypothesis (e.g., Taylor & Crocker, 1981) and/or (b) bias the *interpretation* of information such that disconfirmatory evidence is systemically re-interpreted to confirm a hypothesis or is attributed less importance than hypothesis-congruent information (Gadenne & Oswald, 1986; Lord, Ross, & Lepper, 1979). Indeed, while the BADE experiments have shown that patients with



delusions, and even delusion-prone individuals (Buchy, et al., 2007), do not integrate disconfirmatory evidence as well as non-delusional controls, no study has yet conclusively shown whether these groups attribute more importance on and/or remember more confirming evidence than incongruent evidence, which is what one would expect if this evidence is “hypersalient”. Demonstrating biased interpretation and/or recall of confirming evidence in delusional patients is thus important in establishing the validity of the “hypersalience of evidence-hypothesis matches” account of delusion formation and maintenance.

The few studies that have investigated the confirmation bias among patients with delusions are inconclusive. One such study administered the Wason “2-4-6” task (Wason, 1960) to a sample of schizophrenia patients, who were divided into delusional and non-delusional groups (Peters, et al., 2008). The study did not find any differences in task performance between the two groups, suggesting that the “confirmation bias” is not linked to delusional ideation. However, it has been argued that the nature of the “2-4-6” task itself prohibits falsification, and is therefore not representative of a “true” confirmation bias (see Klayman & Ha, 1987). Another study found that participants with delusions were successfully able to employ a negative test strategy (i.e., where the non-occurrence of a hypothesised event is searched for) equally well as controls, concluding that there was no evidence of any abnormal hypothesis-testing strategies in patients with delusions (Bentall & Young, 1996). However, the task used in the study conditioned participants to select negative-tests by way of negative reinforcement (i.e., removal of a

negative outcome). Thus, it remains unknown if patients with delusions are capable of selecting negative-tests over positive-tests in neutral unconditioned test environments.

The current paper therefore aims to determine the conditions under which a positive-test strategy becomes a true confirmation bias across the psychosis-continuum. If the hypersalience theoretical account is valid, patients with delusions and those identified as “delusion-prone” would be expected to show biased search strategies or a preference for positive-tests over diagnostic-tests (Task 1), and biased recall and interpretation of confirming evidence, above the levels of healthy controls (Task 2).

### **Task 1**

Task 1 was designed to examine biased hypothesis search strategies. To test the hypothesis that individuals with higher delusional tendencies may prefer positive tests over diagnostic tests due to a hypersalience of confirmatory evidence, participants undertook an adapted version of a hypothesis-testing task designed by Samuels and McDonald (2002). Unlike other hypothesis-testing problems, such as Wason’s 2-4-6 open-ended task, the design of this task not only allows the experimenter to control the precise hypothesis to be tested as well as its alternatives, but also whether the tests are positive or negative, or diagnostic or non-diagnostic. To take an example of such a problem, imagine Bobby has three sisters: Julie, who has red hair; Linda, who has brown hair; and Stephanie, who also has brown hair. All of the

sisters are tall, and one them has picked Bobby up from school. If you were asked to work out if Julie picked Bobby up, you could ask if the sister who picked him up had red hair. This would be a *positive* test (as it probes for the hypothesised sister), but also a *diagnostic* test (as it will confirm either the hypothesis or its alternative). Conversely, if you asked if the sister had brown hair, this would be a *negative diagnostic* test, as it probes for a non-hypothesised sister and will confirm or disconfirm the “Julie” hypothesis. Finally, you could ask if the sister who picked Bobby up was tall; however, this is a *positive non-diagnostic* test because *all* of Bobby’s sisters are tall (Samuels & McDonald, 2002). By providing participants with these testing options, it is possible to determine a preference for particular types of tests over others.

## **Method**

### *Participants*

A total of 75 participants were recruited, including 25 clinical participants (15 males and 10 females; 23 outpatients and 2 inpatients) with a diagnosis of schizophrenia and a history of delusions, and 50 non-clinical participants (23 males; 27 females). Non-clinical participants were drawn from hospital staff and the general population via advertisement and word-of-mouth. These participants were screened with the MINI to rule out brain damage and mental illness as confounding factors.

The diagnosis of schizophrenia was confirmed with the Mini-International Neuropsychiatric Interview (MINI), and the Positive and Negative Symptoms Scale (PANSS; Kay, et al., 1987) was employed to determine the severity of current positive symptoms. Both of these instruments were administered by a trained and experienced research nurse. All clinical participants were treated with atypical antipsychotic medications at the time of testing.

All participants were given the PDI-21 (Peters, et al., 2004), which was used to divide the non-clinical participants into a delusion-prone group (i.e., individuals who fell above the median non-clinical PDI score) and a non-delusion-prone group (i.e., individuals who fell below the median non-clinical PDI score).

All participants were fluent in English and were able to complete the task. Premorbid intelligence estimates were made with the NART (Nelson & Willison, 1991), and working memory was assessed with the Wechsler Adult Intelligence Scale-Revised Digits Forward and Backward subtests (Wechsler, 1997). Socio-economic status was estimated using the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957) using highest parental occupation and education level. Clinical and non-clinical groups were matched on social and educational grounds. Scores for these measures and all other demographic information for each group is summarised in Table 1. As indicated in Table 1, the three samples were generally well matched in

relation to their age, educational attainment and scores on standardised measures of cognitive and intellectual functioning.

**Table 1:** Socio-demographic and psychopathological characteristics of participants (mean; SD)

	Schizophrenia <i>n</i> = 25	Delusion-prone <i>n</i> = 25	Non-delusion-prone <i>n</i> = 25
Age	39.96 (10.04)	43.68 (15.93)	41.92 (14.98)
Gender – M:F	15:10	9:16	14:11
Education (no. years)	11.20 (1.41)	11.16 (0.99)	11.72 (1.43)
Index of Social Position <sup>1</sup>	51.96 (10.93)	52.52 (7.87)	48.48 (8.47)
IQ Estimate(NART)	108.27 (5.90)	108.01 (6.08)	111.31 (4.07)
Memory (total)	17.00 (2.92)*	18.36 (3.93)	20.44 (3.65)
PDI-21 (total, median)	82.00	60.00	13.00
PANSS (P1-P7 total)	11.08 (3.12)	N/A	N/A
PANSS-Delusions	2.08 (1.04)	N/A	N/A
Length of illness (years)	14.22 (8.51)	N/A	N/A

<sup>1</sup>Higher scores indicate lower social-economic status

\**p* < .05, between schizophrenia and non-delusion-prone group

### *Materials*

Based on the materials used in the Samuels and McDonald (2002) study, three distinct alien species (i.e., Jawa, Twi'lek, and Hutt) were presented to participants, each possessing six characteristics in a unique combination as summarised in Table 2. This ensured that one characteristic was diagnostic for a particular alien upon presentation of the three aliens. The stimuli were presented pictorially, with each alien's unique set of characteristics displayed directly below this picture. The task was administered using SuperLab V4 software.

**Table 2:** Alien stimuli set (diagnostic characteristic in *italics*)

		<i>Jawa</i>	<i>Twilek</i>	<i>Hutt</i>
<b>Set A</b>	<b><i>Diet</i></b>	Meat	<i>Plants</i>	Meat
	<b><i>Height</i></b>	<i>Short</i>	Tall	Tall
	<b><i>Movement</i></b>	Fast	Fast	<i>Slow</i>
<b>Set B</b>	<b><i>Weight</i></b>	Light	Light	<i>Heavy</i>
	<b><i>Smell</i></b>	<i>Stinky</i>	Odourless	Odourless
	<b><i>Planet</i></b>	Tatooine	<i>Ryloth</i>	Tatooine

### *Design*

The task was split into two test conditions, and each condition was randomly assigned stimuli set A or B (Table 2). The first condition presented participants with a positive diagnostic test and two positive non-diagnostic tests. In the second condition, participants had to choose between a negative diagnostic test and two positive non-diagnostic tests. The tests or questions were given for each alien, one of which was hiding behind a curtain. The participant's task was to choose which question, out of the three, was the optimal for deducing if that particular alien was the creature hiding behind the curtain.

### *Procedure*

Participants were given a brief training session during which they familiarised themselves with the names and characteristics of each alien for one of the two stimuli sets. After a brief introduction to each alien and their set of unique characteristics, participants were tested to determine if they had learnt these sets of characteristics. For instance, participants might be asked “Was the Jawa short or tall?”. This training continued until participants could correctly identify all three characteristics of each alien without making an error on any alien. For most participants, three cycles of training was sufficient to meet this criterion.

After training, participants were informed that one of the three aliens would be hiding behind a curtain, and that their task was to determine which alien this was by considering each creature in turn. They would be presented with three questions, upon which they would select what they deemed to be the best question for that particular alien. In the first test phase, the optimal question would be a positive diagnostic test, while the remaining questions would be positive non-diagnostic tests. For example, when asked to test for the Jawa, participants would choose between “Is the alien behind the curtain short?” (diagnostic), “Is he fast?”, and “Does he eat meat?” (both non-diagnostic). In the second phase, the optimal question was a negative diagnostic test amongst two positive non-diagnostic test (e.g., “Is the alien odourless?”, “Is he light?” and “Is he from Tatooine?” for the Jawa). After each response, participants were asked why they made that decision. This was to determine if participants were merely making a guess or whether they were selecting a particular response for its diagnosticity.

To ensure participants responses were not influenced by positive or negative outcomes, they received no feedback until the end of the task. Moreover, to rule out the possibility that non-diagnostic questions may have been selected due to forgetting each alien's set of characteristics, participants were asked to recall the three dimensions of each creature after each hypothesis test.

The measures of interest were the number of correct choices, defined as selecting the diagnostic test (maximum of 3 per condition); and the number of correct reasons given for a correct choice (maximum of 3 per condition). Correct reasons were identified by a qualitative response that captured the uniqueness of the correct choice. For example, "I selected „is the alien behind the curtain short?“ for the Jawa as he was the only short alien" was a correct reason for selecting this choice; guesses and non-related reasons ("the Jawa is shortest so he can hide under the curtain the easiest") were marked as incorrect.

## **Results**

Table 3 shows the number of correct choices and the number of correct reasons given for selecting a correct choice across both the positive and negative test conditions per group. Similarly, Figure 1 illustrates the distribution of correct responses for each of the three tasks per condition across the groups. Inspection of Figure 1 and Table 3 reveals that all groups performed similarly in the positive test condition and were successful in correctly selecting the optimal diagnostic test from the non-diagnostic tests.



Moreover, the number of correct reasons closely matched the number of correct choices for each group, implying that participants were not simply guessing when making their choices, or that the number of correct choices variable was a reflection of chance. ANOVA analysis revealed no group differences for the number of correct choices ( $F(2, 72) = 2.11, p > .05$ ) or number of correct reasons ( $F(2, 72) = 3.08, p > .05$ ).

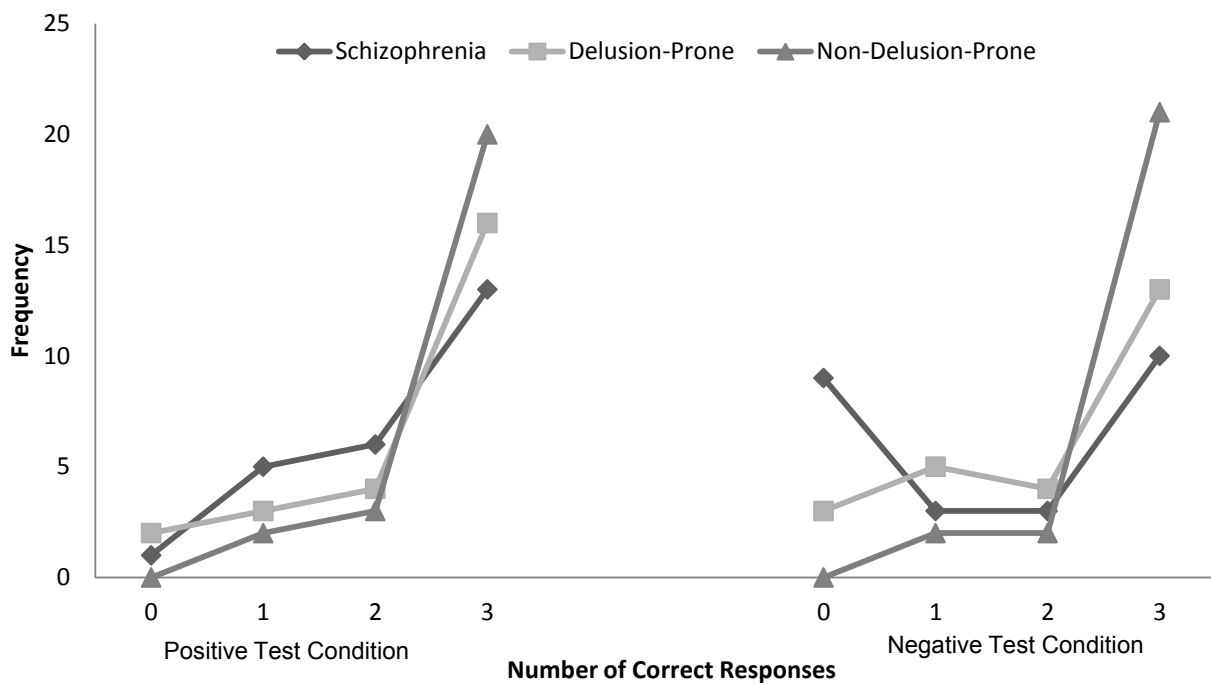
However, there were significant differences between groups for both the number of correct choices ( $F(2, 72) = 7.61, p < .001$ ) and correct reasons ( $F(2, 72) = 11.61, p < .001$ ) on the negative test condition. Bonferroni post-hoc tests confirmed that the schizophrenia group selected significantly fewer correct choices than the non-delusion-prone group, and provided significantly fewer correct reasons for their choices compared to both non-clinical groups (see also Figure 1 and Table 3). Moreover, while the number of correct reasons again closely matched the number correct choices for non-clinical groups, participants with schizophrenia provided fewer correct reasons than the number of correct choices made (Table 3), implying that some of these correct choices were actually guesses. Significant negative correlations were also found for the number of correct choices/reasons and PDI-21 scores ( $r = -.32, p < .05$  and  $r = -.36, p < .05$ , respectively), suggesting delusional ideation is linked to a bias towards selecting positive tests over diagnostic tests.

**Table 3:** Number of correct choices (mean; SD; maximum = 3) and correct reasons (mean; SD; maximum = 3) by delusional ideation for positive and negative test conditions

		Number of Correct Choices (SD)	Number of Correct Reasons (SD)
<b>Positive Condition</b>			
	<b>N</b>		
	Schizophrenia	2.24 (0.93)	2.12 (0.93)
	Delusion-prone	2.36 (0.99)	2.32 (1.03)
	Non-delusion-prone	2.72 (0.61)	2.72 (.061)
<b>Negative Condition</b>			
	<b>N</b>		
	Schizophrenia	1.60 (1.32)*	1.24 (1.39)#
	Delusion-prone	2.08 (1.11)	2.08 (1.11)
	Non-delusion-prone	2.76 (0.59)	2.72 (0.61)

\* $p < .05$ , between schizophrenia and non-delusion-prone group

#  $p < .05$ , between schizophrenia and non-clinical groups



**Figure 1:** Frequency of correct responses by group across positive and negative test conditions

## Discussion

These results suggest that participants with delusions demonstrate biased hypothesis-testing strategies in situations where positive non-diagnostic hypothesis tests can be selected over negative diagnostic tests. The preference for positive tests over more optimal negative tests suggests that individuals with delusions are hypersalient to evidence-hypothesis matches. This biased hypothesis testing strategy represents a “true” confirmation bias as it immunises the hypothesis to falsification.

Although significant differences were found only between the schizophrenia group and non-clinical controls, the bias reported may not be driven by a diagnosis of schizophrenia per se, but rather by the *delusional symptomology* of schizophrenia. For instance, Figure 1 and Table 3 reveal a trend that the delusion-prone group performed less optimally during the negative-test condition compared to non-delusion-prone participants, who actually exhibited a slight improvement. Moreover, correlation analysis suggested that sub-optimal performance during the negative test condition was significantly linked with delusional ideation as measured by the PDI.

Unlike other biases reported in the literature, such as the “over-adjustment” effect often elicited alongside the JTC bias (see Balzan, Delfabbro, Galletly, & Woodward, in press-c), the biases found in this study were not likely to have been caused by miscomprehension of the task’s instructions. The task was originally developed for children as young as nine,

and instructions were carefully worded so as to encourage task comprehension. Further, comprehension was checked at the end of the task. It should also be noted that biased preference for non-diagnostic tests was only observed during the negative test phase; participants with schizophrenia had no difficulty selecting the diagnostic test during the positive test phase, which suggests that they understood the purpose of the task.

Caveats of the present study include the possibility that practice effects may have masked performance during the negative test condition, which was always presented to participants after the positive test condition. As already mentioned, the non-delusion-prone group performed slightly better during the negative test suggesting the presence of a practice effect. It is therefore conceivable that the biased tendencies exhibited by the delusion prone groups may have been even stronger if the negative tests had been presented first.

Another potential weakness of the study was the exclusion of an extra negative test condition, which was included in the original Samuels and McDonald (2002) study. This condition provided participants with a negative diagnostic test and two negative non-diagnostic tests, to determine if children were incapable of using negative diagnostic tests at all. The results in this condition demonstrated that children were capable of selecting the diagnostic test when all options were negative tests. This implied that the preference for positive tests amongst negative diagnostic tests was due to a positive test bias which overrode diagnostic reasoning altogether. Given these results, and the fact that at least ten participants with schizophrenia were able to identify

three correct diagnostic choices in the negative test (Figure 1), it is implausible to conclude that the preference for positive non-diagnostic tests stems from an inability to process negative diagnostic tests. However, given the importance of the conclusion that the bias stems from a hypersalience of evidence-hypothesis matches, future replications of the study should include this extra negative test condition. Finally, the conclusion that the positive test bias stems from a hypersalience of evidence-hypothesis matches is itself based on indirect evidence.

## **Task 2**

Task 1 demonstrated that individuals with a diagnosis of schizophrenia exhibit biased hypothesis search strategies, where positive non-diagnostic tests may be preferred to negative diagnostic tests. It was concluded that this confirmation bias was driven by a hypersalience of evidence-hypothesis matches among individuals with delusions. However, the strength of this assumed hypersalience was not determined. Moreover, the confirmation bias literature reveals there are other conditions under which a positive test strategy can become a confirmation bias, including the biased interpretation and recall of confirmatory evidence. These conditions remain untested among patients with schizophrenia. They also offer a more precise assessment of the hypersalience account, as confirmatory evidence is directly rated for its importance and its ability to be recalled, both of which should be higher if evidence-hypothesis matches are indeed “hypersalient”.

## **Method**

### *Participants*

All schizophrenia, delusion-prone and non-delusion-prone participants from Task 1 also completed Task 2 (n = 75).

### *Materials and Procedure*

Two crime stories were adapted from the original story presented in the Oswald and Gadenne confirmation bias studies which examined the biased interpretation (Gadenne & Oswald, 1986) and recall (Oswald & Gadenne, 1986) of confirmatory evidence. The stories were written in the format of a screenplay rather than a narrative. One story concerned a group of four medical students preparing for an exam. During the course of the evening, one of the students has her handbag stolen, which importantly contained the answers to the upcoming exam. The other story involved four lawyers who had to work back late in order to complete the preparation of a confidential legal document due the next day. This document is saved onto a memory stick, but over the course of the story, it is also stolen by an anonymous thief. Both stories presented one of four suspects as more likely (i.e., the initial hypothesis or “lure”, analogous to the Oswald and Gadenne studies). For example, in the medical student story, one of the students was presented as selfish and suspiciously left the study group moments before the bag was discovered as missing. These two stories were randomly assigned to either a “non-exonerating” condition (always presented first) or an “exonerating” condition where participants were presented with a final piece

of information that not only exonerated the “lure” but also ultimately revealed the “true” culprit conclusively.

After reading the story, participants would rate the likelihood that each of the four suspects had committed the crime (on a five-point Likert scale ranging from “impossible” to “absolutely”), and also rated an additional fifth suspect (which unknowingly at the time was the “true” hypothesis, e.g., “the bag was taken by a stranger from the back balcony”). Following this initial rating, participants were presented with four pieces of confirmatory evidence suggesting that the “lure” was the culprit (e.g. “lure” left unexpectedly before the bag went missing) and four pieces of disconfirmatory evidence suggesting the “lure” may not have been responsible (e.g., “lure” had no time in which to take the bag). After a short distracter task (i.e., three “who am I” styled multiple-choice tasks on famous criminals), participants were asked to recall as many of the extra pieces of evidence as possible. They were then given these eight pieces of information and asked to rate how important they perceived each to be in determining whether the “lure” had committed the crime (five-point Likert scale ranging from “useless” to “vital” for each confirming/disconfirming piece of evidence). In the first “non-exonerating” condition, participants were again asked to rate how likely they thought each of the five suspects were in committing the crime.

In the “exonerating” condition, prior to the recall and importance ratings of the confirming/disconfirming evidence and subsequent final rating of

suspects, participants were given an additional piece of information which completely exonerated the “lure” (given an alibi) and instead revealed the “true” culprit of the crime (e.g., unidentified stranger broke into the apartment and took bag). This exonerating condition was created to determine if delusion-prone individuals would continue to show higher ratings of the “lure” and/or persist in the biased interpretation and recall of confirming evidence despite this final piece of strong disconfirmatory evidence. In contrast, non-delusion-prone controls were expected to respond in a less biased manner given this exonerating information, as observed in the Oswald and Gadenne studies.

Moreover, during the exonerating condition, participants were told to “read the text very carefully and pay particular attention to who said what so you can build different pictures of the people. Take your time and feel free to re-read the story.” This extra “intensive processing” instructional inclusion helped (non-delusion-prone) participants in the Oswald and Gadenne studies process the disconfirming evidence and reduced the strength of confirmation bias, and therefore served as a means to test the limits of the confirmation bias across the psychosis continuum. To ensure this “intensive processing” was not carried over to the non-exonerating condition, the exonerating condition was always presented second.



## Results

### *Non-Exonerating Condition*

Table 4 shows the mean initial and final ratings for lures and true culprits across groups. Participants with schizophrenia scored significantly higher initial ratings for the lure ( $F(2, 72) = 5.15, p < .05$ ) compared to the other groups, suggesting that they were hypersalient to the confirmatory evidence which suggested the lure was the culprit. Initial ratings for the lure were significantly correlated with PDI-21 scores ( $r = .30, p < .05$ ). While not significant, it is worth noting that the schizophrenia group maintained the highest ratings for the final rating of the lure (approached significance), suggesting they were least likely to adapt to the disconfirmatory evidence presented between ratings. All groups maintained stable ratings for the “true” culprit between initial and final ratings (Table 4), as would be expected given that this condition did not provide any extra evidence to suggest that this was the “true” culprit.

Table 5 shows mean ratings of perceived importance for confirming and disconfirming evidence, and the number of confirmatory and disconfirmatory items recalled across both experimental conditions. Both the schizophrenia and delusion-prone groups placed more importance on the confirmatory evidence compared to the non-delusion-prone group ( $F(2, 72) = 6.73, p < .05$ ), again suggesting these groups may be hypersalient to such evidence. Moreover, the schizophrenia group recalled significantly fewer disconfirming points of evidence ( $F(2, 72) = 13.44, p < .05$ ) than the other

groups. However, there were also non-significant trends that the schizophrenia and delusion-prone groups valued the disconfirmatory evidence more and recalled fewer confirming cases than the non-delusion-prone group (Table 5).

Nevertheless, within-group paired-samples *t*-tests showed that participants with schizophrenia placed significantly more importance on confirmatory evidence than disconfirmatory evidence ( $t(24) = 3.97, p < .01$ ) and recalled more confirmatory than disconfirmatory evidence ( $t(24) = 4.38, p < .01$ ). No significant differences were found for delusion-prone and non-delusion-prone groups (although the difference between the perceived importance of confirmatory and disconfirming evidence approached significance for delusion-prone participants).

### *Exonerating Condition*

Based on the Oswald and Gadenne studies, the exonerating condition included two measures designed to reduce the likelihood that participants would exhibit a confirmation bias (i.e., intensive processing of information and a final conclusive piece of evidence which exonerated the lure and strongly indicated the true culprit). As in the non-exonerating condition, the schizophrenia group demonstrated significantly higher ratings for the initial lure ( $F(2, 72) = 4.45, p < .05$ ), as seen in Table 4. Despite the strong piece of exonerating evidence (presented in addition to the disconfirmatory evidence presented in the non-exonerating condition), the schizophrenia and delusion-

prone were less likely to down-rate their ratings for the lure compared to the non-delusion-prone group ( $F(2, 72) = 6.93, p < .05$ ; confirmed by Bonferroni post-hoc tests). Initial and final ratings for the lure were significantly correlated with PDI-21 scores ( $r = .27, p < .05$ ;  $r = .38, p < .001$ , respectively). There were no significant group differences observed for final ratings of the true suspect ( $F(2, 72) = 1.27, p > .05$ ), with all groups showing a tendency to up-scale these ratings. However, analysis of the mean differences between initial and final ratings of the true suspect revealed that the schizophrenia group ( $M = .76$ ) demonstrated significantly less up-rating of the true culprit compared to the non-delusion-prone group ( $M = 1.48$ ) (confirmed Bonferroni post-hoc tests,  $p < .05$ ).

As suggested in Table 5, delusion-prone participants significantly rated the confirmatory evidence as more important compared to non-delusion-prone participants ( $F(2, 72) = 3.18, p < .05$ ; confirmed by Bonferroni post-hoc tests), and patients with schizophrenia recalled fewer disconfirming pieces of evidence compared either non-patient group ( $F(2, 72) = 11.06, p < .05$ ). However, the delusion-prone group also rated disconfirming evidence higher than the other groups (confirmed by significant Bonferroni post-hoc test). Moreover, the schizophrenia group did not rate the confirming or disconfirming information any differently than the non-delusion-prone group (Table 4), yet in addition to remembering less disconfirming evidence they also recalled less confirming evidence ( $F(2, 72) = 3.54, p < .05$ ), suggesting the extra exoneration condition may have made recall more difficult for the patient group.

As observed in the non-exonerating condition, within-group paired-samples *t*-tests showed that participants with schizophrenia again placed more importance on confirmatory evidence than disconfirmatory evidence (approached significance) and recalled more confirmatory than disconfirmatory evidence ( $t(24) = 3.78, p < .01$ ). Delusion-prone participants remembered more confirmatory than disconfirmatory evidence ( $t(24) = 3.06, p < .01$ ). No other significant differences were found for delusion-prone and non-delusion-prone groups.

**Table 4:** Mean (SD) initial and final ratings (maximum = 5) for lure and true culprits for non-exonerating and exonerating conditions across groups

	Schizophrenia	Delusion-prone	Non-delusion-prone
<b><i>Non-Exonerating</i></b>	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
Initial Lure Rating	4.32 (0.63) <sup>#</sup>	3.76 (0.83)	3.76 (0.66)
Initial True Rating	2.92 (1.12)	2.68 (0.99)	2.68 (1.03)
Final Lure Rating	4.04 (0.79)	3.72 (0.94)	3.56 (0.92)
Final True Rating	2.72 (1.10)	2.76 (0.93)	2.44 (1.00)
<b><i>Exonerating</i></b>	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
Initial Lure Rating	4.28 (0.61) <sup>#</sup>	3.80 (0.65)	3.80 (0.71)
Initial True Rating	2.84 (0.96)	2.80 (0.96)	2.44 (0.96)
Final Lure Rating	3.60 (1.00)	3.32 (0.80)	2.72 (0.74)*
Final True Rating	3.60 (0.91)	3.76 (0.60)	3.92 (0.57)

\* $p < .05$ , between non-delusion-prone and schizophrenia/delusion-prone groups

<sup>#</sup> $p < .05$ , between schizophrenia and non-clinical groups

**Table 5:** Mean (SD) ratings for importance of confirming (CE) and disconfirming (DE) evidence (maximum = 20) and number of confirmatory (CE) and disconfirmatory (DE) items recalled (maximum = 4) for non-exonerating and exonerating conditions across groups

	Schizophrenia	Delusion-prone	Non-delusion-prone
<b>Non-Exonerating</b>	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
Importance of CE	<b>15.76 (2.54)</b>	15.76 (2.73)	13.16 (3.35)*
Importance of DE	12.92 (3.13)	13.60 (4.09)	11.60 (3.86)
Recall of CE	<b>1.92 (1.15)</b>	1.92 (1.08)	2.40 (0.96)
Recall of DE	1.12 (1.09) <sup>#</sup>	2.24 (1.23)	2.68 (0.95)
<b>Exonerating</b>	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
Importance of CE	<b>14.36 (3.87)</b>	15.44 (3.34) <sup>^</sup>	12.96 (3.21)
Importance of DE	12.96 (3.21)	14.24 (2.40) <sup>^</sup>	12.24 (3.88)
Recall of CE	<b>1.72 (1.36)<sup>#</sup></b>	<b>2.48 (1.12)</b>	2.56 (1.19)
Recall of DE	0.72 (1.14) <sup>#</sup>	1.64 (1.25)	2.24 (1.05)

\* $p < .05$ , between non-delusion-prone and schizophrenia/delusion-prone groups

<sup>#</sup>  $p < .05$ , between schizophrenia and non-clinical groups

<sup>^</sup>  $p < .05$ , between delusion-prone and non-delusion-prone groups

Scores in **bold** indicate significant within-group comparisons for Importance of CE vs. DE and Recall of CE vs. DE ( $p < .05$ )

## Discussion

Task 2 yielded further evidence that participants higher on delusional ideation are susceptible to a hypersalience of evidence-hypothesis matches. Both the non-exonerating and exonerating conditions suggested that the delusional groups rated “lure suspects” as the most likely culprits to the crime. This hypersalience to the initial lure was so strong that it persisted after viewing disconfirming evidence, and even after evidence which completely exonerated the lure and instead implicated the true culprit in no uncertain terms. Although the final ratings for the lure did not reach significance during the non-exonerating condition, it is suggested that this was because the disconfirmatory evidence presented in this condition was not *strong enough* to distinguish between delusional and non-delusional groups. Indeed, it was expected that all groups would rate lures highly even after the presentation of some disconfirmatory evidence due to the prevalence of the confirmation bias within the general population. However, the exoneration condition was designed to test the limits of biased behaviour between groups, as it had been shown to lead to non-biased ratings within the general population (Gadenne & Oswald, 1986; Oswald & Gadenne, 1986); a finding replicated here. Nonetheless, schizophrenia and delusion-prone groups maintained unreasonably high ratings for the lure even after this strong piece of disconfirmatory exonerating evidence. It is not being suggested that schizophrenia and delusion-prone groups are incapable of down-rating the lure and up-rating the true culprit given disconfirming evidence, as this did occur (see Table 4). However, it is suggested that they are less able to integrate this evidence to modify their initial beliefs compared to non-delusion-

prone individuals due to the hypersalience of the initial confirmatory evidence. These findings have been well replicated in the “BADE” tasks (e.g., Buchy, et al., 2007; Moritz & Woodward, 2006; Woodward, et al., 2006b)

Task 2 aimed to provide more conclusive evidence that these “BADE” effects were driven by a hypersalience of evidence-hypothesis matches by assessing the interpretation and recall of confirmatory evidence. Both conditions yielded mixed results for these variables when analysed for between groups effects. Both delusional groups were found to rate confirming evidence as more important and tended to recall fewer disconfirming pieces of evidence compared to non-delusion-prone participants. However, the delusion-prone group also placed more importance on disconfirming evidence compared to non-delusion-prone participants, which perhaps reflected a tendency to rate *all* evidence as important regardless of its nature. Delusional groups also tended to remember less confirming evidence compared to the non-delusion-prone group. As seen in Table 1, the schizophrenia group experienced a slight memory deficit compared to non-patient groups, and the nature of the task, with long periods between seeing the evidence and having to recall it, may have contributed to these effects. Notwithstanding these mixed between-group results, within-group comparisons of confirmatory and disconfirmatory evidence were more successful in demonstrating biased interpretation and recall of evidence-hypothesis matches, particularly among the schizophrenia group. This analysis removes any memory confounds or global tendencies to rate all evidence highly, inherent in the between-groups analysis.

In sum, Task 2 was successful in demonstrating that participants with schizophrenia and those identified as delusion-prone are more susceptible to a “confirmation bias” style of responding, which is most likely driven by a hypersalience of evidence-hypothesis matches.

## **General Discussion**

The aim of the current paper was to generate further support for the “hypersalience of evidence-hypothesis matches” account of delusion formation and maintenance by using tasks developed to test the confirmation bias within the general population. Using tasks initially developed for the general population serve not only as a benchmark by which to test bias susceptibility across the entire “psychosis continuum”, but the tasks have often been optimised for elucidation of a particular bias, which reduces the risk of introducing confounds such as miscomprehension. The confirmation bias, or the process by which a hypothesis becomes immunised against falsification, occurs when confirmatory information is searched for, interpreted or recalled in a biased manner. These three processes represented the ideal platform to test the hypersalience account. Task 1 observed biased search strategies across the psychosis continuum, and found that patients with schizophrenia (and to a lesser degree, delusion-prone participants) will favour non-diagnostic positive test strategies over negative diagnostic tests. It was assumed that this non-optimal strategy stemmed from the hypersalience of confirming evidence inherent in the positive tests, even when these tests were not as useful as their negative diagnostic alternatives. Task 2 intended to test hypersalience more directly by assessing if confirmatory evidence was



interpreted and recalled better by delusional groups. While results of the group comparison were mixed, within-group analysis showed that confirming evidence was rated as more important and was recalled better than disconfirming evidence. Moreover, the study supported findings from the recent “BADE” literature, where participants with delusions and who are prone to delusions exhibit a failure to integrate disconfirmatory evidence and thereby resist adjusting (or down-rating) their beliefs accordingly. This was most apparent when the nature of disconfirmatory evidence was particularly strong and participants were encouraged to process the evidence “intensely”, prompting non-delusion-prone participants to modify their initial beliefs accordingly.

The results of these experiments have implications for the cognitive bias literature. First, they offer direct support for the hypersalience of evidence-hypothesis matches. This account of delusion formation and maintenance is particularly important, as it serves as an underlying cognitive mechanism unifying several established cognitive biases within the literature, including the jumping to conclusions bias (or “premature decisions”) and the bias against disconfirmatory evidence (BADE).

Second, the results confirm the prevalence of an intensified confirmation bias among delusional participants, itself the result of a hypersalience of evidence-hypothesis matches. While other cognitive biases associated with delusions, such as jumping to conclusions, cannot account for the maintenance of a delusional belief once it has been accepted (Fine, et al., 2007), a confirmation bias represents a means by which a hypothesis (or

delusional belief) becomes immunised against disconfirmatory evidence, and is thereby maintained despite such evidence. Moreover, as the bias was more prevalent in individuals identified as delusion-prone compared to non-delusion-prone participants, it can be assumed that it may also play a role in delusion formation or serve as precipitating factor in the development of a delusion from a benign idiosyncratic belief.

There were some inconsistencies in the findings including the mixed results regarding biased interpretation and recall of confirming evidence between groups. The delusion-prone group exhibited the highest ratings for confirmatory evidence, despite the schizophrenia group demonstrating higher delusional beliefs. Moreover, patients with schizophrenia exhibited comparative deficits in recall regardless of the nature of the evidence. These results may have been driven by the crime story task itself. While designed to reduce the possibility of miscomprehension by explaining the objectives of the task in detail, the task itself was lengthy (e.g. the initial crime story consisted of three pages of dialogue between the suspects). Future replications of the task may reduce the amount of content given to participants.

Other inconsistencies included the fact that the delusion-prone participants were not always significantly distinct from the non-delusion-prone group, although they often showed biased tendencies similar to the schizophrenia group. Other studies employing such a sample have yielded higher delusional ideation scores than those reported in the present paper (e.g., Warman, et al., 2007). It is conceivable then that a delusion-prone group higher in delusional-ideation may generate stronger results than the

sample used here. Similarly, the schizophrenia group consisted of individuals with “minimal” to “mild” active delusions (i.e., PANSS-Delusions,  $M = 2.08$ ) and individuals with remitted delusions. Studies have shown participants with “severe” active delusions may be more susceptible to cognitive biases than individuals with less severe delusions (Speechley, et al., 2010). Replications of this study should therefore distinguish between participants with active severe delusions and participants with remitted or mild delusions.

Practice effects were also a concern for both tasks. Although care was taken to randomise stimuli across conditions, the negative-test (Task 1) and exonerating (Task 2) conditions were always presented in the second phase of each task, and this was when biased behaviour was particularly prominent. Thus it is conceivable that if these conditions had been presented first the biases observed may have even been stronger. That is, prior exposure to the tasks may have mediated the effects observed. This should be taken into consideration in replications of either task.

Despite these inconsistencies and methodological limitations, the present paper was successful in demonstrating an elevated confirmation bias in delusional groups. Patients with schizophrenia, and to a lesser degree, those identified as delusion-prone were more likely to select positive tests over diagnostic tests, place more importance on and recall confirmatory evidence better than disconfirmatory evidence, and demonstrated a resistance to adjust initial hypotheses in the face of disconfirmatory evidence. The results suggest that the hypersalience of evidence-hypothesis matches

represents an underlying cognitive mechanism responsible for delusion formation and maintenance.

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## **CHAPTER 6: Paper 4**

### **Reasoning heuristics across the psychosis continuum:**

#### **The contribution of hypersalient evidence-hypothesis matches**

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##### **Ryan Balzan (Candidate)**

I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

Date: 20/04/2012

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We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We also provided advice on responding to comments by the journal reviewers and editor. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

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Date: 20/04/2012

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## Abstract

Hypersalience of evidence-hypothesis matches has recently been proposed as the cognitive mechanism responsible for the cognitive biases which, in turn, may contribute to the formation and maintenance of delusions. However, the construct lacks empirical support. The current paper investigates the possibility that individuals with delusions are hypersalient to evidence-hypothesis matches using a series of cognitive tasks designed to elicit the representativeness and availability reasoning heuristics. It was hypothesised that hypersalience of evidence-hypothesis matches may increase a person's propensity to rely on judgements of representativeness (i.e., when the probability of an outcome is based on its *similarity* with its parent population) and availability (i.e., estimates of frequency based on the ease with which relevant events come to mind). A total of 75 participants (25 diagnosed with schizophrenia with a history of delusions; 25 non-clinical delusion-prone; 25 non-delusion-prone controls) completed four heuristics tasks based on the original Tversky and Kahneman experiments. These included two representativeness tasks ("coin-toss" random sequence task; "lawyer-engineer" base-rates task) and two availability tasks ("famous-names" and "letter-frequency" tasks). The results across these four heuristics tasks showed that participants with schizophrenia were more susceptible than non-clinical groups to both the representativeness and availability reasoning heuristics. These results suggest that delusional ideation is linked to a hypersalience of evidence-hypothesis matches. The theoretical implications of this cognitive mechanism on the formation and maintenance of delusions are discussed.

Delusions are phenomena that reflect cognitive processes (Miller & Karoni, 1996), so to understand fully how they originate and why they persevere despite evidence to the contrary, one needs to recognise the cognitive processes that may facilitate their formation and maintenance. Several cognitive reasoning processes, or “biases”, which might contribute to delusion onset and preservation, have been identified over the years in individuals with delusions and those identified as “delusion-prone”. These include a jumping to conclusions (JTC) bias where decisions are made on limited evidence (see Fine, et al., 2007 for a systematic review), and a bias against disconfirmatory evidence (BADE), where evidence that contradicts a hypothesis is ignored (Woodward, et al., 2006b). Recent research has suggested that a *hypersalience of positive matches* between a hypothesis and the available evidence (Speechley, et al., 2010) may represent the underlying cognitive mechanism responsible for these biases and, in turn, delusional onset and maintenance. For example, hypersalient evidence-hypothesis matches can lead to an early cessation of data-gathering and encourage hasty decisions based on limited evidence (i.e., JTC), and can also strengthen otherwise weak evidence-hypothesis connections, making them more resistant to counter-evidence (i.e., BADE).

The “hypersalience of evidence-hypothesis matches” is an extension of the theoretical mechanism proposed by Kapur (2003), whereby delusions in schizophrenia are thought to arise from aberrant assignment of salience to external objects and internal representations due to dysregulated dopamine transmission in the ventral striatal dopamine pathway. Although empirical



support that individuals with delusions are hypersalient towards evidence-hypothesis matches still remains limited, there is now an emerging line of research that has begun to investigate the phenomenon by drawing upon established tasks used more widely in the cognitive literature. For example, the confirmation bias, which promotes the immunity of a hypothesis to counter-evidence or falsification, is well suited to studying the validity of the hypersalience mechanism. This bias occurs when people preference positive confirmatory hypothesis tests over more useful diagnostic tests, interpret hypothesis-consistent evidence as more important than hypothesis-incongruent evidence, or recall this confirmatory evidence easier than any disconfirmatory evidence (Oswald & Grosjean, 2004). If individuals with delusions are hypersalient to evidence-hypothesis matches, they should demonstrate a higher propensity to these forms of the confirmation bias. This hypothesis has recently been confirmed in a study which found that patients diagnosed with schizophrenia (high delusional ideation) and delusion-prone participants preferred positive hypothesis tests to negative diagnostic tests, and exhibited biased recall and interpretation of confirming evidence compared to non-delusion-prone controls (Balzan, Delfabbro, Galletly, & Woodward, in press-b).

In line with this research, the current paper intends to examine another group of cognitive biases which may lend support to the hypersalience mechanism; namely, the “representativeness” and “availability” reasoning heuristics (or “rules of thumb”) first proposed by Tversky and Kahneman (1972, 1973, 1974).

Representativeness is defined as a procedure for estimating probabilities by means of similarity or typicality judgements (Tversky & Kahneman, 1974). For example, consider observing a person on the street who appears to be talking to themselves; this person is alone, but smiling and gesturing, which leads you to conclude that this person is mentally unstable or drunk. Consider also taking part in a raffle with tickets numbered 1 to 100. You are offered ticket No. 1, to which you refuse. You are subsequently offered No. 63, which you accept, feeling this is more *representative* of a random number and more likely to be drawn. The representativeness heuristic is employed in both of these examples where the probability of a hypothesis (i.e., person unstable/drunk) is based on its *match* with a set of observations or where the probability of an outcome (i.e., winning ticket) is based on its *similarity* with its parent population (Teigen, 2004). Judgements by representativeness are easy, requiring minimal cognitive resources, and are often correct. However, like all heuristics, they are prone to error; the “mentally unstable” person may simply have been talking on a hands-free mobile phone, and ticket No. 1 is as equally likely to be drawn as No. 63. The representativeness heuristic therefore represents an important means by which to test the hypersalience mechanism among groups differing in delusional ideation. Individuals with delusions may be particularly susceptible to judgements by representativeness due to a hypersalience of evidence (e.g., person smiling and gesturing) – hypothesis (e.g., person unstable/drunk) matches. The established battery of tasks designed to elucidate the heuristic are especially well suited to testing the validity of the hypersalience mechanism because they present participants with particularly

strong confirmatory evidence (i.e., strong evidence-hypothesis matches), which may further distinguish delusional from non-delusional styles of responding.

The availability heuristic is defined as the ease with which the probability of events come to mind when assessing the frequency of such events (Tversky & Kahneman, 1973). Like the representativeness heuristic, the availability heuristic simplifies the amount of cognitive processing required to make a decision, but can often lead to errors. For example, if a married couple were asked to estimate the percentage of their own contribution to the housework, it is likely that each spouse will overestimate their own contribution, so that the sum exceeds one hundred percent (Reber, 2004). This example demonstrates how the availability heuristic can bias judgements of frequency. Each spouse retrieves information that is relevant to the question at hand (e.g., preparing meals, cleaning the house), yet this retrieval is biased as they are more adept at retrieving instances of their own housework than instances of their spouse's work. The information about their own contribution is more available than information about their spouse's contribution. One of the processes responsible for the availability heuristic is the vividness of information available to the individual at the time a judgement is made. The husband may recall in some detail how he prepared an intricate dinner one night; he may also recall his wife cooked a similar dinner on another occasion, but the memories of his own preparations are more vivid which make them easier to access when required (Reber, 2004). Consequently, if evidence-hypothesis matches are hypersalient (and likely

more vivid), and easier to recall among individuals with delusional ideations (Balzan, et al., in press-b), then it can be expected that these individuals would also become more prone to the availability heuristic when assessing the frequency of “evidence-hypothesis” matches, compared to healthy controls.

It is worth noting a small number of studies that have observed the representativeness and availability heuristics within individuals experiencing delusions. One such study found that patients with schizophrenia (with active persecutory delusions) were more susceptible to these heuristics compared to patients with remitted delusions, depressed and healthy controls (Corcoran, et al., 2006). However, it was noted that these effects were observed only for delusion-specific threatening stimuli; no differences were observed between groups for non-delusion-specific stimuli. Moreover, the tasks employed by the study did not resemble the traditional representativeness and availability tasks established by Tversky and Kahneman. It would therefore be beneficial to replicate the Corcoran et al. (2006) study using the original Tversky and Kahneman tasks, as the use of well established tasks reduces the risk of introducing confounds into the experiment, such as delusion-specific stimuli or tasks that may be miscomprehended (for a discussion on the confounding nature of miscomprehension see Balzan, et al., in press-a; Balzan, et al., in press-c).

Other studies have offered mixed support for an increased susceptibility to the representativeness and availability heuristics among individuals with delusions. For example, Kemp, Chua, and David (1997)

reported that patients with delusions were slightly less susceptible to a representativeness heuristic than healthy controls. However, these results were non-significant and only represented categorical trends in the data. Furthermore, the task employed in this paper was designed to test the conjunction fallacy (i.e., when specific conditions are assumed to be more probable than a general condition, Pohl, 2004), rather than the representativeness heuristic per se. More recently, Menon (2005) showed that patients with schizophrenia and active delusions were less susceptible to the availability heuristic compared to controls or non-delusional patients. However, it was concluded that this finding may have been caused by less familiarity of the “available” stimuli within the delusional group compared to the other groups.

The current paper attempted to investigate the representativeness and availability heuristics across the psychosis continuum using delusion-neutral stimuli. The four tasks selected remained close to the original tasks developed by Tversky and Kahneman (1973, 1974), consisting of two representativeness tasks including the random sequence “coin-toss” task and the “lawyer-engineer” base-rate problem; and two availability tasks including the famous-names and letter-frequency tasks (see Method section for full description of each task). Across these experiments, it was hypothesised that patients with delusions and delusion-prone participants would demonstrate a stronger tendency to employ these reasoning heuristics due to an underlying hypersalience of evidence-hypothesis matches.

## **Methods**

### ***Participants***

A sample of 75 participants were recruited consisting of 25 clinical participants (15 males and 10 females; 23 outpatients and 2 inpatients) with a diagnosis of schizophrenia and a history of delusions, and 50 non-clinical participants (23 males; 27 females). The diagnosis of schizophrenia was confirmed with the Mini-International Neuropsychiatric Interview (MINI), and the Positive and Negative Symptoms Scale (PANSS; Kay, et al., 1987) was employed to determine the severity of current positive symptoms. Both of these instruments were administered by a trained and experienced research nurse. Clinical participants were also administered the PDI-21 (Peters, et al., 2004), which assesses delusional conviction, preoccupation, and distress, combining to give a global delusional score. All clinical participants were treated with atypical antipsychotic medications at the time of testing.

Non-clinical participants were drawn from the general population and hospital staff via advertisement and word-of-mouth. These participants were screened with the MINI to rule out brain damage and mental illness as confounding factors. To distinguish between delusion-prone and non-delusion groups, non-clinical participants also completed the PD-21. Individuals who fell above the median non-clinical PDI score (29.5) were identified as delusion-prone and non-delusion-prone if they fell below the median.

All participants were fluent in English and were able to complete all four tasks. Working memory was assessed with the Wechsler Adult

Intelligence Scale-Revised Digits Forward and Backward subtests (Wechsler, 1997), and pre-morbid intelligence estimates were made with the NART (Nelson & Willison, 1991). Socio-economic status was estimated using the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957) using highest parental occupation and education level. Scores for these measures and all other demographic information for each group is summarised in Table 1. As indicated in Table 1, the three samples were generally well matched in relation to their age, educational attainment and scores on standardised measures of cognitive and intellectual functioning.

**Table 1:** Socio-demographic and psychopathological characteristics of participants (mean; SD)

	Schizophrenia <i>n</i> = 25	Delusion-prone <i>n</i> = 25	Non-delusion-prone <i>n</i> = 25
Age	39.96 (10.04)	43.68 (15.93)	41.92 (14.98)
Gender – M:F	15:10	9:16	14:11
Education (no. years)	11.20 (1.41)	11.16 (0.99)	11.72 (1.43)
Index of Social Position <sup>1</sup>	51.96 (10.93)	52.52 (7.87)	48.48 (8.47)
IQ Estimate(NART)	108.27 (5.90)	108.01 (6.08)	111.31 (4.07)
Memory (total)	17.00 (2.92)*	18.36 (3.93)	20.44 (3.65)
PDI-21 (total, median)	82.00	60.00	13.00
PANSS (P1-P7 total)	11.08 (3.12)	N/A	N/A
PANSS-Delusions	2.08 (1.04)	N/A	N/A
Length of illness (years)	14.22 (8.51)	N/A	N/A

<sup>1</sup>Higher scores indicate lower social-economic status

\**p* < .05, between schizophrenia and non-delusion-prone group

### ***Materials and Procedure***

All participants completed the following tasks in a randomised order:

a) *“Coin-toss” Random Sequence Representativeness Task*

Participants were instructed to “imagine a person tossing a fair coin six times in a row. In every toss, the outcome will either be a head (H) or a tail (T).” They were then asked which of the following series of six coin tosses they thought was the most likely:

a) H T T H T H

b) H H H T T T

c) H H H H H H

d) All sequences are equally likely

Previous research has suggested that participants given this task exhibit a tendency to select the first option (i.e., H-T-T-H-T-H) as it appears to be the most “random” despite the true answer that all rows are equally likely (Tversky & Kahneman, 1974). The final true option was presented to participants so that they would not feel forced into making a wrong decision for sake of it being an option, as per recent replications of the task (e.g., Smith, 1998). To gauge the reason why a particular choice was made, all participants were asked why they had selected their option. This would determine whether “biased” choices were due to the representativeness heuristic, as indicated by a response such as “looks the most random”, or whether participants had simply guessed a particular response.



*b) Base-rates Representativeness Task*

This task was a modified version of the famous Kahneman and Tversky (1973) “lawyer-engineer” task. Participants were given short stories similar to the following:

Mary has just finished her final year at high school with excellent grades. She wishes to go on to university, and has been admitted to her two top choices: Alderaan University and Dagobah University. Both are equal in prestige and in distance from Mary's home. Mary visited both universities. She did not like what she saw at Alderaan University. The other students and teaching staff seemed unpleasant and abrupt. She much preferred Dagobah University, where everyone she met seemed nice and enthusiastic. She came away with a pleasant feeling about the campus.

After reading the story, participants had to rate the likelihood that Mary would attend Alderaan University (10-point Likert-scale ranging from “very unlikely” to “very likely”) and the likelihood that she would attend Dagobah University (same scale). They were then presented with base-rate information such as:

Mary has friends at both universities and asks for their advice. Her friends at Alderaan University report that they like the place very much and that they find it very stimulating. Mary's friends at Dagobah University report that they have many complaints on personal, social and educational grounds.

Participants were then given the opportunity to rate the likelihood of each party again. In this way, the initial representative evidence (“lure”) would influence judgements at the first rating; in this example, it would seem more likely that Mary would prefer Dagobah University to Alderaan University. Base-rate evidence was always discordant with the information provided in the initial story (e.g., friends complain about Dagobah University), thereby indicating the final “true” interpretation (e.g., Alderaan University was the better choice). The base-rate information was always presented after the initial description rather than embedded into it. This is in line with studies that have shown that such base-rate information is more carefully attended to if presented separately (Krosnick, Li, & Lehman, 1990). It was expected this would further elucidate differences in responding between the participant groups, whereby non-delusion-prone participants would be more perceptive of the base-rate evidence rather than the representative “lure” evidence. Schizophrenia and delusion-prone groups were expected to show less down-rating on the representative “lure” after discordant base-rate evidence, and also demonstrate less up-rating of the “true” interpretation.

*c) Famous-Names Availability Task*

Based on Tversky and Kahneman’s (1973) experiment to show that estimates of frequency of occurrence depend on availability, participants were presented with a randomised sequence of 39 names (at a rate of three seconds per name). Two stimuli lists were used. One list consisted of 19 famous actor names (e.g., Harrison Ford, Tom Cruise) and 20 less famous actress names (e.g., Claudia Black, Karen Allen); the other list reversed

gender (i.e., 19 famous actresses and 20 less famous actors). A pilot study with 40 undergraduate university students determined that over 90% of famous names were known (not merely recognised) and less than 15% of non-famous names were known, regardless of gender. Stimuli lists were randomised across participants in the present study.

After presentation of the famous/non-famous list of names, participants were asked to judge whether there were more male names (press “m”) or more female names (press “f”) in the list they just saw (order of gender was randomised for this question). Following this, they were asked to quantify the percentage of male names and the percentage of female names. In line with previous studies, it was expected that famousness, regardless of gender, would bias judgements of frequency such that famous-names would be perceived as more frequent than non-famous-names, despite a higher frequency of non-famous-names. Schizophrenia and delusion-prone groups were expected to demonstrate greater susceptibility to this availability heuristic due to a hypersalience of evidence-hypothesis matches. For example, if testing the hypothesis that “male names are more frequent than female names” in the famous-male names list, evidence for “higher frequency of males” would be more available to all participants due to the famousness of these names, but would be even stronger for delusional groups if such confirmatory evidence (“more males”) is hypersalient. As with the pilot study, all participants were asked to rate whether they knew (not recognised) each of the actors/actresses names after they had made their frequency judgements.

d) *Letter Frequency Availability Task*

This task was similar to the famous-names task described above. Participants were given the following instructions based on those used by Tversky and Kahneman (1973, Experiment 3):

There has been some recent research looking at the order of letters within words. The researchers studied all the letters of the alphabet and determined whether they were more likely to appear in the *first* position of all words in the English language or the *third* position of all words in the English language. Your task is to try and guess their results. You will be given five letters of the alphabet. For each letter, you will be asked to judge whether you think this letter is more likely to occur in the *first* position of all English words (press “1”) or is more likely to occur in the third position of all English words (press “3”).

The five letters presented to participants included K, L, N, R, and V, all of which occur more frequently in the third position than the first position. However, as it is easier to retrieve letters in their first position rather than letters in the third position, previous studies have found that most participants will judge the first position to be more likely. For each letter, participants were also asked to provide a percentage of all words that have that letter in the first position and the percentage of words that have the letter in the third position. This was used to determine the strength of the availability heuristic at work. As with the famous-names experiment, it was expected that all participants would demonstrate the availability heuristic (i.e., judge first position as more likely than third position), but that schizophrenia and delusion-prone groups

would be particularly susceptible to the bias due to a hypersalience of evidence-hypothesis matches.

## Results

### *“Coin-toss” Random Sequence Representativeness Task*

Table 2 reveals the proportion of errors and correct responses across groups for judgements of the “most likely” coin-toss sequence. Any response other than “all sequences are equally likely” was considered an error (i.e., “H-T-T-H-T-H” and “H-H-H-T-T-T”; the third error response “H-H-H-H-H-H” was not selected by any participant). The majority of errors were made on the alternating “H-T-T-H-T-H” sequence of coin tosses (Table 2), which would appear to be the most representative of a random sequence. The schizophrenia and delusion-prone groups were significantly more likely to make errors compared to the non-delusion-prone group ( $\chi^2(4, N = 75) = 11.23, p < .05$ ). Only the non-delusion-prone group selected more correct than incorrect responses. Although four patients with schizophrenia made the correct choice, two of these patients stated their choice was based on a guess rather than the laws of probability. All other participants gave sensible reasons for selecting the correct response. Incorrect responses were not significantly correlated with estimated IQ scores (Spearman’s  $\rho = .08, p > .05$ ). Moreover, there were no significant differences in IQ scores for correct ( $M = 109.87; SD = 4.13$ ) and incorrect ( $M = 108.77; SD = 6.31$ ) responses ( $t(73) = .83, p > .05$ ).

**Table 2:** Number of incorrect and correct responses (%) by group for “coin-toss” random sequence representativeness task

	<i>N</i>	Incorrect Response		Correct Response
		“H-T-T-H-T-H”	“H-H-H-T-T-T”	“All Equally Likely”
Schizophrenia	25	19 (76%)*	2 (8%)	4 (16%)
Delusion-prone	25	12 (48%)	3 (12%)	10 (40%)
Non-delusion-prone	25	9 (36%)	1 (4%)	15 (60%)

\* $p < .05$ , between schizophrenia and non-clinical groups

### *Base-rates Representativeness Task*

The ratings of “lures” and “true interpretations” before and after the discordant base-rate information are presented in Table 3 below. Ratings across the four stories were combined for analysis. Overall, there were no differences between groups on pre-base-rate ratings, as all participants rated the “lures” as likely and “true” interpretations as unlikely. Although this would suggest that individuals with delusions are not hypersalient to evidence-hypothesis matches, it proposed these findings are rather a reflection of a ceiling effect due to the strong confirmatory nature of the “lure” stimuli (discussed in more detail below). Following the base-rate information, significant differences were observed between groups, whereby patients with schizophrenia rated “lures” significantly higher ( $F(2, 72) = 6.38, p < .05$ ) and “true” interpretations significantly lower ( $F(2, 72) = 11.36, p < .001$ ) than delusion-prone and non-delusion-prone participants (confirmed by Bonferroni post-hoc tests). Moreover, the schizophrenia group exhibited significantly less down-rating of the “lures” ( $F(2, 72) = 9.91, p < .001$ ) and also less up-rating of

the “true” interpretations ( $F(2, 72) = 7.81, p < .01$ ) following the discordant base-rate information. A significant positive correlation was observed for post-base-rate “lures” and PDI-21 scores ( $r = .26, p < .05$ ) and significant negative correlations were found for PDI-21 and post-rate “true interpretations” ( $r = -.29, p < .05$ ), down-rating of “lures” ( $r = -.26, p < .05$ ) and up-rating of “true interpretations” ( $r = -.18, p < .05$ ). Following presentation of base-rate information the delusion-prone group also demonstrated higher ratings of the “lures” (and less down-rating), and lower ratings of the “true” interpretations (and less up-rating) compared to the non-delusion-prone group (Table 3). However, these trends were non-significant.

**Table 3:** Mean (SD) pre- and post-base-rate (BR) ratings (maximum = 10) for “lures” and “true interpretations” across groups (averaged across the four stories)

	Schizophrenia	Delusion-prone	Non-delusion-prone
	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
Pre-BR Lure Rating	7.37 (1.03)	7.36 (1.30)	7.73 (1.09)
Pre-BR True Rating	2.28 (0.97)	2.73 (1.23)	2.43 (1.05)
Post-BR Lure Rating	6.17 (1.20)*	5.05 (1.44)	4.89 (1.46)
Post-BR True Rating	3.86 (1.18) <sup>#</sup>	5.26 (1.27)	5.39 (1.35)
Lure Pre-Post-BR Difference	1.20 (1.01) <sup>#</sup>	2.29 (1.42)	2.84 (1.49)
True Post-pre-BR Difference	1.57 (1.06)*	2.57 (1.31)	2.96 (1.48)

\* $p < .05$ , between schizophrenia and non-clinical groups

<sup>#</sup> $p < .001$ , between schizophrenia and non-clinical groups

### *Famous-Names Availability Task*

All groups were more likely to report that the famous gender was more frequent than the non-famous gender (schizophrenia: 92%; delusion-prone:

88%; non-delusion-prone: 84%), despite a higher overall frequency of non-famous names (>51%). When asked to estimate the percentage of famous-names to non-famous-names in the list just viewed, the schizophrenia and delusion-prone groups reported higher estimates (64.88% and 60.64%, respectively) than the non-delusion-prone group (57.68%). Although a one-way ANOVA on these group differences only approached significance ( $F(2, 72) = 3.07, p = .052$ ), Bonferroni post-hoc tests confirmed a significant difference between schizophrenia and non-delusion-prone groups ( $p < .05$ ). No significant differences were found between groups in the ability to recognise famous-names names (schizophrenia: 84%; non-clinical: 90%) or non-famous-names (schizophrenia: 14%; non-clinical: 15%), thereby validating the famousness construct.

#### *Letter Frequency Availability Task*

The schizophrenia group were more likely to report that letters K, L, N, R and V appear more frequently in the first position of all English words than in the third position of all English words ( $\chi^2(2, N = 375) = 12.56, p < .01$ ), despite the reality that all of these letters appear more frequently in the third position of words (see Table 4). The schizophrenia group also provided significantly higher ratio estimates for “first-position” words ( $F(2, 72) = 7.83, p < .01$ ) and significantly lower estimates for “third-position” words ( $F(2, 72) = 7.79, p < .01$ ); confirmed by Bonferroni post-hoc tests. A significant positive correlation was observed for the estimated proportion of first-position words and PDI-21 scores ( $r = .24, p < .05$ ). Non-clinical groups still displayed the availability heuristic, in that their estimates favoured the first-position



response choices, but these responses were more conservative compared to the patient group (Table 4).

**Table 4:** Frequency counts (%) of first-position and third-position choices across letters K, L, N, R, V (total observations = 125 per group) and mean (SD) first- and third-position ratio estimates by group

	Schizophrenia	Delusion-prone	Non-delusion-prone
	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 25
First-position choice	89 (71.2%) <sup>^</sup>	63 (50.4%)	68 (54.4%)
Third- position choice	36 (28.8%) <sup>^</sup>	62 (49.6%)	57 (45.6%)
First- position ratio estimate	61.86 (9.28) <sup>^</sup>	51.27 (12.02)	52.00 (10.23)
Third- position ratio estimate	38.06 (9.30) <sup>^</sup>	49.05 (12.05)	47.57 (10.54)

<sup>^</sup>*p* < .01, between schizophrenia and non-clinical groups

## Discussion

The aim of the current paper was to generate further support for the “hypersalience of evidence-hypothesis matches” account of delusion formation and maintenance by using tasks developed to test the representativeness and availability heuristics within the general population. Patients with schizophrenia demonstrated significantly greater susceptibility to these reasoning heuristics compared to non-clinical participants, which suggests the presence of an underlying “hypersalience” mechanism among individuals with active delusions. This mechanism may amplify the intuitive, spontaneous and automatic “heuristic” reasoning over a more deliberate, analytic and reflective reasoning style.

## ***Representativeness***

The representativeness heuristic is a procedure for estimating probabilities where the probability of an outcome is based on its *similarity* with its parent population (e.g. as tested by the coin-toss task) or where the probability of a hypothesis is based on its *match* with a set of observations (as in the base-rates task). During the “coin-toss” task patients with schizophrenia and delusion-prone participants were more likely than non-delusion-prone participants to select the most “typically random” sequence (i.e., H-T-T-H-T-H). The lay hypothetical account of a “prototypical” random sequence is that it should be balanced with equal numbers of events (which could explain why the “H-H-H-H-H-H” option was never selected) and should look orderly (e.g., “H-H-H-T-T-T” is too “structured”) (Teigen, 2004). It is proposed that the heightened propensity to rely on the representativeness heuristic by the schizophrenia and delusion-prone groups is caused by a hypersalience of “evidence” (i.e., H-T-T-H-T-H) and “hypothesis” (i.e., prototypical random sequence) matches among these participants. In contrast, the majority of the non-delusion-prone group (60%) were seemingly less reliant on the representativeness heuristic, and correctly identified that “all sequences were equally likely” (i.e., less salient to evidence-hypothesis matches). Estimated IQ scores were not associated with response choices.

During the first stage of the base-rate task, all participants responded strongly to the representative evidence-hypothesis matching “lures” prior to presentation of the base-rates. Although it was hypothesised that the schizophrenia and delusion-prone groups would be particularly influenced by

the “lures”, this prediction was not borne out by the findings. The evidence implicating the “lures” in this task was much stronger than those used in similar “lure tasks” given to patients with schizophrenia (c.f., Balzan, et al., in press-b). This may have led to a ceiling effect for the initial “lure” ratings in the current task. Therefore, increasing the confirmatory nature of the evidence, so that the “lures” were more representative of the evidence, worked against distinguishing delusional from non-delusional groups. This also suggests that patients were not necessarily more susceptible to a “confirmation bias” during this task. Moreover, previous studies that have shown a hypersalience of evidence-hypothesis matches among delusional patients using “lure” tasks (i.e., Balzan, et al., in press-b) presented evidence to participants gradually and allowed participants to self-select their own focal hypothesis. Evidence that is accumulated gradually and self-selected focal hypotheses (over externally-selected ones) have been found to lead to greater hypothesis acceptance (Whitman & Woodward, in press, submitted), particularly among individuals with delusions (Whitman, Menon, Kuo, & Woodward, submitted). By contrast the present base-rate representativeness task presented all the evidence at once and participants were given the focal hypothesis to test (i.e., not self-selected). This may therefore also account for why significant group differences were not found for initial “lure” ratings, compared to prior “lure-type” tasks (i.e., Balzan, et al., in press-b).

Despite the lack of significant group differences for initial “lure” ratings prior to the discordant base-rate information, the schizophrenia group maintained higher ratings for the “lures” and lower ratings for “true interpretations” following the base-rate information compared to the non-

clinical groups. Patients with schizophrenia were also less likely to down-rate “lure” ratings and up-rate “true” ratings following the base-rates. Delusion-prone participants displayed similar trends compared to the non-delusion-prone group, but these trends were non-significant. These findings are consistent with previous work that has shown that patients with schizophrenia and delusion-prone participants display a bias against disconfirmatory evidence (BADE) (Woodward, et al., 2007; Woodward, et al., 2006b). Moreover, these results highlight differences in the way evidence-hypothesis matches are processed between delusional and non-delusional groups. Indeed, all groups were very receptive to the “lures” prior to the base-rates, which as discussed above, made it difficult to determine if the schizophrenia group was hypersalient to these evidence-hypothesis matches. However, the schizophrenia group maintained higher ratings of the “lures” and demonstrated the least down-rating following the presentation of base-rate information, which suggests that these evidence-hypothesis matches were processed more deeply and became more resistant to counter-evidence. Thus, the hypersalience mechanism could account for a defining characteristic of delusional beliefs which are maintained “despite what constitutes incontrovertible and obvious proof or evidence to the contrary” (DSM-IV-TR, American Psychiatric Association, 2000, p. 821). This set of findings also establishes that the hypersalience account is conceptually different from the “confirmation bias” construct, which would predict that patients should have shown heightened ratings for initial “lures” (i.e., strong confirming evidence) in order to have shown a resistance to the disconfirmatory base-rate evidence.

Furthermore, previous BADE studies have failed to find significant differences between delusional and non-delusional groups in their ability to up-rate “true interpretations” following disconfirmatory evidence. In this study however, patients with schizophrenia were less likely to up-rate these ratings compared to the non-clinical groups. It is assumed that this discrepancy is due to the heightened strength of the evidence-hypothesis matches inherent in these representativeness tasks. That is, particularly strong matches may not only influence initial beliefs, but also block acceptance of alternative beliefs.

Finally, this set of findings may also account for the non-significant group differences for the representativeness heuristic reported in Kemp, et al. (1997), which employed a “conjunction fallacy” task. This task is similar to the traditional representativeness task used in the current study, except participants are not presented with discordant base-rate information, and only rate “lures” and “true interpretations” once. The results reported in Kemp et al. (1997) are then analogous to the current findings, where no significant group differences emerged prior to presentation of the discordant base-rate information. Therefore, these results reinforce the notion that group differences in representativeness reasoning along the psychosis continuum are more clearly discerned by tasks that examine how people respond to the presentation of discordant base-rate information (i.e., which is designed to reduce the veracity of the original evidence). This has implications for the representativeness tasks selected in future studies observing the heuristic within delusional groups.

## ***Availability***

Patients with schizophrenia were more likely to evaluate the probability of events based on the availability heuristic, or the ease with which relevant instances of a class come to mind. Both the famous-names and letter-position tasks required participants to assess the frequency of “evidence-hypothesis” matches. The majority of participants across all groups claimed there were more famous-names (i.e., available or salient “evidence”) than non-famous-names (i.e., less salient “evidence”) when asked to determine whether famous-names or non-famous-names were more frequent (i.e., “hypothesis”). This would at first suggest that groups could not be distinguished by their use of the availability heuristic and therefore on the hypersalience of evidence-hypothesis matches. However, the schizophrenia group over-estimated the proportion of famous-names to non-famous-names compared to the non-clinical groups, suggesting an over-reliance on the availability heuristic. Similarly, when asked to determine whether letters K, L, N, R, and V occurred more frequently in the first position or third position of all words (“hypothesis”), patients with schizophrenia were more likely than the other groups to report that the first position (salient “evidence”) was more common than the third position (i.e., less salient “evidence”). The schizophrenia group also estimated significantly greater proportions of first-position words compared to the non-clinical groups.

Previous research has shown that the availability heuristic is commonly employed within the general population (e.g., Reber, 2004; Tversky & Kahneman, 1973), a finding well replicated in the results of these two tasks. However, taken together, these results suggest that patients with

schizophrenia are particularly prone to make frequency judgements (or estimates on the probabilities of events) on the basis of availability, or the ease of which evidence comes to mind. It proposed that this is a result of a hypersalience of evidence-hypothesis matches among patients with schizophrenia, which causes the available evidence to become more vivid and therefore easier to recall in estimates of frequency. This also supports and extends previous findings that hypothesis-confirming information is better recalled than hypothesis-disconfirming information among patients with schizophrenia (Balzan, et al., in press-b).

### ***Implications for Delusion Formation and Maintenance***

Although a heightened vulnerability to these heuristics further validates the “hypersalience” mechanism, they also have important implications for the development and maintenance of delusions in their own right. Judgements by representativeness can lead to the development of erroneous beliefs within the general population, as seen in the example presented earlier where a reliance on representative behaviour (talking to oneself) may lead to misleading conclusions (person is mentally unstable). Therefore, it is likely that the representativeness heuristic is involved in formative stages of a delusion (e.g., “neighbour is a shady character, always wears dark glasses, seldom seen in public, and is always seen talking on his phone; he may be a CIA operative”), particularly as patients with delusions are more likely to rely on judgements by representativeness compared to healthy controls. Similarly, an over-reliance on the availability heuristic may help maintain a delusional patient’s beliefs. For instance, if one believes their neighbour to be a CIA

operative, any observed behaviour this neighbour conducts that is consistent with that of spy (e.g., they are often seen near their window peering out or taking notes in public) may be particularly salient and vivid to the patient. When it comes to evaluating the “evidence” that the neighbour is a spy, these observed behaviours would be readily available to the patient, and may consequently be subjectively judged as more frequent than they objectively were, thereby further fuelling conviction of the delusion.

### ***Limitations***

Previous work on reasoning heuristics in patients with schizophrenia reported heightened susceptibility to the representativeness and availability heuristics for delusion-specific stimuli (i.e., threatening stimuli for patients with persecutory delusions); no differences were found between groups for delusion-neutral stimuli (Corcoran, et al., 2006). One of the difficulties in interpreting these results is the study employed novel tasks to elucidate the heuristics rather than the established tasks devised by Tversky and Kahneman. It is therefore uncertain whether the tasks were testing genuine biases or simply assessed hyper-sensitivity to threatening stimuli by individuals with persecutory delusions. The current results addressed these issues by employing the original and well replicated versions of the tasks and using delusion-neutral stimuli.

However, the representativeness and availability heuristics literature has not gone unchallenged. Not least is the criticism that the heuristics represent very broad concepts, which make them imprecise and difficult to



falsify, and it has been argued that the underlying processes are not always clear (Teigen, 2004). Indeed, there are alternative theoretical accounts in addition to the proposed hypersalience mechanism which may just as adequately explain the current data. For example, delusional patients may show an increased reliance on these heuristics (which reduce cognitive load), when cognitive resources are put under strain as a result of their delusional symptoms (e.g., preoccupation with delusions). This account may question the need to consider the hypersalience mechanism in the current context. Nevertheless, this mechanism potentially represents not only a theoretical account for reasoning heuristics, but also for the many other cognitive biases which have been linked to delusional ideation (e.g., JTC, BADE, confirmation bias). Indeed, one issue confronting research investigating cognitive biases within delusional populations is the lack of a unifying or underlying cognitive construct that may more parsimoniously account for delusion formation and maintenance (Speechley & Ngan, 2008). Interpreting the current findings within the framework of the “hypersalience mechanism” is therefore not the only valid theoretical proposition available, but it does allow for a more general and unifying account of why patients with delusions are particularly susceptible to particular cognitive biases.

The tasks used to elucidate the heuristics have also been challenged. For example, one’s use of the representativeness heuristic during the “coin-toss” task may depend on their degree of “statistical sophistication” and knowledge on the law of probabilities. It is therefore theoretically possible that the group differences observed for the “coin-toss task” may have been a

reflection of the minor differences in IQ observed between delusional and non-delusional groups (see Table 1). However, these IQ group differences were non-significant, and were not significantly associated with response choices on this task. Moreover, given the statistically significant differences observed for the “base-rates” representativeness task, it seems unlikely that differences in IQ, rather than differences in propensity to the representativeness heuristic, were driving these results.

Some of the “base-rates” stories also assumed prior knowledge of social stereotypes (e.g., personality traits of a lawyer or an engineer), which may have contributed to the differences observed between groups. Replications of these studies may test assumed knowledge of probabilities and opt only for stories that do not rely on prior exposure of social stereotypes (e.g., the “university” story does not assume prior knowledge of Alderaan or Dagobah Universities). It is also worth noting that the availability heuristic is not the only way people can assess frequency, particularly when confronted with low frequencies. In these circumstances, people may simply count the number of events, and this may have occurred during the “famous-names” experiment. Future replications of this study may increase the number of names in the list to dissuade people from this strategy. Nevertheless, despite these criticisms and limitations, the representativeness and availability heuristics remain among the most prominent and robust of the cognitive biases studied within the general population, and their use in clinical populations should persist into the future.

### ***Conclusions***

In conclusion, the present paper suggests that patients with schizophrenia are more susceptible to the representativeness and availability reasoning heuristics, which not only offers further support for the “hypersalience of evidence-hypothesis matches” cognitive mechanism, but also offers further insight into the development and maintenance of delusions.

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## **CHAPTER 7: Paper 5**

### **Illusory correlations and control across the psychosis continuum:**

#### **The contribution of hypersalient evidence-hypothesis matches**

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I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

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We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

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## **Abstract**

It has recently been proposed that individuals with delusions may be hypersalient to evidence-hypothesis matches which may contribute to the formation and maintenance of delusions. However, empirical support for the construct is limited. Using cognitive tasks designed to elicit the illusory correlation bias (i.e., perception of a correlation where none actually exists) and the illusion of control bias (i.e., overestimation of one's personal influence over an outcome), the current paper investigates the possibility that individuals with delusions are hypersalient to evidence-hypothesis matches. It was hypothesised that this hypersalience may increase a person's propensity to rely on such illusory correlations and estimates of control. A total of 75 participants (25 diagnosed with schizophrenia with a history of delusions; 25 non-clinical delusion-prone; 25 non-delusion-prone controls) completed computerised versions of the "fertiliser" illusory correlation task developed by Kao and Wasserman (1993) and the "light-onset" illusion of control task created by Alloy and Abramson (1979). The results across both tasks showed that participants with schizophrenia were more susceptible than non-clinical groups to illusory correlations (i.e., higher estimates of covariation between unrelated events) and illusions of control (i.e., higher estimates of control and perceived connection between responses and the outcome). These results suggest that delusional ideation is linked to a hypersalience of evidence-hypothesis matches. The theoretical implications of this cognitive mechanism on the formation and maintenance of delusions are discussed.

Cognitive illusions or biases are perceptions, judgements or memories that reliably deviate from reality in a systematic and predictable direction, appear involuntarily, and are often difficult to avoid (e.g., Pohl, 2004). They have been studied within the general population for over four decades, and include biases such confirmation bias (i.e., tendency to selectively look for evidence that confirms rather than disconfirms a hypothesis), the representativeness heuristic (i.e., probability judgements based on an outcome's *similarity* with its parent population), and the availability heuristic (i.e., estimates of frequency based on the ease with which relevant events come to mind).

Conceptually, delusions are very similar to cognitive biases, as they also reliably deviate from reality, occur involuntarily, and are difficult to avoid. However, delusions are often viewed as the “pathological twin” of these biases, as they are also held onto despite counter-evidence and rational counter-argument, are often held with great conviction, and are usually not accepted by others living in the social-cultural environment (Gilleen & David, 2005; Langdon & Coltheart, 2000; Miller & Karoni, 1996). There is an increasing body of research which suggests that cognitive biases are not only on the same continuum as delusional beliefs, but that they may also have a role to play in their formation and maintenance. Within this literature, two of the most studied and robust biases include the jumping to conclusions bias (JTC), where decisions are made on limited evidence (see Fine, et al., 2007 for a recent review) and the bias against disconfirmatory evidence (BADE)

where evidence contrary to a hypothesis or pre-existing belief is ignored or down-played (e.g., Woodward, et al., 2006b).

Importantly, recent research has suggested that a *hypersalience of positive matches* between a hypothesis and the available evidence (Speechley, et al., 2010) may represent the underlying cognitive mechanism responsible for the JTC and BADE biases and, in turn, delusional onset and maintenance. “Hypersalience of evidence-hypothesis matches” is an extension of the theoretical mechanism proposed by Kapur (2003), whereby delusions in schizophrenia are thought to arise from aberrant assignment of salience to external objects and internal representations due to dysregulated dopamine transmission in the ventral striatal dopamine pathway. Accordingly, because existing evidence for this unifying cognitive mechanism is limited, there is now growing interest in drawing upon the general cognitive bias literature to identify tasks that might be capable of testing for the hypersalience construct within clinical populations. There are several benefits of employing tasks that elicit recognised cognitive biases over the use of novel tests. First, due to the length of time many of the biases have been studied, the tasks have become optimised to elucidate the biases they are designed to test, and the risk of introducing confounds is reduced. Second, as the cognitive bias tasks have been developed within the general population, there is an established benchmark of performance among non-delusional groups. This makes it easier to detect increased susceptibility to a bias across the assumed “psychosis continuum”, which incorporates both clinical and “delusion-prone” groups (van Os, 2003). Finally, in addition to potentially



yielding further support for an underlying hypersalience mechanism, studying a greater range of cognitive biases beyond the JTC and BADE biases could also improve and expand our understanding of how delusions are formed and maintained.

Thus far, “hypersalience” validity studies have only observed the confirmation bias and the representativeness and availability reasoning heuristics. Nevertheless, the results of these studies are encouraging, and support the theory that individuals diagnosed with schizophrenia (with a high delusional ideation) are hypersalient to evidence-hypothesis matches. For example, patients with delusions preferred positive confirmatory hypothesis tests over more useful diagnostic tests, interpreted hypothesis-consistent evidence as more important than hypothesis-incongruent evidence, and recalled this confirmatory evidence more easily than disconfirmatory evidence (Balzan, et al., in press-b). These patients were also more prone to make judgements by representativeness when judging the likelihood of “evidence-hypothesis” matches, and were more susceptible to the availability heuristic when assessing the frequency of these matches (Balzan, et al., in press-d).

The current paper aims to extend this line of research to investigate the “illusory correlation” and “illusion of control” biases. As with the confirmation bias and reasoning heuristics discussed above, both “illusion” biases are commonly reported within the general population, and both may be driven by a hypersalience of evidence-hypothesis matches. These biases

share a common history, which can be traced back to a simple yet very influential experiment conducted by B.F. Skinner (1948). The experiment consisted of dropping grain at regular intervals to hungry pigeons, irrespective of their current behaviour. It was predicted that whatever behaviour the pigeons were engaged in during food delivery (e.g., pecking, flapping wings) would be repeated on subsequent trials, despite the lack of actual contingency. This is precisely what Skinner observed, and he labelled the phenomenon *superstitious behaviour*. Although later replications of this experiment disputed Skinner's "superstition" explanation (e.g., Staddon & Simmelhag, 1971), his observations nonetheless paved the way for the development of the "illusory correlation" and "illusion of control" theoretical constructs in studies involving humans.

### *Illusory Correlations*

All organisms assess the correlations that exist between important stimulus events in order to predict and control their environment through serial observation (Fiedler, 2004). The ability to recognise the correlations between causes and effects is a basic component of adaptive intelligence, and is crucial for survival and everyday problem solving (e.g., learning which signals accompany danger or safety, or which behaviours are forbidden or permitted). There are numerous human and animal studies that testify to an organism's high sensitivity to differential event frequencies and ability to detect non-contingency (e.g., Alloy & Abramson, 1979; Seligman & Maier, 1967). However, as the Skinner "superstitious" study demonstrated, organisms are also capable of making subjective assessments of correlations

that deviate substantially from “reality”. This perception of a correlation where none actually exists is referred to as an “illusory correlation” (Fiedler, 2004).

Unequal weighting of information is one of the proposed mechanisms responsible for illusory correlations, as demonstrated by a prominent experiment conducted by Kao and Wasserman (1993). The experimental task concerned an unknown exotic plant, the Lanyu. Participants were presented with 2 x 2 cause/effect contingency tables, similar to the one presented below in Table 1, and were asked to rate the value of a fertiliser in promoting the Lanyu to bloom. The contingency tables revealed the frequencies with which the effect (i.e., blooming Lanyu) occurred or did not occur given the presence or absence of the cause (i.e., fertiliser), yet the overall correlation between the cause and effect was always zero. Few participants ever saw this lack of contingency. For example, when the absolute frequency of blooming in the presence of the fertiliser was high (as seen in Table 1), participants perceived a positive causal influence of the fertiliser. Similarly, participants perceived a negative relationship between blooming and the fertiliser when the absolute frequency of blooming in the presence of the fertiliser was low. In sum, it was concluded that the co-occurrence of a present cause with a present effect (i.e., Cell A in Table 1) receives the highest weight in correlation assessment, followed by present cause and missing effect (Cell B) and absent cause and present effect (Cell C), while Cell D (i.e., absent cause and missing effect) receives the least weight. This is despite the fact that all cells should have an equivalent influence on judgements (i.e., A/D equivalent positive influence; B/C equivalent negative influence).

The “unequal weighting” mechanism of illusory correlations has important implications for hypothesis testing paradigms, and more particularly, the hypersalience of evidence-hypothesis matches. The Kao and Wasserman task can easily be interpreted as a hypothesis-test task, where participants are asked to test the hypothesis that a particular fertiliser has an effect (either positive or negative) on the Lanyu’s ability to bloom. The combination of present cause (fertiliser) and effect (blooming) of Cell A represents two cases of present “evidence”, and would therefore lead to the strongest evidence-hypothesis “matches” across delusional and non-delusional groups. However, if delusional groups are particularly hyper-salient to these matches, then they will attribute higher weight to this cell compared to non-delusional groups.

As in the original study, it is expected that non-contingent problems with a high frequency of plants in Cell A relative to other cells should trigger a positive causal influence between the fertiliser and plant, whereas a lower frequency of plants in this cell would lead to negative correlation estimates. Again, these positive and negative illusory correlation estimates are expected to be stronger among participants with delusions if they are indeed hypersalient to evidence-hypothesis matches, and are therefore attributing more weight to Cell A. Delusional groups would also be expected to place higher weight on Cell B (present cause evidence) and Cell C (present effect evidence) relative to non-delusional groups, whilst additionally attributing the least weight to Cell D (no present evidence).

**Table 1:** Example of the 2 x 2 cause (fertiliser) / effect (blooming) contingency table (zero correlation)

		<i>Effect</i>	
		Plant bloomed	Plant did not bloom
<i>Cause</i>	Received fertiliser	133 (Cell A)	49 (Cell B)
	Did not receive fertiliser	19 (Cell C)	7 (Cell D)

### *Illusions of Control*

The other psychological construct that can trace its history back to the Skinner “superstitious” experiments is the “illusion of control” cognitive bias. Related to the illusory correlation mechanism, illusions of control occur when individuals overestimate their personal influence over an outcome (Thompson, 2004). This was first proposed by Langer (1975) when she observed that people behaved as if their actions had direct influence over purely chance situations. For example, she found that people would place larger bets in a gambling task if given the opportunity to practice their moves, or would be less willing to trade a lottery ticket they picked themselves, despite the entirely chance nature of these situations. In another series of experiments designed to test the illusory construct of control more directly, Alloy and Abramson (1979) provided participants with a light-onset task, where they attempted to illuminate a light by pressing a button. In reality, however, there was no relationship between their actions and the onset of the light, which was programmed to come on in 25% or 75% of the trials. Despite the lack of contingency, participants rated their level of control as high,

particularly in the 75% condition. Similar results have been found using tasks where participants attempt to terminate a (non-contingent) tone by finding the “correct sequence” of button pushes (Matute, 1994; Matute, 1995)

This body of previous research, led to the proposition of a *control heuristic*, which people use to determine whether they have control over an outcome (Thompson, et al., 1998). The heuristic comprises of two elements or cues: (a) *intentionality* which represents a person’s intention to achieve an outcome; and (b) the perceived *connection between responses and outcomes*. Thus, perceptions of control will be more likely where one intends or desires an outcome, and where one can see a connection between one’s own action and the outcome. As with most heuristics, the control heuristic will often lead to accurate judgments of control because people will apply the simple rule to situations where control actually exists. However, as Langer observed, the heuristic can also lead to overestimations of control because people can have a strong desire for the outcome and perceive a response-outcome connection in situations where actual control does not exist.

The illusion of control construct, and particularly the “perceived connection” component of the control heuristic, provides another means to test the validity of the hypersalience of evidence-hypothesis matches among individuals with delusions. According to this theory, if individuals with delusions are asked to assess the amount of control they have over an outcome (i.e., to test the hypothesis that they have control), their level of perceived connection between their responses and outcomes (evidence-hypothesis matches) will be higher and will also result in higher estimates of

control (even in non-contingent situations), compared to individuals without delusions.

### *Illusory Correlations and Illusions of Control within Schizophrenia*

A small number of studies have observed illusory correlations and illusions of control among individuals diagnosed with schizophrenia with active delusions, but the results have been mixed. Brennan and Hemsley (1984) administered one of the first illusory correlation tasks to patients with paranoid schizophrenia, non-paranoid schizophrenia, and non-clinical controls. The task used was based on the original Chapman (1967) illusory correlation experiment, which had demonstrated that when participants were presented with particular word pairs (i.e., words with a strong associative link like “knife-fork” or words atypically long like “envelope-pavement”), they were reported as appearing together more frequently than those without such a link. Brennan and Hemsley (1984) reported that individuals with paranoid schizophrenia showed stronger illusory correlations than the other groups. In a critique of the study by Brennan and Hemsley, Chadwick and Taylor (2000) claimed the reported bias was “content-specific”, in that the elevated illusory correlations were triggered only because the stimuli included threatening words, which had special emotional salience for the paranoid schizophrenia group. By contrast, they argued that a “content-general” bias occurs regardless of the materials or stimuli used. In an attempt to overcome this possible confound, Chadwick and Taylor (2000) replicated the Chapman study employing only neutral word-pairs, and found no evidence to support the notion that delusional individuals show an exaggerated illusory correlation

effect. However, the Chapman word-pair task, while influential in the development of the illusory correlation construct, does not provide a direct measure of co-occurrence, unlike other experiments such as Kao and Wasserman's "fertiliser task". Rather, the basic theoretical intention of the word-pair task is to demonstrate that the "top-down" impact of prior knowledge can override the "bottom-up" processing of the data (Fiedler, 2004). The "bias" is therefore an over-estimation of the *frequency* of co-occurrence in hindsight, rather than a direct over-estimation of co-occurrence *itself*. This limits the conclusions made by the Chadwick and Taylor (2000) study.

The only illusion of control study conducted with patients with schizophrenia (Kaney & Bentall, 1992) is similarly problematic. The task used in this study was an adaption of the Alloy and Abramson "light-onset" task, and showed that patients with schizophrenia demonstrated exaggerated illusions of control compared to non-delusional controls. However, this adaption of the "light-onset" task employed success and failure feedback, which confounds the experimental design and limits interpretability of the results. For example, given failure feedback, patients with delusions demonstrated lowered ratings of control compared to controls. Taken together, this suggests that patients may simply have been more receptive to the feedback itself, consistent with studies that have shown that when failure feedback is present, biased behaviour is no longer exhibited (e.g., Matute, 1994).



The present study is an attempt to investigate whether individuals higher in delusional ideation demonstrate exaggerated illusory correlations and illusions of control due to a hypersalience of evidence-hypothesis matches. It will employ more direct tests of illusory correlation, such as the Kao and Wasserman “fertiliser” task, and more conservative adaptations of the Alloy and Abramson “light-onset” task without introducing confounds such as success and failure feedback.

## **Method**

### ***Participants***

A sample of 75 participants was recruited consisting of 25 clinical participants (15 males and 10 females) with a diagnosis of schizophrenia and a history of delusions, and 50 non-clinical participants (23 males; 27 females). The diagnosis of schizophrenia was confirmed with the Mini-International Neuropsychiatric Interview (MINI), and was used to rule out a history of substance and alcohol abuse and previous brain injury or concussion. The Positive and Negative Symptoms Scale (PANSS; Kay, et al., 1987) was employed to determine the severity of positive symptoms. Both of these instruments were assessed by a trained and experienced research nurse. Clinical participants were also administered the PDI-21 (Peters, et al., 2004), which assesses delusional conviction, preoccupation, and distress, combining to give a global delusional score. All clinical participants were being treated with atypical antipsychotic medications at the time of testing.

Non-clinical participants were drawn from the general population and hospital staff via advertisement and word-of-mouth. These participants were screened with the MINI to rule out brain damage, substance abuse and mental illness as confounding factors. To distinguish between delusion-prone and non-delusion groups, non-clinical participants also completed the PDI-21. Individuals who fell above the median non-clinical PDI-21 score (29.5) were identified as delusion-prone and non-delusion-prone if they fell below the median.

All participants were fluent in English and were able to complete all four tasks. Working memory was assessed with the Wechsler Adult Intelligence Scale-Revised Digits Forward and Backward subtests (Wechsler, 1997), and pre-morbid intelligence estimates were made with the NART (Nelson & Willison, 1991). Socio-economic status was estimated using the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957) using highest parental occupation and education level. Scores for these measures and all other demographic information for each group is summarised in Table 2. As indicated in Table 2, the three samples were generally well matched in relation to their age, educational attainment and scores on standardised measures of cognitive and intellectual functioning.

**Table 2:** Socio-demographic and psychopathological characteristics of participants (mean; SD)

	Schizophrenia <i>n</i> = 25	Delusion-prone <i>n</i> = 25	Non-delusion-prone <i>n</i> = 25
Age	39.96 (10.04)	43.68 (15.93)	41.92 (14.98)
Gender – M:F	15:10	9:16	14:11
Education (no. years)	11.20 (1.41)	11.16 (0.99)	11.72 (1.43)
Index of Social Position <sup>1</sup>	51.96 (10.93)	52.52 (7.87)	48.48 (8.47)
IQ Estimate(NART)	108.27 (5.90)	108.01 (6.08)	111.31 (4.07)
Memory (total)	17.00 (2.92)*	18.36 (3.93)	20.44 (3.65)
PDI-21 (total, median)	82.00	60.00	13.00
PANSS (P1-P7 total)	11.08 (3.12)	N/A	N/A
PANSS-Delusions	2.08 (1.04)	N/A	N/A
Length of illness (years)	14.22 (8.51)	N/A	N/A

<sup>1</sup>Higher scores indicate lower social-economic status

\**p* < .05, between schizophrenia and non-delusion-prone group

### ***Materials and Procedure***

All participants completed the following tasks in a randomised order:

#### ***a) Illusory Correlation “Fertiliser” Task***

##### ***Design***

This task was modelled on Kao and Wasserman’s (1993) fertiliser task, comprising of four contingent and 26 non-contingent problems (i.e., zero contingency). The non-contingent problems held to the principle of  $A/B = C/D$ , where A, B, C, D represent the four cells of the 2 x 2 contingency table (Table 1). On the basis of this principle, 13 different types of non-contingent problems were developed over three categories: one “four-cells-identical” (FCI) problem, where the frequencies of the four cells are equal (e.g.,  $A = B = C = D$ ); four “paired-cells-identical” (PCI) problems, where the frequencies of

the four cells are equal in two pairs (e.g.,  $A = B \neq C = D$ ); and eight “four-cells-different” problems, where all cells differ from one another (e.g.,  $A \neq B \neq C \neq D$ ). Table 3 lists the 13 different non-contingent problems by their category. As in the original study, the frequencies of these 13 problems were multiplied by seven to give a total of 26 non-contingent problems. As mentioned earlier, Kao and Wasserman (1993) also reported that when “Cell A” had the highest frequency participants would rate the contingency as “positive”, or “negative” when the frequency of “Cell A” was less than at least one other cell, despite the lack of actual contingency. On this basis, the non-contingent problems were further distinguished as either “positive” or “negative” (see Table 3). Finally, participants were also given four contingent problems (two positive and two negative) to assure that all information was being attended to in each covariation problem.

### *Procedure*

Participants were presented with the following set of instructions:

Pretend you are working for the Australian Flowering Plants Laboratory. The Laboratory has been developing 30 experimental fertilisers, which are labelled L1 through to L30. These fertilisers were all designed to promote an exotic plant, the Lanyu, to bloom. Your task is to test these 30 fertilisers to see how many make the Lanyu bloom. You test each fertiliser on a completely different group of plants. Within each of these 30 groups of plants, you give

the fertiliser to some plants but not to others. You watered all plants at the same time daily.

After one month, you look at the groups of plants for each of the 30 fertilisers (L1 to L30). You notice that there are four types of plants for each fertiliser:

A - Plant received the fertiliser and bloomed

B - Plant received the fertiliser and did not bloom

C - Plant did not receive the fertiliser, but bloomed

D - Plant did not receive the fertiliser, and did not bloom

*[Participants were also shown this information in a contingency table, as in Table 1. Pictures of a blooming/non-blooming plant and fertiliser/no fertiliser were added to ease comprehension.]*

Based on this data, your task is to rate how good each fertiliser is in helping the Lanyu to bloom. You rate each fertiliser on a scale from -10 to +10. A score of -10 means you think the fertiliser has a strong negative effect on the plant's blooming. A score of 0 means you think the fertiliser has no effect on the plant's blooming. A score of +10 means you think the fertiliser has a strong positive effect on the plant's blooming. Of course, you can use any score in between these values on the scale.

Participants were then presented with the 30 problems to rate, which were randomised. The rating scale appeared below each contingency table.

**Table 3:** Non-Contingent (i.e.,  $A/B = C/D$ ) and contingent “fertiliser” problems (only 1X shown<sup>1</sup>)

Problem Type			Cell			
			A	B	C	D
<b>Non-contingent problems</b>						
i	FCI	-	7	7	7	7
ii	PCI	Positive	19	19	7	7
iii		Negative	7	7	19	19
iv		Positive	19	7	19	7
v		Negative	7	19	7	19
vi	FCD	Negative	7	19	49	133
vii		Positive	133	49	19	7
viii		Negative	7	49	19	133
ix		Positive	133	19	49	7
x		Negative	19	7	133	49
xi		Negative	49	133	7	19
xii		Negative	19	133	7	49
xiii		Negative	49	7	133	19
<b>Contingent problems</b>						
i		Positive	49	7	19	133
ii		Negative	7	49	133	19

Note: FCI = four-cells-identical; PCI = paired-cells-identical; FCD = four-cells-different

<sup>1</sup>All 1x cells displayed here were also multiplied by 7 to give a total of 30 problems (26 non-contingent; 4 contingent)

### *b) Illusion of Control Task*

The illusion of control task was a computerised version of the original Alloy and Abramson (1979) light-onset study. In this original task, participants

pushed a button to see if they could control the onset of a light. In the current version, participants were presented with images of an illuminated light bulb (“light on” stimulus) or an unilluminated bulb (“light off” stimulus). They were instructed that their task was to determine how much control they had over the illumination of the bulb. Before they saw either bulb, participants were presented with a single red dot in the middle of the screen, which would be displayed for a maximum of three seconds. It was during this time that participants could choose to hit the spacebar (which would immediately trigger the next illuminated/unilluminated stimulus) or do nothing (i.e., wait three seconds for the stimulus to appear automatically). Participants were instructed that there were therefore four possible outcomes to consider when gauging personal control over the illuminated bulb: press the spacebar and the bulb is illuminated; do nothing and the bulb is illuminated; press the spacebar and the bulb remains off; and do nothing and the light remains off.

As in the original study, light onset was completely pre-programmed to occur. During the 25% set the light was illuminated on 10 of the 40 trials (i.e., 25% trials), and on 30 of the 40 trials of the 75% set (i.e., 75% trials). Trials were randomised within each set, and the order of sets was randomised between participants.

At the conclusion of each stimulus set, participants were asked:

Which of your responses was responsible for the illumination of the bulb (at least some of the time)?

- a) Pressing the spacebar [i.e., perceived control]
- b) Combination of pressing/not pressing the spacebar [i.e., perceived control]
- c) My responses did nothing towards the illumination of the bulb [i.e., no control perceived]

They were also asked to judge their level of control on a 100-point scale, labelled “0 = no control”, “25 = little control”, “50 = intermediate control”, “75 = mostly control” and “100 = full control”. Finally, to gauge levels of perceived connection between their responses and the outcome, participants were asked to report on how many of the trials the bulb was illuminated as a result of their response (e.g., 30 trials = “full control” during the 75-stimuli set).

## **Results**

### *Illusory Correlation “Fertiliser” Task*

#### *Ratings of non-contingent and contingent problems*

Mean ratings of non-contingent and contingent problems are summarised by category (i.e., positive/negative; four/paired cells identical/different) across schizophrenia, delusion-prone and non-delusion-prone groups in Table 4. Although there were no significant differences between groups for the four-cells-identical ( $F(2, 72) = 2.76, p > .05$ ) or paired-cells-identical (positive,  $F(2, 72) = 1.44, p > .05$ ; negative,  $F(2, 72) = 2.83, p$



>.05) non-contingent problems, the schizophrenia group tended to deviate the furthest from zero (i.e., zero was the correct response).

Although all groups were quite inaccurate when assessing the positive four-cells-different non-contingent problems (Table 4), the schizophrenia and delusion-prone groups reported significantly higher ratings for the ( $F(2, 72) = 10.90, p <.05$ , confirmed by Bonferroni post-hoc tests) relative to the non-delusion-prone group. Similarly, there was a significant difference in ratings between schizophrenia and the non-delusion-prone group for the negative four-cells-different non-contingent problems ( $F(2, 72) = 4.43, p <.05$ , confirmed by Bonferroni post-hoc tests). PDI-21 scores significantly correlated with both positive ( $r = .39, p < .01$ ) and negative ( $r = -.28, p < .05$ ) four-cells-different non-contingent problems.

All groups correctly identified positive and negative correlations for the four contingent problems (Table 4). However, the schizophrenia group demonstrated the lowest ratings with the highest variation for the positive contingent problems ( $F(2, 72) = 9.22, p <.05$ , confirmed by Bonferroni post-hoc tests) relative to the non-clinical groups. It is assumed this was a result of the incorrect negative ratings some patients with schizophrenia reported for these positive contingent problems. No significant differences were found for negative contingent problems ( $F(2, 72) = 0.36, p >.05$ ).

**Table 4:** Mean (SD) ratings (range: -10 to 10) for non-contingent and contingent “fertiliser” problems across groups (N = 75)

		Schizophrenia <i>n</i> = 25	Delusion-prone <i>n</i> = 25	Non-delusion-prone <i>n</i> = 25
<b>Non-contingent problems</b>				
FCI	-	0.76 (1.93)	0.28 (1.03)	-0.10 (0.50)
PCI	Positive	0.69 (1.76)	0.35 (1.48)	0.03 (0.62)
	Negative	-1.39 (1.95)	-0.71 (1.43)	-0.41 (0.92)
FCD	Positive	5.98 (2.64)	5.19 (2.93)	2.63 (2.61)*
	Negative	-2.67 (2.21) <sup>#</sup>	-1.97 (2.23)	-0.88 (1.97)
<b>Contingent problems</b>				
	Positive	2.74 (4.43) <sup>^</sup>	5.64 (2.06)	6.21 (2.06)
	Negative	-5.76 (2.31)	-5.34 (2.97)	-5.96 (2.56)

Note: FCI = four-cells-identical; PCI = paired-cells-identical; FCD = four-cells-different

\**p* < .05, between non-delusion-prone and schizophrenia/delusion-prone groups

<sup>#</sup>*p* < .05, between schizophrenia and non-delusion-prone group

<sup>^</sup>*p* < .05, between schizophrenia and non-clinical groups

### *Subjective Cell Importance*

The pairwise comparison analysis as reported by Kao and Wasserman (1993) was conducted to determine how each group subjectively weighted Cells A, B, C and Cell D. A distinct weighting difference between Cells A and D can be computed by comparing the raw score ratings of those problems in which the B and C cells were equal but A and D cells were unequal (i.e., Problem Types ii and v; iii and iv; vi and ix; xii and xiii; x and xiii; and xi and xii in each numerical magnitude problem set, see Table 3). Scores from each of the 12 paired comparisons can then be summed (six from the 1x problem set and six from the 7x problem set), whereby the frequencies of Cells A and D

will be equal giving the weighting differences between Cells A and D. Similar comparisons can also be applied to distinguish the weighting difference between Cells B and C (12 comparisons), Cells A and B, Cells A and C, Cells A and B, and between Cells C and D (each of these contrasts can generate only six paired comparisons).

To illustrate this, Table 5 shows the weighting difference between Cells A and B. Comparing Cells A and B and deleting the equivalent contents of Cells C and D generates six paired comparisons, where the frequencies of A and B will be equal. This will give the weighting differences between Cells A and B (Kao & Wasserman, 1993).

**Table 5:** Pairwise comparisons for the weighting difference between Cells A and B

Problem Pair	Cell				Weighting difference	Rating difference (all groups)	
	A	B	C	D			
(1x)	ii	19	19	7	7	$12W_A - 12W_B$	0.29
	i	7	7	7	7		
(1x)	vii	133	49	19	7	$114W_A - 42W_B$	4.19
	iv	19	7	19	7		
(1x)	xi	49	133	7	19	$42W_A - 114W_B$	-0.95
	v	7	19	7	19		
(7x)	ii	133	133	49	49	$84W_A - 84W_B$	-0.13
	i	49	49	49	49		
(7x)	vii	931	343	133	49	$798W_A - 294W_B$	4.42
	iv	133	49	133	49		
(7x)	xi	343	931	49	133	$294W_A - 798W_B$	-0.13
	v	49	133	49	133		
<b>Total</b>					$1,344W_A - 1,344W_B$ or $1,344(W_A - W_B)$		7.69

The results of all six types of cell weighting differences are presented in Table 6. Replicating the results of Kao and Wasserman (1993), the weight of Cell A was greater than that of Cells B, C and D; the weight of Cell B was greater than that of Cells C and D; and the weight of Cell C was greater than that of Cell D for all groups (i.e.,  $A > B > C > D$ ). However, these weighting differences were significantly greater for the schizophrenia group for Cells A – D compared to both non-clinical groups ( $F(2, 72) = 10.54, p < .001$ , confirmed by Bonferroni post-hoc tests), and for Cells B – D compared to the non-delusion-prone group ( $F(2, 72) = 10.54, p < .01$ , confirmed by Bonferroni post-hoc test). Weighting differences between groups for Cells C – D approached significance ( $F(2, 72) = 3.07, p = .053$ ), but Bonferroni post-hoc tests confirmed that the schizophrenia group demonstrated significantly higher differences than either non-clinical group ( $p < .05$ ). Overall, these results suggest that Cell A was particularly salient for the schizophrenia group and that Cell D received the least weight.

**Table 6:** Weighting differences (relative weighting differences<sup>1</sup> in parenthesis) for Cells A, B, C, D (combined and across groups)

Weighting difference	Problem (1x and 7x)	Weighting difference (relative weighting difference <sup>1</sup> )			
		Combined <i>n</i> = 75	Schizophrenia <i>n</i> = 25	Delusion-prone <i>n</i> = 25	Non-delusion-prone <i>n</i> = 25
2,688( $W_A - W_D$ )	ii – v	37.15 (0.014)	56.98 <sup>^</sup> (0.021)	35.14 (0.013)	19.32 (0.007)
	iv – iii				
	xi – xii				
	xiii – x				
	ix – vi				
1,344( $W_B - W_D$ )	vii – viii	14.24 (0.011)	22.32 <sup>#</sup> (0.017)	15.12 (0.011)	5.28 (0.004)
	i – v				
	ii – xii				
1,344( $W_A - W_C$ )	iii – viii	8.76 (0.007)	12.08 (0.009)	8.68 (0.007)	5.52 (0.004)
	iv – i				
	ix – ii				
1,344( $W_A - W_B$ )	xiii – iii	7.69 (0.006)	10.72 (0.008)	7.06 (0.005)	5.28 (0.004)
	ii – i				
	vii – iv				
1,344( $W_C - W_D$ )	xi – v	6.46 (0.005)	11.86 <sup>^</sup> (0.009)	4.28 (0.003)	3.24 (0.002)
	i – iii				
	iv – x				
2,688( $W_B - W_C$ )	v – vi	8.85 (0.003)	11.82 (0.004)	12.46 (0.004)	2.28 (0.001)
	iv – ii				
	iii – v				
	ix – xii				
	vi – viii				
	x – xii				
	xiii – xi				

Note: <sup>1</sup>Relative weighting distance was calculated by dividing ( $W_A - W_D$ ) and ( $W_B - W_C$ ) comparisons by 2,688 (i.e., 2,688 is the sum of weighting differences for ( $W_A - W_D$ ) and ( $W_B - W_C$ ) pairs in the same way that the sum of weighting differences for the ( $W_A - W_B$ ) pair was 1,344 as shown in Table 5). All other comparisons were divided by 1,344.

<sup>^</sup>*p* < .05, between schizophrenia and non-clinical groups

<sup>#</sup>*p* < .01, between schizophrenia and non-delusion-prone group

### Illusions of Control Task

Participants with schizophrenia exhibited stronger illusions of control over both 75% and 25% light-onset condition across all measures of control. Participants with schizophrenia were significantly more likely to express they had control over the light at least some of the time ( $\chi^2(2, N = 75) = 18.42, p < .001$ , for the 75% condition;  $\chi^2(2, N = 75) = 15.71, p < .001$ , for 25% condition), whether that involved simply pressing the spacebar on most trials or a pattern of pressing and not pressing the spacebar (see Table 7).

Similarly, participants with schizophrenia reported significantly higher percentages of estimated control compared to both non-clinical groups (75% condition:  $F(2, 72) = 19.94, p < .001$ ; 25% condition:  $F(2, 72) = 6.06, p < .01$ , confirmed by Bonferroni post-hoc tests) and significantly higher levels of perceived connection between pressing the spacebar and light-onset (75% condition:  $F(2, 72) = 21.24, p < .001$ ; 25% condition:  $F(2, 72) = 10.31, p < .001$ , confirmed by Bonferroni post-hoc tests). Delusion-prone participants also exhibited significantly higher estimates of perceived connection compared to the non-delusion-prone group (Bonferroni post-hoc test,  $p < .05$ ). PDI-21 scores significantly correlated with estimates of control (75%:  $r = .42, p < .001$ ; 25%:  $r = .30, p < .01$ ) and connection (75%:  $r = .50, p < .001$ ; 25%:  $r = .29, p < .05$ ).

**Table 7:** Perceptions of control (*n*) over 75% and 25% light-onset conditions across groups

	Schizophrenia ( <i>n</i> = 25)	Delusion-prone ( <i>n</i> = 25)	Non-delusion-prone ( <i>n</i> = 25)
<b>75% Condition</b>			
<b>Illusion of Control</b>			
<i>Total*</i>	22 (88%)	14 (56%)	7 (28%)
<i>“Press spacebar”</i>	15 (60%)	4 (16%)	4 (16%)
<i>“Combination spacebar”</i>	7 (28%)	10 (40%)	3 (12%)
<b>No Control</b>	3 (12%)	11 (44%)	18 (72%)
<b>25% Condition</b>			
<b>Illusion of Control</b>			
<i>Total*</i>	20 (80%)	9 (36%)	7 (28%)
<i>“Press Spacebar”</i>	8 (32%)	2 (8%)	2 (8%)
<i>“Combination spacebar”</i>	12 (48%)	7 (28%)	5 (20%)
<b>No Control</b>	5 (20%)	16 (64%)	18 (72%)

\**p* < .001, significant chi-squared

**Table 8:** Mean (SD) estimated percentages of control and perceived connection over 75% and 25% light-onset conditions across groups

	Schizophrenia ( <i>n</i> = 25)	Delusion-prone ( <i>n</i> = 25)	Non-delusion-prone ( <i>n</i> = 25)
<b>75% Condition</b>			
<b>Percentage of Control</b>	53.56 (26.51) <sup>^</sup>	22.60 (24.54)	11.80 (21.50)
<b>Perceived Connection</b>	20.80 (9.98) <sup>^</sup>	9.36 (10.45) <sup>*</sup>	3.84 (7.44)
<b>25% Condition</b>			
<b>Percentage of Control</b>	24.36 (19.34) <sup>^</sup>	10.72 (17.43)	8.40 (15.59)
<b>Perceived Connection</b>	7.84 (4.46) <sup>^</sup>	2.92 (4.88)	2.56 (4.43)

Note: Variance is high due to some participants in each group selecting “0” (i.e., no control)

<sup>^</sup>*p* < .001, between schizophrenia and non-clinical groups

<sup>\*</sup>*p* < .05, between delusion-prone and non-delusion-prone groups

## **Discussion**

The aim of the current paper was to further investigate the “hypersalience of evidence-hypothesis matches” account of delusion formation and maintenance by using tasks developed to test the illusory correlation and illusion of control biases within the general population. Patients with schizophrenia demonstrated significantly greater susceptibility to these biases compared to non-clinical participants, which suggests the presence of an underlying “hypersalience” mechanism among individuals with active delusions.

### ***Illusory Correlations***

As with the original non-contingent “fertiliser” task developed by Kao and Wasserman (1993), the majority of participants in the current study perceived positive correlations when the frequency of plants in Cell A were high, and negative correlations when the frequency in Cell A was comparatively low relative to the other cells. Unequal weighting of information was found to be the cause of these illusory correlation, whereby all participants placed more weight on Cell A (co-occurrence of a present cause with a present effect) than all other cells, followed by present cause and missing effect (Cell B) and absent cause and present effect (Cell C), while Cell D (i.e., absent cause and missing effect) received the least weight. This replicated the results of the Kao and Wasserman (1993) study. However, it was also found that patients with schizophrenia (and active delusions) exhibited greater propensity to these biased correlation estimates compared



to delusion-prone and non-delusion-prone participants. Comparatively, their estimates of covariation were stronger, as they attributed more weight to Cell A and less to Cell D than the non-clinical groups. Delusion-prone participants also reported significantly higher positive estimates of covariation than non-delusion-prone participants. Estimates of covariation also significantly correlated with PDI-21 scores, suggesting the bias is linked to delusional ideation.

These findings suggest that individuals with delusions (and to a lesser extent, those identified as delusion-prone) particularly value present evidence (i.e., Cell A) over absent evidence (Cell D), despite the fact that this “absent evidence” is still confirmatory in nature. It is assumed that this increased propensity to the illusory correlation bias is driven by a hypersalience of evidence-hypothesis matches (i.e., fertiliser/blooming) among individuals with delusions. Cell A represents the strongest evidence-hypothesis match (two pieces of “present” evidence), while Cell D would appear to have the weakest evidence-hypothesis match (only “absent” evidence). Even in the contingent problems, participants with schizophrenia over-relied on the frequency of Cell A in their judgements of covariation (i.e., high frequency = “positive”; low frequency = “negative”). For example, Cell A had a relatively lower frequency than that of Cell D for the positive contingent problem set (see Table 3), which resulted in significantly lower ratings of (actual) covariance, due to many patients assuming that the positive correlation was actually negative.

### ***Illusions of Control***

Illusions of control occur when individuals overestimate their personal influence over an outcome, and result when people have a strong desire for the outcome (i.e., high intentionality) and perceive a response-outcome connection in situations where actual control does not exist (i.e., perceived connection). The illusion of control task used in the current study was based on the classic “light-onset” task first devised by Alloy and Abramson (1979), as this task does not include any manipulations to modify perceptions of intentionality (e.g., monetary incentives for correct responses). Therefore, it was assumed that any differences in control estimates between groups would result from differences in perceived connection due to a hyper-salience of evidence (i.e., pressing spacebar/light-onset combination) – hypothesis (i.e., “I control light-onset”) matches among delusional groups.

As with the illusory correlation task, all participants over-estimated the degree of covariation between their responses (pressing spacebar) and the outcome (light-onset), which led to inflated estimates of control. However, over both 75% and 25% conditions, significantly more participants with delusions expressed that they thought they had control over the light, and reported significantly higher estimates of control and perceived connection than the non-clinical groups. The fact that the schizophrenia group maintained significantly higher estimates of control and connection even in the 25% condition, where evidence-hypothesis matches are greatly reduced in frequency compared to the 75% condition, is testament to the hypersalience of these matches for this group. Estimates of control and perceived connection were also significantly correlated with PDI-21 scores, confirming

the association between illusory control and delusional ideation, and in turn, hyper-salient evidence-hypothesis matches.

### ***Implications for Delusion Formation and Maintenance***

Although the illusory correlation and control tasks used in the current study further validate the “hypersalience” mechanism, they also have important implications for the development and maintenance of delusions in their own right. Although it has not been the focus of much research, conceivably delusions could result from or be maintained by making false associations between events where no association actually exists. For example, a persecutory delusion that one’s coffee is constantly being poisoned may have arisen from a prior concurrence of feeling unwell soon after drinking coffee. Although the two events are potentially unrelated, their concurrence may particularly stand out in the patient’s mind, and could lead to the formation of the delusional belief. Such associations need not even be very frequent, as patients with schizophrenia are also more susceptible to the availability heuristic, whereby estimates of frequency are exaggerated due to the ease with which relevant events come to mind (Balzan, et al., in press-d). Illusions of control may also have their own role to play in delusion formation and maintenance, particularly in relation to grandiose delusions, where over-estimations of personal control may lead patients to believe they are omnipotent or possess particular powers and abilities (e.g., control the weather). Moreover, the delusion-prone group often exhibited greater propensity to both biases relative to the non-delusion-prone group. This coupled with the finding that both illusory correlations and illusions of control

were significantly correlated with PDI-21 scores (i.e., increased along with the psychosis continuum), suggests that these biases may play a role in the early stages of delusion formation among “at risk” individuals.

### ***Limitations and Future Work***

Previous work on illusory correlations and illusions of control in patients with schizophrenia has been inconclusive. The illusory correlation “bias” reported by Chadwick and Taylor (2000) was an over-estimation of the frequency of co-occurrence in hindsight, rather than a direct over-estimation of co-occurrence itself. Similarly, the only illusion of control study conducted with patients with schizophrenia (Kaney & Bentall, 1992) employed success and failure feedback, which confounded the experimental design and limited interpretability of the results. The current paper avoided these methodological issues and was therefore more conclusive in demonstrating that patients with schizophrenia possess a heightened propensity to these biases. However, there are some considerations to take into account in future replications employing these tasks. The Kao and Wasserman (1993) “fertiliser” task is one of the most direct and effective ways of assessing illusory correlations, particularly compared to earlier tasks such as the original Chapman (1967) illusory correlation experiment, which presented participants with particular word pairs (e.g., “knife-fork”, “envelope-pavement”). However, conceptually the task is more difficult to grasp than these word association tasks, and susceptibility to the bias is as likely to be linked to prior mathematical knowledge of probabilities as hypersalience of evidence-hypothesis matches. Although no differences in level of education were reported among the groups

in this study, future studies could include tests of probability to control for this potential influence. Similarly, the Alloy and Abramson (1979) task has the advantage of directly assessing control, but has been criticised for its lack of “real world” realism seen in earlier illusion of control tasks, such as Langer’s lottery and competitive games studies (Thompson, 2004). This limits the task’s external validity. Furthermore, although the “light-onset” task did not actively attempt to modify levels of intentionality, there is a chance that some participants may have differed in their levels of intention to achieve the outcome (e.g., finish sooner by pressing spacebar more frequently). Future studies may attempt to control for this by including measures of intentionality or manipulations to diminish intentionality (e.g., introduce a cost to responding).

### ***Conclusions***

In conclusion, the present paper suggests that patients with schizophrenia are more susceptible to the illusory correlation and illusion of control cognitive biases, which not only offers further support for the proposed “hypersalience of evidence-hypothesis matches” mechanism, but also offers further insight into the development and maintenance of delusions.

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**SECTION C:**

**Towards a Targeted Metacognitive Training Program**

## **CHAPTER 8: Paper 6**

### **Metacognitive training for patients with schizophrenia: Preliminary evidence for a targeted single-module program**

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#### *Statement of Contributors*

##### Ryan Balzan (Candidate)

I was responsible for study conception, literature review, data collection and analysis, manuscript drafting and preparation, manuscript submission, response to reviewers and revisions to the paper.

Signed:

Date: 20/04/2012

Assoc Prof Paul Delfabbro, Prof Cherrie Galletly and Assoc Prof Todd Woodward (Co-authors)

We provided ongoing supervision throughout the research program that lead to this manuscript and there was ongoing collaboration between Mr Balzan and us in refining the direction of the research. Mr Balzan was responsible for writing this manuscript; our role was to comment on drafts, make suggestions on the presentation of material in the paper, and to provide editorial input. We hereby give our permission for this paper to be incorporated in Mr Balzan's submission for the degree of Doctor of Philosophy from the University of Adelaide.

Signed:

Date: 20/04/2012

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## Abstract

Metacognitive training (MCT) is a treatment program for people with schizophrenia that targets the cognitive biases (e.g., jumping to conclusions, bias against disconfirmatory evidence) thought to contribute to the genesis and maintenance of delusions. The program currently consists of eight modules and is usually administered in groups. The present paper is an investigation into the efficacy of a shorter and more targeted single-module MCT program (MCT-T), administered individually, which focuses specifically on countering the “hypersalience evidence-hypothesis matches” mechanism among patients with delusions. The “hypersalience” construct has recently been proposed as one of the underlying mechanisms responsible for the cognitive biases observed among delusional patients. It was hypothesised that a more targeted MCT module could still improve performance on these bias tasks and reduce delusional ideation whilst improving insight and quality of life. A sample of 24 patients diagnosed with schizophrenia and active delusions either participated in the MCT-T program ( $n = 14$ ), or continued treatment as usual (TAU;  $n = 10$ ). All patients were assessed using clinical measures designed to assess delusional ideation, quality of life and insight. They also completed two cognitive bias tasks optimised for elucidating hypersalient evidence-hypothesis matches. After a two-week interval post-training, MCT-T patients exhibited significant decreases in delusions, significant increases in quality of life and insight, and significant improvements in performance on the cognitive bias tasks relative to TAU controls. Patients also evaluated the training positively. Although interpretations of these results are limited due to the lack of an optimally designed randomised controlled trial and a small sample size the results are promising, and warrant further investigation into targeted versions of the MCT program.

Schizophrenia is a severe and disabling psychiatric disorder. It causes considerable suffering for those who have the disorder as well as their families, and creates substantial costs to the community (Landa, et al., 2006; Moritz, et al., 2011). Delusions and hallucinations are “core symptoms” of the illness, and approximately three quarters of all people with schizophrenia experience these symptoms (Kaplan & Saddock, 1995). Ineffective and harsh treatments such as psychosurgery and insulin shock were replaced in the 1950s by dopamine receptor blocker “antipsychotic” drugs. Despite recent advances in antipsychotic treatments, the traditional and dominant psychopharmacological treatment approach is often met with medium effect sizes relative to placebo, high levels of relapse, issues with compliance and illness insight, and serious side-effects (see Leucht, et al., 2009).

Psychotherapies such as cognitive-behavioural therapy (CBT) are now being used alongside the psychopharmacological approach in the treatment of the core symptoms of schizophrenia, such as delusions (e.g., Barrowclough, et al., 2006; Bechdolf, et al., 2010; Garety, et al., 1994; Granholm, et al., 2006; Landa, et al., 2006; Lecomte, et al., 2008; Lecomte, et al., 2003; Spidel, et al., 2006). CBT, whether administered individually or in group settings, aims to identify and actively modify maladaptive delusional beliefs, attitudes and behaviours often associated with schizophrenia. Recent reviews and meta-analyses of its efficacy as an adjunct therapy to psychopharmacological treatments have revealed small to moderate effect sizes equal to, and sometimes reportedly better than, the efficacy of

antipsychotic medication (Wykes, Steel, Everitt, & Tarrier, 2008; Zimmermann, Favrod, Trieu, & Pomini, 2005).

Nevertheless, current treatment approaches lag behind recent theoretical developments regarding the cognitive factors surrounding the formation and maintenance of the symptoms of schizophrenia, such as delusions. An ever increasing body of literature has linked cognitive biases (i.e., problematic thinking styles or distortions in the collection and processing of information, rather than performance deficits) to delusional experiences and delusion-prone tendencies (for reviews see Bell, et al., 2006; Freeman, 2007; Garety & Freeman, 1999). These cognitive biases include attribution biases, where individuals are prone to exhibiting an externalising bias for negative events (e.g., Bentall, et al., 1994); theory of mind impairments, which lead to biases in assessing the intentions of others (e.g., Brune, 2005); and a hypersalience of evidence-hypothesis matches, where even weak matches between the available evidence and existing beliefs or hypotheses are enhanced (e.g., Balzan, et al., in press-a; Balzan, et al., in press-c; Speechley, et al., 2010). It has recently been proposed that this hypersalience mechanism is itself responsible for other commonly reported biases within schizophrenia populations, such as the jumping to conclusions bias (e.g., Fine, et al., 2007) and belief inflexibility, or a bias against disconfirming evidence (e.g., Woodward, et al., 2006b). Other manifestations of the hypersalience mechanism have also been reported including the confirmation bias (Balzan, et al., in press-b), illusory correlations and perceptions of control (Balzan, Delfabbro, Galletly, & Woodward, submitted), and reasoning

heuristics (Balzan, et al., in press-d). CBT has been labelled a “front door” psychotherapeutic approach as it focuses directly on the symptoms of psychosis (Aghotor, et al., 2010), rather than the cognitive biases thought to underlie and maintain these symptoms. Predictably then, randomised controlled trials have demonstrated that the cognitive biases experienced by patients with delusions remain unaltered following CBT (Freeman, in press; Garety, et al., 2008).

However, a new “back door” psychotherapeutic training program has been developed that indirectly targets psychotic symptoms by focussing on the underlying cognitive biases rather than the idiosyncratic delusions of the individual patient. Developed by Moritz and Woodward (see Moritz & Woodward, 2007b for a review), “metacognitive training for patients with schizophrenia” (MCT) aims to bring to the attention of patients the cognitive dysfunctions that may be causing and/or maintaining their delusional symptoms (i.e., “metacognitive” implies “thinking about one’s thinking”). Thus, one of the three fundamental components of the program is knowledge translation. Patients are informed of current empirical research which links cognitive biases to delusion formation/maintenance, and are provided with illustrative examples demonstrating how this cognitive mechanism works. The second component is a demonstration of the negative consequences of these cognitive biases via exercises that target each bias individually and which simultaneously establish the fallibility of human cognition generally, and more specifically, the thinking biases relevant to psychosis. Finally, patients are offered alternative thinking strategies, which may help them to arrive at more

appropriate inferences and thereby avoid the “cognitive traps” that otherwise lead to delusional beliefs (Moritz & Woodward, 2007b). The full MCT program, in either its group-implementation or individually administered (i.e., MCT+) guises, can be obtained cost-free online (<http://www.uke.de/mkt>), and is currently available in 23 languages. The program presently consists of eight modules (two cycles of each are available) and cover attribution biases (module 1); jumping to conclusions (modules 2 and 7), belief inflexibility (module 3); theory of mind and social cognition deficits (modules 4 and 6); overconfidence in memory errors (module 5); and low self-esteem and depression (module 8). Modules usually take 45-60 minutes to administer, and can be run in any order, with patients ideally undergoing both of the parallel but distinct cycles of each module.

Preliminary research into the efficacy of the MCT program has thus far yielded promising results. Relative to controls, patients with delusions who were randomised into the MCT intervention group exhibited significant improvements in delusion distress, memory and social quality of life, illness insight, and jumping to conclusions (Aghotor, et al., 2010; Moritz, et al., 2011). Non-significant improvements on delusional severity scales such as the Positive and Negative Syndrome Scale (PANSS) have also been observed (Aghotor, et al., 2010). Importantly, patients who received MCT training have expressed greater subjective training success and satisfaction with the program, and greater willingness to recommend it compared to controls who received other interventions such as CogPack (Aghotor, et al., 2010; Moritz & Woodward, 2007a).

Nevertheless, more research into the efficacy of the MCT program is required. One of the challenges of conducting such research is the length of time required to conduct the program in full (i.e., minimum of eight weeks, sixteen recommended), which can lead to high drop-out rates (e.g., Aghotor, et al., 2010). Moreover, to date, there has been little research conducted on the efficacy of an individually administered MCT program (or MCT+). This variant of the program combines the process-oriented approach of the group training with elements from individual cognitive-behavioural therapy (i.e. relates information from the modules to individual experiences, observations, and symptoms of the patient). Finally, the individual contribution of each module has not been determined, and the possibility that certain modules may be more effective than others is of clinical importance. For example, there is evidence that the jumping to conclusions (JTC) and belief inflexibility (BADE) cognitive biases are the most closely related to delusion severity (So, et al., 2010).

The influence and efficacy of a one module “bias-specific” program has recently been investigated (Ross, Freeman, Dunn, & Garety, 2011). Employing the exercises from the jumping to conclusions and belief inflexibility modules (i.e., modules 2, 3 and 7), the study found participants showed a significant increase in data processing post-training. The single module intervention also lead to increases in belief flexibility and less conviction in delusions, although these trends were non-significant (Ross, et al., 2011). These non-significant trends may have be related to the exclusion of delusion relevant material, which are a core component of the MCT

program, as they link the cognitive bias to delusional experience. The newly developed Maudsley Review Training Programme substantially extends the adapted MCT module used by Ross et al. (2011), importantly incorporating delusion relevant material similar to the original MCT modules. Preliminary results of this program are more encouraging, suggesting improvements in JTC (effect size = 0.30), belief flexibility (effect size = 0.82) and delusional conviction (effect size = 1.06) following treatment (study referenced by Freeman, in press). While promising, the study would benefit from replications employing larger samples and a randomised control design. Furthermore, given the increasing evidence for the “hypersalience of evidence-hypothesis matches” as a cognitive mechanism that may unify JTC and BADE effects, replications should include other cognitive bias tasks that have been shown to tap into this hypersalience mechanism (e.g., representativeness heuristic and illusion of control tasks).

The purpose of the current study was to implement a shorter and more targeted individually administered MCT module (MCT-Targeted or MCT-T) that combined aspects of the existing JTC and BADE modules. Unlike previous attempts to condense the modules, the current study would stay closer to the original MCT format, incorporating all three fundamental components of the program (i.e., knowledge translation; demonstration of the negative consequences of cognitive biases; and alternative thinking strategies). The study would also include cognitive bias tasks better optimised for assessing the “hypersalience of evidence-hypothesis matches” construct than those tasks used in previous MCT efficacy studies (e.g., “beads task”). It was hypothesised that this MCT-T program would still be effective in reducing

a patient's susceptibility to the hypersalience construct (as determined by the cognitive bias tasks) and would thereby reduce delusional severity, distress, conviction and preoccupation, whilst improving insight into one's illness and symptoms and one's subjective quality of life.

## **Methods**

### ***Participants***

A total of 24 participants with a diagnosis of schizophrenia and a history of delusions were recruited from the Lyell McEwin Health Service Clinical Trials Unit. The diagnosis of schizophrenia was confirmed with the Mini-International Neuropsychiatric Interview (MINI). Exclusion criteria included a history of substance and alcohol abuse and previous brain injury or concussion. All participants were being treated with atypical antipsychotic medications at the time of testing, and had been taking this medication for over 12 months.

A sub-sample of 14 participants (11 males and 3 females) was initially run in the targeted metacognitive training (MCT-T) condition, and another 10<sup>2</sup> participants (7 males and 3 females) were then allocated to the treatment-as-usual (TAU) control group (i.e., no intervention but continued treatment as usual<sup>3</sup>). All participants were fluent in English and were able to complete all tasks. Working memory was assessed with the Wechsler Adult Intelligence Scale-Revised Digits Forward and Backward subtests (Wechsler, 1997), and

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<sup>2</sup> Three control patients who had completed the first session could not complete the second session at the two-week follow-up and were dropped from analysis.

<sup>3</sup> After the second session, controls were fully debriefed about the nature of the study, and were told that they would be entitled to MCT-T sessions in the near future.



pre-morbid intelligence estimates were made with the NART (Nelson & Willison, 1991). Socio-economic status was estimated using the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957) using highest parental occupation and education level. Scores for these measures and all other demographic information for each group is summarised in Table 1. As indicated in Table 1, the two samples were generally well matched on their age, educational attainment and scores on standardised measures of cognitive and intellectual functioning. The MCT-T group had been diagnosed with schizophrenia for a significantly longer time ( $t(22) = 2.79, p < .05$ ).

**Table 1:** Socio-demographic and psychopathological characteristics of participants (mean; SD)

	<b>MCT-T group (n = 14)</b>	<b>Control group (n = 10)</b>
Age	38.00 (8.11)	33.10 (8.43)
Gender – M:F	11:3	7:3
Education (no. years)	11.07 (1.64)	10.08 (1.23)
Index of Social Position <sup>1</sup>	52.21 (12.86)	56.40 (6.65)
IQ Estimate (NART)	106.94 (5.97)	103.23 (5.43)
Memory (total)	16.79 (2.29)	16.00 (2.71)
Length of illness (years)	15.89 (8.51)*	7.60 (4.60)

\* $p < .05$

### ***Metacognitive Training (MCT-T)***

The adapted MCT-T module was run with patients individually, which allowed for the personal experiences and symptoms of the patient to be incorporated into the program, similar to the existing MCT+ program. However, the individual delusions of the patient were not challenged or made the focus of the program, as would be the case in a CBT session. The MCT-T

session ran for approximately 60 minutes per patient. The session aimed to bring to the attention of the patient the cognitive underpinnings of delusional ideation, and particularly the possibility that delusions may be caused and/or maintained by a hypersalience of evidence-hypothesis matches (i.e., “knowledge translation”). Examples of how hypersalient evidence-hypothesis matches may lead to or maintain delusional beliefs were presented to patients (e.g. a hypersalience between evidence [“my doctor has a foreign accent”] and a belief [“my doctor is a spy”] can lead to hasty decisions and resistance to disconfirmatory evidence). Patients were then given a series of exercises taken from the existing JTC modules (Modules 2 and 7) and belief flexibility/BADE module (Module 3). These exercises were designed to point out the negative consequences of making hasty decisions and inflexible belief systems. For example, visual materials would be presented that typically lead to false responses if decisions are made prematurely; patients are thus shown that delaying decisions until sufficient evidence has been collected is more optimal. How these hasty decisions and inflexible beliefs could be caused by a hypersalience of evidence-hypothesis matches, and how they could lead to the adoption and pertinence of unusual beliefs, was discussed. Patients were also invited to relate these experiences to personal examples. The exercises in Modules 2, 3 and 7 are discussed in more detail in Moritz and Woodward (2007a, 2007b) or can be viewed in full at <http://www.uke.de/mkt>. Finally, patients were offered alternative thinking strategies (e.g., delaying decisions; being open to different conclusions from those initially accepted), which were summarised onto a cue-card as a “take home” message. Patients were instructed to go over these strategies

whenever they felt insulted or threatened in the time between the training and follow-up sessions.

### **Assessments**

Psychopathological symptoms were assessed using the positive scale of the Positive and Negative Syndrome Scale (PANSS; Kay, et al., 1987), the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen & Olsen, 1982) and the 21-item Peters et al Delusions Inventory (PDI-21; Peters, et al., 2004), which provides a scale for global delusional ideation, and subscales for delusional distress, preoccupation and conviction. Quality of life was determined by the World Health Organization Quality of Life scale (WHOQoL-BREF; WHO, 2004), which provides estimates for psychological and social wellbeing. Clinical insight was estimated using the Schedule for Assessing Insight (SAI) for psychosis patients (adapted from David, 1990), and the Beck Cognitive Insight Scale (BCIS; Beck, Baruch, Balter, Steer, & Warman, 2004), which assesses levels of self-reflectiveness and self-certainty (i.e., overconfidence in interpretation of a person's experiences). Finally, patients receiving the intervention completed the subjective evaluation of the MCT-T program, which has been used in other MCT efficacy studies (Aghotor, et al., 2010; Moritz & Woodward, 2007a), and has satisfactory internal consistency (Cronbach's alpha = .73). The evaluation contained eight items covering different aspects of training satisfaction: effectiveness, usefulness, applicability to daily life, transparency of the aims, and fun. Each item was rated on a 5-point scale (1 = fully disagree; 5 = fully agree), so that higher scores indicated greater satisfaction. Patients were also given a brief five item

follow-up evaluation at the next session, which attempted to gauge how often they used the principles of their training, and how effective they found these principles to be during the interval.

The PANSS, SAPS and SAI were performed by a trained research nurse. Due to the non-random sequential allocation of patients to either group, rater blindness to group-allocation was not possible. All other measures were completed by self-report. Patients were instructed to complete these self-report assessments based on recent events (i.e., over the last month) for the first session, and over the last fortnight at the second session. All assessments were made prior to and two weeks following the intervention (or treatment as usual for controls).

### ***Cognitive Bias Tasks***

Previous MCT efficacy studies have either used the “beads task” (Moritz, et al., 2011; Ross, et al., 2011) or the “BADE” task (Aghotor, et al., 2010) to assess cognitive reasoning improvements post MCT. However, as the MCT-T module was more focused on the underlying “hypersalience” mechanism behind the JTC and BADE biases, other tasks that were more optimally related to this mechanism were used to monitor reasoning improvements. Prior research indicates that individuals with delusions are particularly susceptible to the “lawyer-engineer” base-rates task used to test the representativeness heuristic and the “light-onset” illusion of control task, compared to non-delusion-prone controls (Balzan, et al., in press-d; submitted, respectively). Both tasks are optimised for testing hypersalient

evidence-hypothesis matches, and also gauge hasty decisions and belief inflexibility.

### *Representativeness Task*

The representativeness task was a modified version of the famous Kahneman and Tversky (1973) “lawyer-engineer” task. Participants were given short stories similar to the following:

Peter wants to go overseas shortly and is in the process of choosing which cities to visit. He asks his friend for his advice between San Francisco and Los Angeles. "San Francisco is a much nicer city" says his friend. "The buildings are beautiful, the weather is perfect, the food is fantastic, and there is so much to see and do. Los Angeles is busy, dirty and expensive. There is not as much to see and getting around is more difficult. I would go to San Francisco."

After reading the story, participants must rate the likelihood that Peter will visit San Francisco (10-point Likert-scale ranging from “very unlikely” to “very likely”) and the likelihood that he will visit Los Angeles (same scale). They are then presented with discordant base-rate information such as:

Peter later reads in a travel magazine that San Francisco has less favourable reviews from previous travellers than Los Angeles.

Participants were then given the opportunity to rate the likelihood of each city again. In this way, the initial representative evidence (“lure”) would

influence judgements at the first rating; in this example, it would seem more likely that Peter will visit San Francisco than Los Angeles. Base-rate evidence was discordant with the information provided in the initial story (e.g., travel magazine suggested San Francisco had many negative reviews), thereby indicating the final “true” interpretation (e.g., Los Angeles is the better choice). The base-rate information was always presented after the initial description rather than embedded into it. This is in line with studies that have shown that such base-rate information is more carefully attended to if presented separately (Krosnick, et al., 1990). Individuals with delusions have previously demonstrated less down-rating on the representative “lure” after discordant base-rate evidence and less up-rating of the “true” interpretation, relative to non-delusion prone controls (Balzan, et al., in press-d). A total of four stories were presented across the two test sessions (two stories at the first session; two stories at the second session), and were randomised across participants.

### *Illusion of Control Task*

The illusions of control task was a computerised version of the original Alloy and Abramson (1979) light-onset study. In this original task, participants pushed a button to see if they could control the onset of a light. In the current version, participants were presented with images of an illuminated light bulb (“light on” stimulus) or an unilluminated bulb (“light off” stimulus). They were instructed that their task was to determine how much control they had over the illumination of the bulb. Before they saw either bulb, participants were presented with a single red dot in the middle of the screen, which would be displayed for a maximum of three seconds. During this time participants could

choose to hit the spacebar (which would immediately trigger the next illuminated/unilluminated stimulus) or do nothing (i.e., wait three seconds for the stimulus to appear automatically). Participants were instructed that there were four possible outcomes to consider when gauging personal control over the illuminated bulb: press the spacebar and the bulb is illuminated; do nothing and the bulb is illuminated; press the spacebar and the bulb remains off; and do nothing and the light remains off. As in the original study, light onset was pre-programmed to occur on 30 of the 40 trials (i.e., 75% trials), the order of which was randomised for each participant.

At the conclusion of each stimulus set, participants were asked:

Which of your responses was responsible for the illumination of the bulb (at least some of the time)?

- d) Pressing the spacebar [i.e., perceived control]
- e) Combination of pressing/not pressing the spacebar [i.e., perceived control]
- f) My responses did nothing towards the illumination of the bulb [i.e., no control perceived]

They were also asked to judge their level of control on a 100-point scale, labelled “0 = no control”, “25 = little control”, “50 = intermediate control”, “75 = mostly control” and “100 = full control”. Finally, to gauge levels of perceived connection between their responses and the outcome, participants were asked to report on how many of the trials the bulb become illuminated as a result of their response (e.g., 30 trials = “full control”).

## Results

Group differences on the various clinical assessments and cognitive tasks were calculated with 2 Group x 2 Time ANOVA with repeated-measures on Time with a significance level of  $p < .05$ . Effect sizes were estimated using partial eta squared ( $\eta_p^2$ ) statistics.

### Clinical Assessments

Table 2 summarises the various assessments used to determine symptom severity, delusional ideation, quality of life and insight at baseline and at the two-week follow-up for both groups. There were significant interaction effects between Group and Time for all three measures of symptom severity (PANSS-Positive Scale:  $F(1, 22) = 14.87, p < .001, \eta_p^2 = .40$ ; SAPS:  $F(1, 22) = 13.62, p < .001, \eta_p^2 = .38$ ; PDI-21-Global:  $F(1, 22) = 5.89, p < .05, \eta_p^2 = .21$ ), whereby patients in the MCT-T group demonstrated significantly greater decreases in symptom severity post-training relative to the TAU controls, whose symptoms remained essentially the same (Table 2). There were similar significant interaction effects for the delusions subscale of the PANSS ( $F(1, 22) = 8.41, p < .01, \eta_p^2 = .28$ ), as well as for the preoccupation and conviction subscales of the PDI-21 ( $F(1, 22) = 5.48, p < .05, \eta_p^2 = .20$ ;  $F(1, 22) = 5.77, p < .05, \eta_p^2 = .21$ , respectively). Although an interaction effect for the distress subscale of the PDI-21 approached significance ( $F(1, 22) = 3.98, p = .059, \eta_p^2 = .15$ ), there was a significant main effect of Time ( $F(1, 22) = 10.90, p < .01, \eta_p^2 = .33$ ), whereby both groups



showed significant decreases in delusional distress at the two-week follow-up session.

There were significant interaction effects for both quality of life measures (psychological wellbeing:  $F(1, 22) = 6.28, p < .05, \eta_p^2 = .22$ ; social wellbeing:  $F(1, 22) = 4.91, p < .05, \eta_p^2 = .18$ ), where MCT-T patients rated their psychological and social wellbeing significantly higher post-training, compared to TAU controls, where wellbeing slightly decreased (Table 2).

The SAI measure of insight also yielded a significant Group by Time interaction, such that MCT-T patients showed significant improvements in insight into their illness relative to TAU controls post-training, where insight remained stable ( $F(1, 22) = 13.87, p < .001, \eta_p^2 = .39$ ). However, neither BCIS self-reported measures of insight (i.e., self-reflectiveness and self-certainty) yielded significant main or interaction effects (i.e., self-reflectiveness:  $F < 1$ , main effect for Time and Time x Group interaction, and  $F(1, 22) = 2.76, p > .05$ , main effect for Group; self-certainty:  $F < 1$ , main effect for Time and Time x Group interaction, and  $F(1, 22) = 2.44, p > .05$ , main effect for Group).

## **Cognitive Tasks**

### **Base-rates Representativeness Task**

The ratings of “lures” and “true interpretations” before and after the discordant base-rate information are presented in Table 3 below. Ratings across stories were combined for analysis. There were no significant main or interaction effects on pre-base-rate ratings for “true” interpretations, but there was a significant main effect for Time on pre-base-rate ratings for the “lures”

( $F(1, 22) = 4.66, p < .05, \eta_p^2 = .18$ ). This suggests that all participants were slightly less willing to rate the “lures” as highly during the second testing session. However, this is not to suggest that all participants were less hypersalient to evidence-hypothesis matches at the second test session. Rather, the significant Group by Time interactions for post-base-rate ratings for “lures” ( $F(1, 22) = 4.99, p < .05, \eta_p^2 = .19$ ) and “true” interpretations ( $F(1, 22) = 7.51, p < .05, \eta_p^2 = .23$ ) suggests that MCT-T patients were significantly more capable than TAU controls at adapting prior beliefs to fit the current evidence post-training. It is proposed that this improvement was caused by the intervention, which attempted to abate the hypersalience of evidence-hypothesis matches. Following their training, MCT-T patients were more willing to down-rate “lure” ratings and up-rate the “true” interpretations following the disconfirmatory base-rate information (Table 3). Conversely, during the second session, TAU controls actually showed slight up-rating of “lure” and down-rating of “true” interpretation post-base-rates, suggesting the findings for MCT-T patients was not the result of practice effects.

**Table 2:** Pre and post clinical assessments of symptom severity (PANSS; SAPS; PDI-21), quality of life (WHOQoL) and insight (SAI; BCIS) for intervention and control groups (mean; SD)

	<b>MCT-T group (n = 14)</b>		<b>Control group (n = 10)</b>	
	<b>Pre</b>	<b>Post</b>	<b>Pre</b>	<b>Post</b>
<b>Symptom Severity</b>				
PANSS (Positive) <sup>^</sup>	14.07 (3.45)	12.00 (3.14)	11.20 (1.81)	11.40 (2.07)
<i>PANSS-Delusions</i> <sup>^</sup>	3.14 (1.03)	2.43 (1.02)	2.30 (.48)	2.20 (.63)
SAPS <sup>^</sup>	22.14 (8.23)	15.07 (7.55)	11.10 (3.78)	10.70 (3.53)
PDI-21-Global*	95.71 (45.60)	65.57 (45.64)	56.60 (34.64)	54.60 (28.38)
<i>PDI-21-Distress</i> <sup>#</sup>	27.00 (12.94)	17.29 (11.09)	17.20 (12.30)	14.80 (8.52)
<i>PDI-Preoccupation</i> *	27.07 (13.81)	18.86 (13.82)	15.40 (9.34)	15.40 (8.99)
<i>PDI-Conviction</i> *	32.07 (16.36)	22.00 (17.28)	18.20 (12.16)	18.20 (10.59)
<b>Quality of Life</b>				
WHOQoL-Psychological*	40.21 (19.88)	58.57 (12.59)	59.50 (23.09)	56.40 (16.14)
WHOQoL-Social*	37.07 (22.68)	56.29 (27.61)	53.10 (23.12)	49.40 (23.40)
<b>Insight</b>				
SAI <sup>^</sup>	11.50 (4.81)	13.64 (5.11)	14.10 (4.53)	14.20 (4.32)
BCIS-Self-reflectiveness	23.07 (4.84)	24.50 (8.50)	19.90 (6.06)	20.00 (5.40)
BCIS-Self-certainty	12.64 (3.37)	12.29 (2.20)	11.30 (3.27)	10.60 (3.41)

Note: PANSS = Positive and Negative Syndrome Scale; SAPS = Scale for the Assessment of Positive Symptoms; PDI-21 = 21-item Peters et al Delusions Inventory; WHOQoL = World Health Organization Quality of Life scale; SAI = Schedule for Assessing Insight; BCIS = Beck Cognitive Insight Scale

<sup>^</sup>*p* < .01, significant Group by Time interaction effect

\**p* < .05, significant Group by Time interaction effect

<sup>#</sup>*p* < .01, significant main effect for Time

**Table 3:** Mean (SD) prior- and post-base-rate (BR) ratings (maximum = 10) for “lures” and “true interpretations” across groups pre and post intervention

	MCT-T group ( <i>n</i> = 14)		Control group ( <i>n</i> = 10)	
	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>
Prior-BR Lure Rating <sup>#</sup>	8.57 (1.54)	7.95 (1.52)	8.27 (1.46)	7.83 (1.30)
Prior-BR True Rating	1.57 (1.58)	2.50 (1.39)	1.60 (1.17)	1.13 (1.45)
Post-BR Lure Rating*	5.50 (1.52)	4.20 (.93)	5.00 (2.04)	5.50 (1.46)
Post-BR True Rating*	4.59 (1.66)	5.80 (.93)	5.05 (2.24)	4.00 (1.27)

\**p* < .05, significant Group by Time interaction effect

<sup>#</sup>*p* < .05, significant main effect for Time

### *Illusion of Control Task*

In the pre-training session, a majority of participants from both groups (>70%) indicated that they had control over the outcome ( $\chi^2(1, N = 24) < 1$ ), despite the lack of actual contingency (see Table 4). However, following training, patients within the MCT-T group were significantly less likely to believe they had control over the outcome ( $\chi^2(1, N = 24) = 5.66, p < .05$ ), whilst the illusion of control persisted within the control group (Table 4).

**Table 4:** Perceptions of control (*n*) for MCT-T and control groups over pre and post-training sessions

	<b>MCT-T group</b> ( <i>n</i> = 14)	<b>Control group</b> ( <i>n</i> = 10)
<b>Pre-training</b>		
<b>Illusion of Control</b>	11 (78.6%)	7 (70%)
<b>No Control</b>	3 (21.4%)	3 (30%)
<b>Post-training*</b>		
<b>Illusion of Control</b>	3 (21.4%)	7 (70%)
<b>No Control</b>	11 (78.6%)	3 (30%)

\**p* < .05, significant chi-squared

Table 5 shows patient's estimated percentage of control and perceived connection both pre- and post-training. There were significant Group by Time interaction effects for both of these measures of control (percentage of control:  $F(1, 22) = 11.13, p < .01, \eta_p^2 = .34$ ; perceived connection:  $F(1, 22) = 6.10, p < .05, \eta_p^2 = .22$ ). As shown in Table 5, the MCT-T patient group significantly reduced their estimates of control and perceived connection post-training, relative to TAU controls, where estimates of control were slightly inflated at the second test session. This again demonstrates the lack of potentially confounding practice effects.

**Table 5:** Mean (SD) estimated percentages of control and perceived connection for 75% light-onset condition across groups

	MCT-T group ( <i>n</i> = 14)		Controls group ( <i>n</i> = 10)	
	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>
<b>Percentage of Control<sup>^</sup></b>	48.14 (34.51)	10.35 (18.34)	32.50 (31.20)	39.00 (33.15)
<b>Perceived Connection<sup>*</sup></b>	18.50 (12.35)	5.71 (10.72)	15.10 (13.83)	15.20 (14.32)

Note: Variance is high due to some participants in each group selecting “0” (i.e., no control)

<sup>^</sup>*p* < .01, significant Group by Time interaction effect

<sup>\*</sup>*p* < .05, significant Group by Time interaction effect

### Evaluation of MCT-T

Patients in the MCT-T group (*N* = 14) subjectively evaluated the program quite favourably on a 5-point evaluation scale (1 = fully disagree; 5 = fully agree). Training was seen as useful (*M* = 4.00; *SD* = 1.41); important to their treatment (*M* = 3.57; *SD* = 1.16); helpful to their daily routine (*M* = 3.79; *SD* = 1.25); and fun (*M* = 3.50; *SD* = 1.23). The goals of the training were clear (*M* = 3.86; *SD* = 1.23) and they would recommend the training to others (*M* = 4.07; *SD* = 1.30). Negative feedback was generally minimal: “I will not apply the lessons learned to everyday life” (*M* = 1.64; *SD* = .93); and “I would rather have spent my time doing something else” (*M* = 2.07; *SD* = 1.14).

During the follow-up session participants were asked to complete a second evaluation. Here participants agreed that they had used the principles from training (*M* = 3.71; *SD* = .99); that training had helped them cope with their special ideas/beliefs (*M* = 3.86; *SD* = .95); that training had been an important part of their treatment (*M* = 3.93; *SD* = .92); what had been learnt

was useful to their daily routine ( $M = 3.57$ ;  $SD = .85$ ); and that they would still recommend the training to others ( $M = 4.50$ ;  $SD = .65$ ).

## **Discussion**

The current study was an investigation into the feasibility of an individually administered, shorter and more targeted meta-cognitive training program. The targeted MCT (MCT-T) module developed for this paper combined aspects of the existing JTC and BADE modules, and remained closer to the original MCT format than previous attempts to condense these modules (Ross, et al., 2011), incorporating all three fundamental components of the program (i.e., knowledge translation; demonstration of the negative consequences of cognitive biases; and alternative thinking strategies). The study also included cognitive bias tasks that were optimised for assessing the “hypersalience of evidence-hypothesis matches” construct.

Overall, the results from the clinical assessments and cognitive bias tasks demonstrated the potential benefit of this shorter and more targeted single-module MCT program. Delusional severity as assessed by the PANSS, SAPS and PDI-21 had significantly reduced after a two-week interval for patients who had received the training relative to TAU controls. Although delusional distress had significantly diminished across all patients at follow-up, only patients receiving the training expressed significant drops in delusional preoccupation and conviction. Independently assessed levels of insight and self-assessed quality of life also significantly improved for MCT-T

patients relative to TAU controls. Effect sizes were small to moderate across these measures.

Furthermore, MCT-T patients demonstrated significant performance improvements post-training on both cognitive tasks. These patients were less susceptible to the representativeness heuristic and illusion of control bias, suggesting greater belief flexibility, less hasty decision-making, and that evidence-hypothesis matches had become less salient. Conversely, no improvements were observed for TAU controls across the two sessions, which suggests that improvements incurred by patients in the intervention condition were not likely to have been a result of practice effects. These cognitive bias performance improvements are particularly of note, as they are more resilient to the limitations inherent in the clinical assessments (e.g. self-report bias and rater bias, both discussed in more detail below). Again, effect sizes were small to moderate. In sum, these results suggest that the intervention was successful in reducing the hypersalience of evidence-hypothesis matches which, in turn, may have resulted in the observed improvements in delusional severity, preoccupation, and conviction as well as improved insight and subjective quality of life.

Finally, MCT continues to be evaluated as a useful, important, helpful, and fun treatment program (for similar evaluations see Aghotor, et al., 2010; Moritz & Woodward, 2007a). Patients generally reported that the goals of training were clear, that they had used the principles from the training which had helped them cope with their illness and would recommend the training to others.



Although these findings are encouraging, particularly considering that the MCT-T program consisted of a single session, there are a number of caveats limiting the interpretability of these results. Most noteworthy was the lack of an optimally designed randomised controlled trial. Therefore, the rater who assessed all patients was not blind to a patient's group membership, which may have lead to a rater bias. Some of the clinical assessment results may be a reflection of this bias. For example, while there was a significant Group by Time interaction for the rater-assessed Schedule for Assessing Insight (SAI) scale, no significant differences were found for the self-assessed Beck Cognitive Insight Scale (BCIS). This discrepancy may have been due to the different approaches of each scale (i.e., BCIS gauged overconfidence and self-reflectiveness, while SAI was more concerned with attitudes to diagnosis and medication adherence). However, the possibility remains that a rater bias may have influenced these results.

However, the significant Group by Time interactions found for rater-assessed delusional measures cannot entirely be explained as a rater bias, because the self-assessed PDI-21 also yielded significant Group by Time interaction effects for delusional severity, preoccupation and conviction. Nevertheless, even these findings warrant caution, because not all delusional subscales yielded significant interaction effects (i.e., PDI-21-Distress only had a significant main effect for Time, suggesting that both MCT-T patients and TAU controls reported decreases in delusional stress over the two-week interval between test sessions). Moreover, like all self-report measures, there is the possibility that participants were responding in a manner consistent with the experimenter's expectations. For example, patients in the MCT-T knew

that the purpose of the intervention was to help people with delusions cope with their symptoms. This may have influenced the way they responded to the PDI-21 and the quality of life scale at the follow-up session. As mentioned earlier, these “experimenter-induced” patterns of responding were less likely to have had an influence on performance of the cognitive bias tasks, where the objectives and parameters of interest remained unknown to the patient until the final test session, when all patients were fully debriefed on the nature of both tasks.

Another limitation of the current results is the discrepancy between the two patient samples. Although TAU controls closely matched the MCT-T group on several parameters (e.g., age, gender ratio, education, social position, IQ and memory), MCT-T patients had a longer duration of mental illness and a higher delusional severity at baseline relative to TAU controls. It is worth noting, however, that only the SAPS delusional scale resulted in a significant main effect for Group, while all other clinical assessment measures (i.e., delusional, quality of life and insight) were non-significant for main effect Group differences. Nevertheless, these sample discrepancies, and an overall small sample size and unequal numbers of patients in each group (due to drop-outs), limit the interpretability of these results.

Ongoing research into the efficacy of this targeted MCT module, and the original MCT program, is required. Future studies should incorporate a randomised controlled trial into the experimental design, and match patient

groups on illness duration and baseline delusional severity. An active control condition rather than a TAU control group should be incorporated into the design (e.g., administering controls CogPack, which is a cognitive remediation program aimed at memory, attention and other basic cognitive functions). This would help determine the unique benefits of the MCT program over other similar, but less targeted, cognitive programs. Larger samples are also required; Aghotor, et al. (2010) conservatively estimated that a sample size of 86 patients in each group would be optimal. Further follow-up sessions (e.g., 6-month; 24-month) are also warranted to accurately determine the long-term effects of any improvements observed. It would also be beneficial to run MCT and cognitive-behavioural treatment sessions (CBT) together within the one study. Both individually and group administered CBT sessions have also yielded significant decreases in symptom severity with comparable small to moderate effect sizes (Garety, et al., 1994; Lecomte, et al., 2008; Wykes, et al., 2008). Hence, the potential benefits of a combined treatment approach, which might optimise psychosocial adjuncts to pharmacotherapy in the treatment of schizophrenia, is worthy of investigation. For example, the treatment outcomes of a combination therapy are more likely to be sustained than either treatment approach used in isolation. These investigations would also benefit from comparing the efficacy of group verses individually administered MCT/CBT interventions. With the exception of the current paper, all MCT efficacy studies to date have only investigated group administered modules, and while there are benefits to the group approach such as higher patient turnarounds (Lecomte, et al., 2008), the unique contribution and benefits of a individualised treatment program are not yet

fully determined. For example, group-based interventions may not be as effective as individually administered interventions, which could account for the lack of statistically significant decreases in delusional severity as reported in previous MCT efficacy studies (Aghotor, et al., 2010; Moritz, et al., 2011).

In conclusion, despite the methodological limitations, the present investigation into the efficacy of a shorter and more targeted MCT module demonstrated that MCT-T was a safe and effective intervention. Relative to TAU controls, patients who had received MCT-T experienced significant decreases in delusional severity, preoccupation and conviction, as well as improvements in quality of life and insight into their illness. MCT-T patients also demonstrated significant improvements on two cognitive bias tasks, suggesting that the intervention had successfully reduced the hypersalience of evidence-hypothesis matches mechanism, which is assumed to play a role in delusion formation and maintenance. This line of research should continue and be combined with other psychosocial interventions, so that the current treatment approaches to schizophrenia can more effectively deal with the symptoms of this debilitating disorder.

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## **CHAPTER 9: General Conclusion**

### **Overview of Thesis Aims**

The broad aim of the present thesis was to investigate the role of cognitive biases in the development and maintenance of delusions across the psychosis continuum. The thesis was divided into three sections, each one covering a distinct research aim. The first section, titled “Validity of the Over-adjustment Bias”, was guided by the following research questions:

- How do people with delusions treat disconfirmatory evidence: do they over-react to it (i.e., “over-adjustment”) or ignore it (i.e., Bias Against Disconfirming Evidence or BADE)?
- Is the Jumping to Conclusions (JTC) bias (i.e., “premature decisions” and “over-adjustment”), typically elucidated by the “beads task”, being driven by a miscomprehension of this task, and/or the way this task is administered, and/or the level of delusion-proneness of the participant?
- Can the apparent “over-adjustment” bias be significantly reduced by improving the comprehension of the beads task?

The second section, titled “Validity of the „Hypersaliency of Evidence-hypothesis Matches” Account of Delusion Formation and Maintenance”, was guided by the following research questions:

- Is there an underlying “hypersalience of evidence-hypothesis matches” mechanism that might be responsible for cognitive reasoning biases, such as the JTC bias and the BADE effect, which, in turn, may lead to the development and maintenance of delusional beliefs?
- Are people with delusions, and those identified as delusion-prone, more susceptible to confirmation biases, reasoning heuristics, illusory correlations and illusions of control due to this “hypersalience” mechanism?

The third and final section, titled “Towards a Targeted Metacognitive Training Program”, was guided by the following research question:

- Can a more focussed metacognitive training (MCT) program, which targets specific cognitive reasoning biases, be effective in reducing delusional severity, conviction, preoccupation and distress, and also improve insight and perceived quality of life among people with active delusions?

## **Review of Papers**

### *Section A: Validity of the Over-adjustment Bias*

#### *Paper 1*

This paper was one of the first empirical studies to investigate the possibility that the JTC bias, and particularly the “over-adjustment” aspect to

this bias (i.e., an over-reaction to disconfirmatory evidence), may be an artefact of the beads task. Previous studies had suggested that the “over-adjustment” effect may actually represent a miscomprehension of the instructions of the beads task (e.g., Moritz & Woodward, 2005). The study employed a sample of non-clinical participants, who were identified as either delusion-prone or non-delusion-prone, and who were presented with computerised and non-computerised versions of the beads task. Therefore, the paper was also an investigation into whether non-clinical delusion-proneness and/or task administration could influence the elucidation of the “premature decisions” and “over-adjustment” effects. Importantly, the paper also included a qualitative measure of miscomprehension, whereby participants were asked to justify their response choices and to reveal the strategies they had used throughout the task. It was hoped that the inclusion of these qualitative measures would determine if any “illogical responses” made by participants during the task were really being driven by a misunderstanding of the task’s instructions.

Ultimately, delusion-proneness and task administration were not found to have a significant influence the JTC bias or levels of miscomprehension; yet miscomprehension itself was significantly associated with both aspects of the bias (i.e., “premature decisions” and “over-adjustment”). Beyond these preliminary findings, which would be expanded in Paper 2, the real strength of this first paper was that the qualitative evidence confirmed that any “illogical responses” participants made when presented with a “disconfirmatory bead” (e.g., one green bead in a sequence of nine red beads), was a result of participants incorrectly assuming containers had swapped at this point in the

sequence. This suggested that the apparent “over-adjustment” effect was actually “miscomprehension”. This set of findings established the premise for the next paper.

### *Paper 2*

This paper extended the findings of Paper 1 to a clinical sample of people with schizophrenia who were experiencing delusions, in addition to non-clinical delusion-prone and non-delusion-prone groups. The study employed the same computerised version of the beads task from Paper 1, but also introduced an intervention that was designed to improve the comprehension of the beads task. The intervention included additional instructions that made it clearer to participants that containers were not swapping during the task. It was hypothesised that this intervention would significantly reduce the “over-adjustment” effect.

The intervention was successful in improving comprehension across all groups, which also significantly reduced the “over-adjustment” effect across all participants. Consistent with previous studies, Paper 2 also demonstrated that the “premature decisions” component of the JTC bias was heightened within the clinical sample, and that this effect was not influenced by miscomprehension (this was not fully determined by the results of Paper 1). Therefore, Paper 2 was instrumental in reaffirming the “premature decisions” aspect of the JTC bias within delusional samples, and confirmed that the “over-adjustment” effect was likely to be an artefact of the beads task, driven by a miscomprehension of that task’s instructional set.



This set of findings effectively resolved the theoretical conflict regarding how people with delusions treat and respond to disconfirmatory evidence; findings from the beads task would now be consistent with the theoretical approach that disconfirmatory evidence is ignored or downplayed (i.e., BADE). Crucially, Paper 2 also offered preliminary insight into the “hypersalience” mechanism and how it can account for the JTC bias. The possibility that this mechanism may also account for other cognitive biases associated with delusional belief, such as the BADE, formed the premise for the next section of the thesis.

*Section B: Validity of the “Hypersalience of Evidence-hypothesis Matches”  
Account of Delusion Formation and Maintenance*

This section of the thesis tested the validity of the “hypersalience of evidence-hypothesis matches” cognitive mechanism by investigating whether people with delusions, and those identified as delusion-prone, are more susceptible to confirmation biases (Paper 3), reasoning heuristics (Paper 4), and illusory correlations and illusions of control (Paper 5). All three papers utilised the same sample consisting of people with schizophrenia who were experiencing active delusions ( $n = 25$ ), non-clinical delusion-prone participants ( $n = 25$ ), and healthy non-delusion-prone controls ( $n = 25$ ).

*Paper 3*

This paper included two tasks designed to capture three core facets of the confirmation bias (i.e., biased search for confirming evidence; biased

interpretation of confirming evidence; and biased recall of confirming evidence), which all lead to the immunisation of a hypothesis against falsification. The first task observed biased search strategies, which are characterised by the preference of *non-diagnostic positive* tests over *diagnostic negative* tests. A positive test seeks to confirm a hypothesis, while a negative test seeks to test the alternative hypothesis. A diagnostic test involves a search for evidence that will support a hypothesis *or* its alternative, whereas non-diagnostic tests search for evidence in such a way that captures both the hypothesised event *and* its alternative, and can lead to spurious confirmation of hypotheses. When the task involved choosing between diagnostic and non-diagnostic positive tests, all participants selected the diagnostic option over the non-diagnostic option. This reaffirmed previous findings that people generally prefer more optimal diagnostic tests over less useful non-diagnostic tests, and suggested that all participants understood the purpose of the task. However, when the choice was between *positive non-diagnostic* hypothesis tests and *negative diagnostic* tests, participants with delusions were more likely than non-delusional participants to select the suboptimal positive non-diagnostic test. The preference for positive non-diagnostic tests over more optimal negative diagnostic tests suggested that individuals with delusions were hypersalient to evidence-hypothesis matches, which can lead to biased search strategies that immunise hypotheses and beliefs (including delusional beliefs) against falsification.

The second task of Paper 3 was intended to test the hypersalience mechanism more directly by determining if confirmatory evidence was *interpreted* and *recalled better* by participants with delusions and those

identified as delusion-prone relative to the non-delusional group. Participants were presented with two crime stories which contained information that initially suggested a “lure” was responsible, but over the course of the task, were given disconfirmatory evidence that either moderately suggested the “lure” was no longer responsible or completely exonerated the “lure” and revealed the “true” culprit. Consistent with the BADE studies, participants with higher delusional ideation failed to integrate disconfirmatory evidence to modify prior hypotheses. This was most apparent in the exonerating condition, when the nature of disconfirmatory evidence was particularly strong and participants were encouraged to process the evidence “intensely”, which prompted non-delusion-prone participants to modify their initial beliefs accordingly. Moreover, the task was able to show that this “BADE effect” may be driven by hypersalient evidence-hypothesis matches, because within-group analysis showed that the schizophrenia group and the delusion-prone group better recalled confirming evidence relative to disconfirmatory evidence, and rated this evidence as more important than disconfirming evidence.

In sum, Paper 3 was successful in demonstrating that people with delusions, and even those identified as delusion-prone, are more susceptible to a “confirmation bias” style of responding which is most likely driven by a hypersalience of evidence-hypothesis matches.

#### *Paper 4*

This paper extended the approach established in Paper 3 to the representativeness and availability reasoning heuristics. It was hypothesised that, if the “hypersalience” mechanism was associated with delusional ideation, people with delusions and delusion-prone individuals would have a greater propensity to rely on judgements of representativeness (i.e., when the probability of an outcome is based on its *similarity* with its parent population) and availability (i.e., estimates of frequency based on the ease with which relevant events come to mind). Four heuristics tasks were adapted from the original Tversky and Kahneman experiments, consisting of two representativeness tasks (“coin-toss” random sequence task; “lawyer-engineer” base-rates task) and two availability tasks (“famous-names” and “letter-frequency” tasks).

The “coin-toss” task involved participants deciding which of four sequences of six coin-tosses was the most likely to occur. Despite one of the response choices containing the correct answer (i.e., that all coin-toss sequences were equally likely), patients with schizophrenia were more likely than either non-clinical group to pick the more “representatively random” coin sequence (i.e., “H-T-T-H-T-H”). The “lawyer-engineer” base-rates task was similar the “lure” task in Paper 3, where participants were presented with pieces of information that would initially suggest the “lure” was the most likely response choice. They would then be given disconfirmatory base-rate information that suggested the “lure” was no longer the correct option, but that the alternative “true” option was now more likely. As the nature of the confirming evidence concerning the “lure” was particularly strong (i.e., strong

evidence-hypothesis matches), it was hypothesised that this would further distinguish delusional from non-delusional styles of responding. Support for this hypothesis was not immediately apparent, in that all participants were strongly influenced by the “lures”. However, the schizophrenia group maintained higher ratings of the “lures” after the discordant base-rate information (i.e., they were the least willing to adapt to the new information), which suggests that evidence-hypothesis matches for the “lures” were processed more deeply and became more resistant to counter-evidence. This finding also suggested that, while the “hypersalience” and “confirmation bias” concepts are very similar, they are not necessarily the same (i.e., patients in this task did not exhibit a heightened confirmation bias relative to controls, but it is assumed that they exhibited a heightened hypersalience of evidence-hypothesis matches which “protected” the “lures” from the disconfirmatory base-rate information).

Both of the availability tasks were based on the premise that estimates of frequency of occurrence are influenced by the relative availability of information. The first task presented participants with a list of actors and actresses who varied in their famousness (i.e., one stimuli set contained 20 famous actresses and 19 non-famous actors; the other set contained 20 famous actors and 19 non-famous actresses). Based on previous findings, it was assumed that famous names would be more available to participants and would bias judgements of gender frequency (i.e., the more famous gender would be perceived to be more frequent despite the slightly higher frequency of non-famous names). The other availability task presented five letters to participants (i.e., K, L, N, R, and V), and they were asked to judge whether

there were more English words that contained these letters in the first position (e.g., king) or third position (e.g., liking). In reality, all these letters occur more frequently in the third position than the first position. However, as it is easier to retrieve letters in the first position of words than letters in the third position, it was again assumed that participants would be biased by the availability heuristic and judge the first position words to be more frequent. Although all participants demonstrated the availability heuristic in their estimates of frequency across both tasks (i.e., first position words > third position words), patients with schizophrenia were much more susceptible to this bias than the non-delusional controls. It was proposed that a hypersalience of evidence-hypothesis matches among patients with schizophrenia causes the available evidence to become more vivid and therefore easier to recall in estimates of frequency. This also supports and extends findings from Paper 3, that hypothesis-confirming information is better recalled than hypothesis-disconfirming information among patients with schizophrenia.

### *Paper 5*

The final paper in this section on the validity of the hypersalience construct observed the illusory correlation (i.e., perception of a correlation where none actually exists) and illusion of control (i.e., overestimation of one's personal influence over an outcome) cognitive biases. The task used to test the illusory correlation was based on the Kao and Wasserman (1993) "fertiliser" task, which tests the assumption that illusory correlations are caused by an unequal weighting of information; that is, information which conveys and combines a present "cause" (e.g., a fertiliser designed to

promote the growth of a plant) with a present “effect” (e.g., evidence this plant has grown) is assigned more *importance* than information that conveys an absent cause/effect combination (e.g., no fertiliser/no growth). Illusory correlations therefore stem from favouring information which suggests a cause/effect relationship, even when such a relationship does not exist. The task asked participants to rate the likelihood of a plant blooming given different combinations of present or absent cause (fertiliser)/effect (blooming), although the majority of the problems were non-contingent (i.e., no objective association between fertiliser and the rate of blooming). Participants with delusions and those identified as delusion-prone were found to be particularly susceptible to the illusory correlation bias, as evidenced by the significantly higher estimates that there was a causal relationship between the fertiliser and the rate of blooming. Participants with schizophrenia also attributed the most weight to present cause/effect combinations and the least weight to absent cause/effect combinations. It was concluded that these results were driven by the “hypersalience” mechanism (i.e., present cause/effect combinations represent particularly strong “evidence-hypothesis matches” that there is a causal relationship).

The illusion of control task was a computerised version of the original Alloy and Abramson (1979) light-onset study. Participants were asked to determine if their action of hitting the spacebar (or a combination of hitting and not hitting the spacebar) led to the illumination of an animated light bulb onscreen. Light-onset was pre-programmed and all responses were non-contingent. Despite the objective non-contingency, people with schizophrenia and delusion-prone participants significantly over-estimated their level of

control over the illumination of the light bulb relative to non-delusion-prone controls. Illusions of control are caused by, at least in part, a perception of a response-outcome *connection*. Therefore, it was assumed that these higher estimates of control among the delusional groups were a result of differences in perceived connection due to a hyper-salience of evidence (i.e., “pressing spacebar/light-onset”) – hypothesis (i.e., “I control light-onset”) matches among delusional groups.

Collectively, the findings from this series of three papers have yielded stronger support for the position that people who exhibit delusional beliefs, and to a lesser extent those who are prone to such beliefs, are hypersalient to evidence-hypothesis matches. Concurrently, the papers extended the cognitive reasoning biases studied within the context of delusional belief beyond the JTC and BADE biases, and have demonstrated that delusional beliefs may be caused and/or maintained by a heightened propensity to confirmation biases, reasoning heuristics, and illusory associations.

### *Section C: Towards a Targeted Metacognitive Training Program*

#### *Paper 6*

The third and final section of the thesis examined the efficacy of the recently developed metacognitive training (MCT) program. The program represents a novel approach for the treatment of delusions in people with schizophrenia, as it targets the cognitive biases thought to underlie the development and maintenance of delusional belief. Paper 6 specifically



examined the efficacy of a shorter and more targeted MCT program, with a single module which would focus on the “hypersalience of evidence-hypothesis matches” mechanism investigated in the previous section.

The targeted module used (dubbed MCT-T) was adapted from the existing JTC and BADE (or belief inflexibility) MCT modules, and was administered individually to a sample of 14 patients diagnosed with schizophrenia who were currently experiencing delusions. Another ten people with schizophrenia, who were also experiencing delusions, received treatment as usual. Both groups were assessed using clinical measures designed to assess delusional ideation, quality of life and insight. They also completed two cognitive bias tasks optimised for elucidating hypersalient evidence-hypothesis matches (i.e., the representativeness “lawyer-engineer” base-rates task and the illusion of control “light-onset” task). These measures were collected at the initial assessment prior to training and again at a two-week follow-up post-training (or treatment as usual). Relative to controls, participants in the treatment group exhibited significant decreases in delusions, significant increases in quality of life and insight, and significant improvements in performance on both cognitive bias tasks. These results reaffirm the contention that reducing a patient’s propensity to particular cognitive biases (specifically the hypersalience of evidence-hypothesis matches) may reduce their delusional ideation. The results also have clinical implications, as even a relatively short single-module psychotherapeutic intervention may be beneficial in the treatment of delusions.

### **Overall Significance of Main Findings**

Over the course of the six manuscripts outlined above, this thesis has contributed to, and expanded upon, the cognitive approach to the study of how delusions are developed and maintained. These findings have both theoretical and clinical implications. The first main contribution of the thesis was that it addressed the theoretical conflict surrounding how people with delusions treat disconfirmatory evidence. Some studies suggested that people with delusions over-react or “over-adjust” to such evidence, which stands in contrast to the conventional definition of delusions (i.e., that delusion belief is resistant to counter-argument). The “over-adjustment” effect has also contrasted with the BADE effect, which states that disconfirmatory evidence is ignored. A number of theoretical approaches have been put forward to explain the discrepancy of the “over-adjustment” effect, but the current thesis offered perhaps the most parsimonious explanation; that “over-adjustment” is likely to be an artefact of the beads task, which in its traditional form, promotes miscomprehension. Although this position was first put forward by Moritz and Woodward (2005), the first two papers of the thesis provided compelling qualitative evidence that “illogical responses”, previously labelled “over-adjustment”, were being driven by the erroneous belief that “containers were swapping”. Paper 2 went further, and showed that by improving comprehension on the original beads task, the “over-adjustment” effect could be significantly reduced. Therefore, the first two papers successfully addressed the first aim of the thesis, as they resolved the conflict surrounding the “over-adjustment” and BADE effects, and in doing so

reaffirmed the validity of the BADE effect as well as the “premature decisions” component of the JTC bias.

The second aim of the thesis was to investigate the validity of the “hypersalience” account, which may represent the underlying cognitive mechanism responsible for cognitive reasoning biases, such as the JTC and BADE. The concept was introduced in the first two papers, but became the focus of Papers 3 to 5, all of which successfully demonstrated that people with delusions, and even those identified as “delusion-prone”, are hypersalient to evidence-hypothesis matches. The concept of an “underlying” cognitive mechanism from which many cognitive biases may arise, has important theoretical implications, particularly for the two-factor theory of delusion development and maintenance. The precise nature of the second factor has always been a topic of theoretical discussion, and there is still no consensus on what this factor is, other than to suggest that it represents an impairment in belief evaluation. Although it was mentioned in Chapter One that it was never the contention of this thesis to suggest that any particular cognitive bias represents the second factor, it is conceivable given the findings from Papers 3 to 5 that a “hypersalience of evidence-hypothesis matches” may represent the mechanism that impairs belief evaluation among people with delusions. At the very least, the findings provide substantial empirical support that people with delusions experience impaired cognitive reasoning within specific contexts. This stands in contrast to Maher’s “one-factor” approach that delusions result from *normal* cognitive appraisals of anomalous perceptual experiences, and further validates the concept that a “second factor” must also be at work to explain why a delusional hypothesis,

once formulated, is *adopted* and *maintained* despite the availability of potentially overwhelming counter-evidence.

Another important contribution from this section of the thesis was that it expanded upon the cognitive reasoning biases studied within clinical populations. The majority of studies observing cognitive biases within samples that experience delusions have focussed on the BADE and particularly the JTC biases. In demonstrating the validity of the hypersalience mechanism, it became important to extend the knowledge base beyond these biases. Indeed, the findings from this thesis have confirmed that people with delusions are also more susceptible to confirmation biases, representativeness and availability reasoning heuristics and illusory correlations and illusions of control, in addition to the commonly cited JTC and BADE effects. These findings not only provided empirical evidence for the hypersalience mechanism, they also highlighted the different ways in which delusions may develop or become resistant to disconfirmatory evidence. Using established tasks from the extensive cognitive bias literature also minimised introducing confounds, such as miscomprehension, into the experimental design.

The use of the delusion-prone group for this series of papers was also of theoretical importance. While participants in this group did not always significantly differ from the non-delusion group, they often tended to sit “in between” this group of participants and the clinical schizophrenia group. That is, the delusion-prone group often exhibited a heightened susceptibility toward particular cognitive biases relative to the non-delusion-prone group. This reaffirms the position that these cognitive biases are important to the

*formation* of delusional belief, and that they may affect “at risk” individuals long before delusions arise. The findings also offer further support to the “psychosis continuum” construct, which states that psychotic symptoms, and the factors that cause and maintain them, are continuously distributed in the general population.

The third aim of the thesis was to investigate the efficacy of a shorter and more targeted metacognitive training program (MCT-T), which was shown, in Paper 6, to be a successful approach in the treatment of delusional belief. These findings have important theoretical implications, in that they confirm the causal role of cognitive biases in the development and maintenance of delusions. However, the primary benefit of this study was its application to therapy. Current psychotherapeutic approaches, such as cognitive behaviour therapy, have weak to moderate effect sizes. Therefore, the development of adjunct therapies, such as MCT, may improve the efficacy of these treatments and further improve the lives of patients who experience delusions. The MCT-T program investigated in this thesis may be especially beneficial as its administration is very straightforward; it is perceived to be “useful” and “fun” by patients undergoing treatment; it is delivered in a single session lasting one hour, and yet it still appears to be effective in reducing delusional severity and improving insight and quality of life.

### **Methodological Limitations and Future Directions**

Like all research projects, the current thesis has a number of methodological limitations. Many of these have been discussed in detail in the

previous chapters, and do not necessitate repeating here. However, the assumption that individuals are invariably able and willing to report accurately on their past behaviours, a conjecture which underlies much psychological research, has a significant bearing on the interpretation of the results within this thesis. This assumption is especially relevant to the construct of “delusion-proneness”, which is based on self-report scores from the Peters et al. Delusions Inventory (PDI); a questionnaire that asks participants about potentially personal and confronting unusual experiences and beliefs. Although participants were encouraged to respond with full disclosure, one can only assume that participants were responding in an accurate manner consistent with their actual experiences and beliefs. Self-report errors are a shortcoming inherent in many psychological research projects, but it is an issue that deserves additional emphasis when it could influence the validity of “delusion-prone” and “non-delusion-prone” distinction.

The inclusion of the “delusion-prone” group itself may limit the interpretation of the findings. One of the problems with early research studies investigating the link between cognitive biases and delusional belief was that they did not make it easy to determine if the biases were *preceding* the occurrence of delusions, or whether they were simply co-occurring with them. Therefore, including a “delusion-prone” group consisting of people who have not yet developed delusions but who might be more susceptible to delusional ways of thinking, has been an effective way of circumventing this problem. However, the problem of including a delusion-prone group, in addition to the assumption that self-report errors will be low, is that it does not fully distinguish the disorder of “schizophrenia” from the symptom of “delusional

belief". Indeed, the heightened susceptibility to the cognitive biases observed in this thesis may have been unique to people with schizophrenia for reasons other than their delusional ideation. The only way to fully avoid this issue is to include another control group, consisting of people with schizophrenia, but who do not have a history of delusional beliefs.

Compounding these issues is the consideration that the same sample was used in Papers 2 through to 5, and that the sample size of each identified group was relatively small (i.e.,  $n = 25$ ). Therefore the findings from these papers may have been a reflection of sampling bias, which may limit the generalising the findings to the wider population of people with schizophrenia and/or individuals identified as delusion-prone. Although Paper 6 used a completely different sample of patients with schizophrenia and found similar biased behaviours within this group relative to those reported in Papers 3 to 5, the influence of a sampling bias should not be overlooked.

Therefore, there are a number of future directions that this research should follow, which might avoid some of the limitations inherent in findings within the current thesis. First, the confirmation bias, reasoning heuristics and illusory correlation and control tasks used in Papers 3 to 5 should be replicated using a larger sample of people with schizophrenia. This sample should also include a schizophrenia control group consisting of people who do not have a history of delusional beliefs. This would further distinguish "disorder" from "symptom", and a larger sample would also make it possible to investigate the possibility that particular delusional subtypes might be more strongly associated to particular cognitive biases than others. For example, it

is theoretically probable that people with grandiose delusions (e.g., “I am omnipotent”) are more susceptible to illusions of control than people with persecutory delusions.

This thesis aimed to investigate the validity of the “hypersalience of evidence-hypothesis matches” account of delusion formation and maintenance. Although the findings reported within this thesis are consistent with this mechanism, there are other theoretical positions which might also account for these findings. For instance, there is some tentative evidence that delusional patients with schizophrenia exhibit a hypersalience to *self-selected hypotheses* (Whitman, et al., submitted). Therefore, it would be useful for future studies to investigate the conditions under which people with delusions are hypersalient to self-selected hypotheses or evidence-hypothesis matches. Other theoretical mechanisms, such as the *liberal acceptance bias* where people with delusions are thought to readily accept multiple explanations of events, should also be considered in future research observing the association between cognitive biases and delusional belief. Empirical evidence for the liberal acceptance effect comes from Moritz and Woodward (2004), who administered a series of ambiguous pictures from the Thematic Apperception Task to people with schizophrenia experiencing active delusions and healthy controls. The sample was asked to rate the plausibility of several interpretations for each picture. Participants with delusions were found to accept multiple interpretations, even for interpretations considered implausible by healthy participants. Although it may be considered as a precursor to the “hypersalience” mechanism adopted by the current thesis,



the concept of “liberal acceptance bias” may offer unique insights into how hypotheses are adopted by people with delusions.

Finally, the modified MCT-T module has much potential for future research. More efficacy studies are required before the program can become a useful clinical tool for treating delusions with schizophrenia. As suggested in Paper 6, one avenue for future research would be to combine the MCT-T program with existing cognitive-behavioural therapies, which could yield greater effect sizes than running either treatment in isolation. Other avenues of research could investigate how effective the MCT programs are at treating delusions outside of schizophrenia, such as patients with brain injury who might experience monothematic delusions (such as the Capgras delusion), and people with other psychiatric disorders such as bipolar depression.

### **Concluding Statement**

*Eerrare humanum est* (“to err is human”)

- Cicero, 116-43 BC

The present thesis was an investigation into the role that cognitive biases, or human errors, may play in development, maintenance and treatment of delusions across the psychosis continuum. This broad undertaking was met with moderate success, and has led to some important findings, particularly with regard to the validity of the “over-adjustment” and

“hypersaliency of evidence-hypothesis matches” constructs, as well as the efficacy of a more targeted metacognitive training program. However, it should be made clear that this thesis represents only a preliminary step toward more fully understanding the association between cognitive biases and delusional belief.

Indeed, the cognitive approach to the study of delusions is a rapidly emerging area of study, and theoretical accounts are constantly evolving to suit the wealth of empirical evidence that is currently being amassed. By contrast, as the above quote from Cicero alludes to, “human error” is a constant phenomenon that has always influenced our cognitive abilities. However, the ultimate aim of this body of research is that these “errors” will one day no longer influence the development and maintenance of what can be viewed as one of the most severe afflictions of our humanity: delusional belief.

## REFERENCES

- Aghotor, J., Pfueller, U., Moritz, S., Weisbrod, M., & Roesch-Ely, D. (2010). Metacognitive training for patients with schizophrenia (MCT): Feasibility and preliminary evidence for its efficacy. *Journal of Behavior Therapy and Experimental Psychiatry, 41*, 207-211.
- Alloy, L. B., & Abramson, L. Y. (1979). Judgment of contingency in depressed and nondepressed students: Sadder but wiser? *Journal of Experimental Psychology: General, 108*, 441-485.
- American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders* (Text Revised, 4th ed.). Washington, DC: American Psychiatric Association.
- Andreasen, N. C., & Olsen, S. (1982). Negative vs. positive schizophrenia: Definition and validation. *Archives of General Psychiatry, 39*, 789-794.
- Balzan, R. P., Delfabbro, P. H., & Galletly, C. (in press-a). Delusion-proneness or miscomprehension? A re-examination of the jumping-to-conclusions bias. *Australian Journal of Psychology*.
- Balzan, R. P., Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press-b). Confirmation biases across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches. *British Journal of Clinical Psychology*.
- Balzan, R. P., Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press-c). Over-adjustment or miscomprehension? A re-examination of the jumping to conclusions bias. *Australian and New Zealand Journal of Psychiatry*.

- Balzan, R. P., Delfabbro, P. H., Galletly, C., & Woodward, T. S. (in press-d). Reasoning heuristics across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches. *Cognitive Neuropsychiatry*.
- Balzan, R. P., Delfabbro, P. H., Galletly, C., & Woodward, T. S. (submitted). Illusory correlations and control across the psychosis continuum: The contribution of hypersalient evidence-hypothesis matches. University of Adelaide.
- Barrowclough, C., Haddock, G., Lobbas, F., Jones, S., Siddle, R., Roberts, C., et al. (2006). Group cognitive-behavioural therapy for schizophrenia. *The British Journal of Psychiatry*, *189*, 527-532.
- Bechdolf, A., Knost, B., Nelson, B., Schneider, N., Veith, V., Yung, A. R., et al. (2010). Randomized comparison of group cognitive behaviour therapy and group psychoeducation in acute patients with schizophrenia: Effects on subjective quality of life. *The Australian and New Zealand Journal of Psychiatry*, *44*, 144-150.
- Beck, A. T., Baruch, E., Balter, J. M., Steer, R. A., & Warman, D. M. (2004). A new instrument for measuring insight: the Beck Cognitive Insight Scale. *Schizophrenia Research*, *68*, 319-329.
- Bell, V., Halligan, P. W., & Ellis, H. D. (2006). Explaining delusions: a cognitive perspective. *Trends in Cognitive Sciences*, *10*, 219-226.
- Bentall, R. P., Corcoran, R., Howard, R., Blackwood, N., & Kinderman, P. (2001). Persecutory delusions: A review and theoretical integration. *Clinical Psychology Review*, *21*, 1143-1192.

- Bentall, R. P., & Kaney, S. (1989). Content specific processing and persecutory delusions: an investigation using the emotional Stroop test. *British Journal of Clinical Psychology*, *62*, 355-364.
- Bentall, R. P., Kinderman, P., & Kaney, S. (1994). The self, attributional processes and abnormal beliefs: Towards a model of persecutory delusions. *Behaviour Research and Therapy*, *32*, 331-341.
- Bentall, R. P., Rowse, G., Shryane, N., Kinderman, P., Howard, R., Blackwood, N., et al. (2009). The cognitive and affective structure of paranoid delusions: A transdiagnostic investigation of patients with schizophrenia spectrum disorders and depression. *Archives of General Psychiatry*, *66*, 236-247.
- Bentall, R. P., & Young, H. F. (1996). Sensible hypothesis testing in deluded, depressed and normal subjects. *British Journal of Psychiatry*, *168*, 372-375.
- Brennan, J., & Hemsley, D. (1984). Illusory correlations in paranoid and non-paranoid schizophrenia. *British Journal of Clinical Psychology*, *23*, 225-226.
- Broome, M. R., Johns, L. C., Valli, I., Woolley, J. B., Tabraham, P., Brett, C., et al. (2007). Delusion formation and reasoning biases in those at clinical high risk for psychosis. *British Journal of Psychiatry*, *191*, 38-42.
- Brune, M. (2005). „Theory of mind“ in schizophrenia: A review of the literature. *Schizophrenia Bulletin*, *31*, 21-42.

- Buchy, L., Woodward, T. S., & Liotti, M. (2007). A cognitive bias against disconfirmatory evidence (BADE) is associated with schizotypy. *Schizophrenia Research, 90*, 334-337.
- Chadwick, P., & Taylor, G. (2000). Are deluded people unusually prone to illusory correlation? *Behavior Modification, 24*, 130-141.
- Chapman, L. (1967). Illusory correlation in observational report. *Journal of Verbal Learning and Verbal Behaviour, 6*, 151-155.
- Colbert, S., & Peters, E. R. (2002). Need for closure and jumping-to-conclusions in delusion-prone individuals. *Journal of Nervous and Mental Disease, 190*, 27-31.
- Coltheart, M., Langdon, R., & McKay, R. (2007). Schizophrenia and monothematic delusions. *Schizophrenia Bulletin, 33*, 642-647.
- Coltheart, M., Langdon, R., & McKay, R. (2011). Delusional belief. *Annual Review of Psychology, 62*, 271-298.
- Coltheart, M., Menzies, P., & Sutton, J. (2010). Abductive inference and delusional belief. *Cognitive Neuropsychiatry, 15*, 261-287.
- Corcoran, R., Cummins, S., Rowse, G., Moore, R., Blackwood, N., Howard, R., et al. (2006). Reasoning under uncertainty: heuristic judgments in patients with persecutory delusions or depression. *Psychological Medicine, 36*, 1109-1118.
- Corcoran, R., Mercer, G., & Frith, C. (1995). Schizophrenia, symptomology and social inference: Investigating "Theory of mind" in people with schizophrenia. *Schizophrenia Research, 17*, 5-13.
- Corvin, A. (2011). Two patients walk into a clinic...a genomics perspective on the future of schizophrenia. *BMC Biology, 9*, 77.

- David, A. S. (1990). Insight and psychosis. *British Journal of Psychiatry*, *156*, 798-808.
- Davies, M., Coltheart, M., Langdon, R., & Breen, N. (2001). Monothematic delusions: Towards a two-factor account. *Philosophy, Psychiatry, and Psychology*, *8*, 133-158.
- Dudley, R. E. J., John, C. H., Young, A. W., & Over, D. E. (1997). Normal and abnormal reasoning in people with delusions. *British Journal of Clinical Psychology*, *36*, 243-258.
- Eaton, W. W., Romanoski, A., Anthony, J. C., & Nestadt, G. (1991). Screening for psychosis in the general population with a self-report interview. *Journal of Nervous and Mental Disease*, *179*, 689-693.
- Ellett, L., Freeman, D., & Garety, P. A. (2008). The psychological effect of an urban environment on individuals with persecutory delusions: The Camberwell walk study. *Schizophrenia Research*, *99*, 77-84.
- Fear, C. F., & Healy, D. (1997). Probabilistic reasoning in obsessive-compulsive and delusional disorders. *Psychological Medicine*, *27*, 199-208.
- Fiedler, K. (2004). Illusory correlation. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 97-114). East Sussex: Psychology Press.
- Fine, C., Gardner, M., Craigie, J., & Gold, I. (2007). Hopping, skipping or jumping to conclusions? Clarifying the role of the JTC bias in delusions. *Cognitive Neuropsychiatry*, *12*, 46-77.
- Foulds, G. A., & Bedford, A. (1975). Hierarchy of classes of personal illness. *Psychological Medicine*, *5*, 181-192.

- Freeman, D. (2006). Delusions in the non-clinical population. *Current Psychiatry Reports*, 8, 191-204.
- Freeman, D. (2007). Suspicious minds: The psychology of persecutory delusions. *Clinical Psychology Review*, 27, 425-457.
- Freeman, D. (in press). Improving cognitive treatments for delusions. *Schizophrenia Research*.
- Freeman, D., & Garety, P. A. (2000). Comments on the content of persecutory delusions: Does the definition need clarification? *British Journal of Clinical Psychology*, 39, 407-414.
- Freeman, D., Garety, P. A., Fowler, D., Kuipers, E., Bebbington, P., & Dunn, G. (2004). Why do people with delusions fail to choose more realistic explanations for their experiences? An empirical investigation. *Journal of Consulting and Clinical Psychology*, 72, 671-680.
- Freeman, D., Garety, P. A., Kuipers, E., Fowler, D., & Bebbington, P. E. (2002). A cognitive model of persecutory delusions. *British Journal of Clinical Psychology*, 41, 331-347.
- Freeman, D., Pugh, K., & Garety, P. A. (2008). Jumping to conclusions and paranoid ideation in the general population. *Schizophrenia Research*, 102, 254-260.
- Frith, C. (1992). *The cognitive neuropsychology of schizophrenia*. Hove, East Sussex: Lawrence Erlbaum Associates.
- Frith, C. (1994). Theory of mind in schizophrenia. In A. S. David & J. C. Cutting (Eds.), *The Neuropsychology of Schizophrenia* (pp. 147-162). Hillsdale, NJ: Erlbaum.



- Frith, C. (in press). Explaining delusions of control: The comparator model 20 years on. *Consciousness and Cognition*.
- Gadenne, V., & Oswald, M. E. (1986). Entstehung und Veränderung von Bestätigungstendenzen beim Testen von Hypothesen (Formation and alteration of confirmatory tendencies during the testing of hypotheses). *Zeitschrift für Experimentelle und Angewandte Psychologie*, 33, 360-374.
- Garety, P. A., Fowler, D. G., Freeman, D., Bebbington, P., Dunn, G., & Kuipers, E. (2008). Cognitive-behavioural therapy and family intervention for relapse prevention and symptom reduction in psychosis: randomised controlled trial. *The British Journal of Psychiatry*, 192, 412-423.
- Garety, P. A., & Freeman, D. (1999). Cognitive approaches to delusions : A critical review of theories and evidence. *British Journal of Clinical Psychology*, 38, 113-154.
- Garety, P. A., Freeman, D., Jolley, S., Dunn, G., Bebbington, P., Fowler, D., et al. (2005). Reasoning, emotions, and delusional conviction in psychosis. *Journal of Abnormal Psychology*, 114, 373-384.
- Garety, P. A., Hemsley, D. R., & Wessely, S. (1991). Reasoning in deluded schizophrenic and paranoid patients: Biases in performance on a probabilistic inference task. *Journal of Nervous and Mental Disease*, 179, 194-201.
- Garety, P. A., Kuipers, E., Fowler, D., Chamberlain, F., & Dunn, G. (1994). Cognitive behavioural therapy for drug-resistant psychosis. *British Journal of Medical Psychology*, 67, 259-271.

- Gilleen, J., & David, A. S. (2005). The cognitive neuropsychiatry of delusions: from psychopathology to neuropsychology and back again. *Psychological Medicine, 35*, 5-12.
- Granholm, E., Auslander, L. A., Gottlieb, J. D., McQuaid, J. R., & McClure, F. S. (2006). Therapeutic factors contributing to change in cognitive-behavioral group therapy for older persons with schizophrenia. *Journal of Contemporary Psychotherapy, 36*, 31-41.
- Hollingshead, A. (1957). *Two-Factor Index of Social Position*. New Haven (CT): Yale University Press.
- Huq, S. F., Garety, P. A., & Hemsley, D. R. (1988). Probabilistic judgements in deluded and non-deluded subjects. *Quarterly Journal of Experimental Psychology, 40A*, 801-812.
- Jibson, M. D. (2010). Overview of psychosis. In D. S. Basow, T. L. Schwerk & R. Hermann (Eds.), *UpToDate*. Waltham, MA: UpToDate.
- Johns, L. C., & van Os, J. (2001). The continuity of psychotic experiences in the general population. *Clinical Psychology Review, 21*, 1125-1141.
- Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgement of representativeness. *Cognitive Psychology, 3*, 430-454.
- Kahneman, D., & Tversky, A. (1973). On the psychology of prediction. *Psychological Review, 80*, 237 - 251.
- Kaney, S., & Bentall, R. P. (1992). Persecutory delusions and the self-serving bias: Evidence from a contingency judgement task. *Journal of Nervous and Mental Disease, 180*, 773-779.
- Kao, S., & Wasserman, E. A. (1993). Assessment of an information integration account of contingency judgment with examination of

- subjective cell importance and method of information presentation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 1363-1386.
- Kaplan, H., & Saddock, B. (1995). *Comprehensive textbook in psychiatry*. Baltimore, MD: Williams and Wilkins.
- 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.
- Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The Positive and Negative Syndrome Scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, 13, 261-276.
- Kelemen, O., Erdélyi, R., Pataki, I., Benedek, G., Janka, Z., & Kéri, S. (2005). Theory of mind and motion perception in schizophrenia. *Neuropsychology*, 19, 494-500.
- Kemp, R., Chua, S., & David, A. (1997). Reasoning and delusions. *British Journal of Psychiatry*, 170, 398-405.
- Kinderman, P., & Bentall, R. (1996). Self-discrepancies and persecutory delusions. *Journal of Abnormal Psychology*, 105, 106-113.
- Kinderman, P., & Bentall, R. P. (1997). Causal attributions in paranoia and depression: Internal, personal, and situational attributions for negative events. *Journal of Abnormal Psychology*, 106, 341-345.
- Klayman, J., & Ha, Y. (1987). Confirmation, discontinuation, and information in hypothesis testing. *Psychological Review*, 94, 211-228.
- Krosnick, J. A., Li, F., & Lehman, D. R. (1990). Conversational conventions, order of information acquisition, and the effect of base rates and

- individuating information on social judgments. *Journal of Personality and Social Psychology*, 59, 1140-1152.
- Landa, Y., Silverstein, S., Schwartz, F., & Savitz, A. (2006). Group cognitive behavioral therapy for delusions: Helping patients improve reality testing. *Journal of Contemporary Psychotherapy*, 9-17.
- Langdon, R., & Coltheart, M. (2000). The cognitive neuropsychology of delusions. In M. Coltheart & M. Davies (Eds.), *Pathologies of Belief* (pp. 183-126). Oxford: Blackwell Publishers.
- Langdon, R., Coltheart, M., Ward, P., & Catts, S. (2001). Mentalising, executive planning and disengagement in schizophrenia. *Cognitive Neuropsychiatry*, 6, 81-108.
- Langdon, R., Ward, P. B., & Coltheart, M. (2008). Reasoning Anomalies Associated With Delusions in Schizophrenia. *Schizophrenia Bulletin*, 36, 321-330.
- Langer, E. (1975). The illusion of control. *Journal of Personality and Social Psychology*, 32, 311-328.
- Lecomte, T., Leclerc, C., Corbiere, M., Wykes, T., Wallace, C., & Spidel, A. (2008). Group cognitive behavior therapy or social skills training for individuals with a recent onset of psychosis? Results of a randomized controlled trial. *The Journal of Nervous and Mental Disease*, 196, 866-875.
- Lecomte, T., Leclerc, C., Wykes, T., & Lecomte, J. (2003). Group CBT for clients with a first episode of psychosis. *Journal of Cognitive Psychotherapy: An International Quarterly* 17, 375-384.

- Leucht, S., Komossa, K., Rummel-Kluge, C., Corves, C., Hunger, H., Schmid, F., et al. (2009). A Meta-Analysis of Head-to-Head Comparisons of Second-Generation Antipsychotics in the Treatment of Schizophrenia. *The American Journal Psychiatry*, 166, 152-163.
- Linney, Y. M., Peters, E. R., & Ayton, P. (1998). Reasoning biases in delusion-prone individuals. *British Journal of Clinical Psychology*, 37, 285-302.
- Lord, C. G., Ross, L., & Lepper, M. R. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology*, 37, 2098-2109.
- Maher, B. A. (1974). Delusional thinking and perceptual disorder. *Journal of Individual Psychology*, 30, 98-113.
- Maher, B. A. (1988). Anomalous experience and delusional thinking: The logic of explanations. In T. F. Oltmanns & B. A. Maher (Eds.), *Delusional Beliefs*. New York: Wiley.
- Maher, B. A., & Spitzer, M. (1993). Delusions. In C. G. Costello (Ed.), *Symptoms of Schizophrenia*. New York: Wiley.
- Martin, J., & Penn, D. (2002). Attributional style in schizophrenia. *Schizophrenia Bulletin*, 28, 131-141.
- Matlin, M. W. (2004). Pollyanna Principle. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory*. East Sussex: Psychology Press.

- Matute, H. (1994). Learned helplessness and superstitious behaviour as opposite effects of uncontrollable reinforcement in humans. *Learning and Motivation*, 25, 216-232.
- Matute, H. (1995). Human reactions to uncontrollable outcomes: Further evidence for superstitions rather than helplessness. *Quarterly Journal of Experimental Psychology*, 48, 142-157.
- McKay, R. (submitted). Delusional inference. Royal Holloway, University of London.
- McKay, R., & Cipolotti, L. (2007). Attributional style in a case of Cotard delusion. *Consciousness and Cognition*, 16, 349-359.
- McKay, R., & Dennett, D. (2009). The evolution of misbelief. *Behavioral and Brain Sciences*, 32, 493-561.
- McKay, R., & Efferson, C. (2010). The subtleties of error management. *Evolution and Human Behavior*, 31, 309-319.
- McKay, R., Langdon, R., & Coltheart, M. (2005a). Paranoia, persecutory delusions and attributional biases. *Psychiatry Research*, 136, 253-245.
- McKay, R., Langdon, R., & Coltheart, M. (2005b). "Slights of mind": Delusions, defences, and self-deception. *Cognitive Neuropsychiatry*, 10, 305-326.
- McKay, R., Langdon, R., & Coltheart, M. (2007a). The defensive function of persecutory delusions: An investigation using the Implicit Association Test. *Cognitive Neuropsychiatry*, 12, 1-24.
- McKay, R., Langdon, R., & Coltheart, M. (2007b). Jumping to delusions? Paranoia, probabilistic reasoning, and need for closure. *Cognitive Neuropsychiatry*, 12, 362-376.

- Meehl, P. E. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist*, 17, 827-838.
- Menon, M. (2005). Heightened stimulus salience renders deluded schizophrenics less susceptible to the 'famous names illusion'. *Schizophrenia Research*, 80, 369-371.
- Menon, M., Mizrahi, R., & Kapur, S. (2008). „Jumping to conclusions“ and delusions in psychosis: Relationship and response to treatment. *Schizophrenia Research*, 98, 225-231.
- Miller, E., & Karoni, P. (1996). The cognitive psychology of delusions: A review. *Applied Cognitive Psychology*, 10, 487-502.
- Moritz, S., Kerstan, A., Veckenstedt, R., Randjbar, S., Vitzthum, F., Schmidt, C., et al. (2011). Further evidence for the efficacy of a metacognitive group training in schizophrenia. *Behaviour Research and Therapy*, 49, 151-157.
- Moritz, S., & Woodward, T. S. (2004). Plausibility judgment in schizophrenic patients: Evidence for a liberal acceptance bias. *German Journal of Psychiatry*, 7, 66-74.
- Moritz, S., & Woodward, T. S. (2005). Jumping to conclusions in delusional and non-delusional schizophrenic patients. *British Journal of Clinical Psychology*, 44, 193-207.
- Moritz, S., & Woodward, T. S. (2006). A generalized bias against disconfirmatory evidence in schizophrenia. *Psychiatry Research*, 142, 157-165.
- Moritz, S., & Woodward, T. S. (2007a). Metacognitive training for schizophrenia patients (MCT): A pilot study on feasibility, treatment

- adherence, and subjective efficacy. *German Journal of Psychiatry*, 10, 69-78.
- Moritz, S., & Woodward, T. S. (2007b). Metacognitive training in schizophrenia: from basic research to knowledge translation and intervention. *Current Opinion in Psychiatry*, 20, 619-625.
- Navarro, D. J., & Perfors, A. F. (2011). Hypothesis generation, sparse categories, and the positive test strategy. *Psychological Review*, 118, 120-134.
- Nelson, H. E., & Willison, J. (1991). *Manual for National Adult Reading Test (NART)* (2nd Edition ed.). Windsor, Berkshire: The NFER-NELSON Publishing Company, Ltd.
- Oswald, M. E., & Gadenne, V. (1986). Der Einfluss von Speicherung und Suchstrategie auf die Erinnerungsleistung hypothesenkonformer und -kontrarer Information [The influence of hypothesis confirming and disconfirming information on memory performance]. *Sprache & Kognition*, 5, 195-201.
- Oswald, M. E., & Grosjean, S. (2004). Confirmation bias. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 79-96). East Sussex: Psychology Press.
- Peters, E. R., Day, S., & Garety, P. A. (1997). From preconscious to conscious processing: Where does the abnormality lie in delusions? *Schizophrenia Research*, 24, 120.
- Peters, E. R., & Garety, P. A. (2006). Cognitive functioning in delusions: A longitudinal analysis. *Behaviour Research and Therapy*, 44, 481-514.



- Peters, E. R., Joseph, S., Day, S., & Garety, P. A. (2004). Measuring delusional ideation: The 21-item Peters et al. Delusions Inventory (PDI). *Schizophrenia Bulletin*, *30*, 1005-1022.
- Peters, E. R., Joseph, S. A., & Garety, P. A. (1999). Measurement of delusional ideation in the normal population: Introducing the PDI (Peters et al. Delusions Inventory). *Schizophrenia Bulletin*, *25*, 553-576.
- Peters, E. R., Thornton, P., Siksou, L., Linney, Y. M., & MacCabe, J. H. (2008). Specificity of the 'jump-to-conclusions' bias in deluded patients. *British Journal of Clinical Psychology*, *47*, 239-244.
- Picchioni, M. M., & Murray, R. M. (2007). Schizophrenia. *BMJ*, *335*, 91-95.
- Pohl, R. (2004). Introduction: Cognitive illusions. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 1-20). East Sussex: Psychology Press.
- Poulton, R., Caspi, A., Moffitt, T. E., Cannon, M., Murray, R., & Harrington, H. (2000). Children's self-reported psychotic symptoms and adult schizophreniform disorder. *Archives of General Psychiatry*, *57*, 1053-1058.
- Randall, F., Corcoran, R., Day, J., & Bentall, R. (2003). Attention, theory of mind, and causal attributions in people with persecutory delusions. *Cognitive Neuropsychiatry*, *8*, 287-294.
- Reber, R. (2004). Availability. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 147-166). East Sussex: Psychology Press.

- Rodier, M., Prévost, M., Renoult, L., Lionnet, C., Kwann, Y., Dionne-Dostie, E., et al. (in press). Healthy people with delusional ideation change their mind with conviction. *Psychiatry Research*.
- Ross, K., Freeman, D., Dunn, G., & Garety, P. A. (2011). A Randomized Experimental Investigation of Reasoning Training for People With Delusions. *Schizophrenia Bulletin*, 37, 324-333.
- Samuels, M. C., & McDonald, J. (2002). Elementary school-age children's capacity to choose positive diagnostic and negative diagnostic tests. *Child Development*, 73, 857-866.
- Seligman, M., & Maier, S. (1967). Failure to escape traumatic shock. *Journal of Experimental Psychology*, 74, 1-9.
- Skinner, B. H. (1948). Superstition in the pigeon. *Journal of Experimental Psychology*, 38, 168-172.
- Smith, H. D. (1998). Misconceptions of chance: Developmental differences and similarities in use of the representativeness heuristic. *Psychological Reports*, 83, 703-707.
- Smith, N., Freeman, D., & Kuipers, E. (2005). Grandiose Delusions: An Experimental Investigation of the Delusion as Defense. *The Journal of Nervous and Mental Disease*, 193, 480-487.
- So, S., Freeman, D., & Garety, P. A. (2008). Impact of state anxiety on the jumping to conclusions delusion bias. *Australian and New Zealand Journal of Psychiatry*, 42, 879-886.
- So, S. H., Garety, P. A., Peters, E. R., & Kapur, S. (2010). Do Antipsychotics Improve Reasoning Biases? A Review. *Psychosomatic Medicine*, 72, 681-693.

- Speechley, W., Moritz, S., Ngan, E., & Woodward, T. S. (in press). Impaired integration of disconfirmatory evidence and delusions in schizophrenia. *Journal of Experimental Psychopathology*.
- Speechley, W., & Ngan, E. T. C. (2008). Dual-stream modulation failure: A novel hypothesis for the formation and maintenance of delusions in schizophrenia. *Medical Hypotheses*, *70*, 1210-1214.
- Speechley, W., Whitman, J., & Woodward, T. S. (2010). The contribution of hypersalience to the "jumping to conclusions" bias associated with delusions in schizophrenia. *Journal of Psychiatry and Neuroscience*, *35*, 7-17.
- Spidel, A., Lecomte, T., & LeClerc, C. (2006). Community implementation successes and challenges of a cognitive-behavior therapy group for individuals with a first episode of psychosis. *Journal of Contemporary Psychotherapy*, *36*, 51-58.
- Staddon, J., & Simmelhag, V. (1971). The "superstition" experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, *78*, 3-43.
- Startup, M., & Startup, S. (2005). On two kinds of delusion of reference. *Psychiatry Research*, *137*, 87-92.
- Strauss, J. S. (1969). Hallucinations and delusions as points on continua function. Rating scale evidence. *Archives of General Psychiatry*, *21*, 581-586.
- Szöke, A., Trandafir, A., Dupont, M., Méary, A., Schürhoff, F., & Leboyer, M. (2008). Longitudinal studies of cognition in schizophrenia: meta-analysis. *The British Journal of Psychiatry*, *192*, 248-257.

- Taylor, S. E., & Crocker, J. (1981). Schematic bases of social information processing. In E. T. Higgins, C. P. Herman & M. P. Zanna (Eds.), *Social Cognition: The Ontario Symposium* (Vol. 1, pp. 89-134). Hillsdale, NJ: Lawrence Erlbaum Associates Inc.
- Teigen, K. H. (2004). Judgements by representativeness. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 165-182). East Sussex: Psychology Press.
- Thompson, S. (2004). Illusions of control. In R. F. Pohl (Ed.), *Cognitive Illusions: A Handbook on Fallacies and Biases in Thinking, Judgement and Memory* (pp. 115-126). East Sussex: Psychology Press.
- Thompson, S., Armstrong, W., & Thomas, C. (1998). Illusions of control, underestimations, and accuracy: A control heuristic explanation. *Psychological Bulletin*, 123, 143-161.
- Trope, Y., & Bassok, M. (1982). Confirmatory and diagnosing strategies in social information gathering. *Journal of Personality and Social Psychology*, 43, 22-34.
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, 5, 207-232.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185, 1124-1131.
- Van Dael, F., Versmissen, D., Janssen, I., Myin-Germeys, I., van Os, J., & Krabbendam, L. (2006). Data gathering: Biased in psychosis? *Schizophrenia Bulletin*, 32, 341-351.

- van Hooren, S., Versmissen, D., Janssen, I., Myin-Germeys, I., Campo, J., Mengelers, R., et al. (2008). Social cognition and neurocognition as independent domains in psychosis. *Schizophrenia Research*, *103*, 257-265.
- van Os, J. (2003). Is there a continuum of psychotic experiences in the general population? *Epidemiologia e Psichiatria Sociale*, *12*, 242-252.
- van Os, J., Hanssen, M., Bijl, R. V., & Vollebergh, W. (2001). Prevalence of psychotic disorder and community level of psychotic symptoms. *Archives of General Psychiatry*, *58*, 663-668.
- van Os, J., & Kapur, S. (2009). Schizophrenia. *The Lancet*, *374*, 635-645.
- van Os, J., Linscott, R. J., Myin-Germeys, I., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness–persistence–impairment model of psychotic disorder. *Psychological Medicine*, *39*, 179-195.
- Warman, D. M., Lysaker, P. H., Martin, J. M., Davis, L., & Haudenschild, S. L. (2007). Jumping to conclusions and the continuum of delusional beliefs. *Behaviour Research and Therapy*, *45*, 1255-1269.
- Warman, D. M., & Martin, J. M. (2006). Jumping to conclusions and delusion proneness: The impact of emotionally salient stimuli. *Journal of Nervous and Mental Disease*, *194*, 760-765.
- Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. *The Quarterly Journal of Experimental Psychology*, *12*, 129-140.
- Wechsler, D. (1997). *Wechsler Memory Scale III (WMS-III)* (3rd Edition ed.). San Antonio, Texas: The Psychological Corporation.

- Whitman, J., Menon, M., Kuo, S., & Woodward, T. S. (submitted). Bias in favor of self-selected hypotheses is increased in delusional schizophrenia patients. University of British Columbia.
- Whitman, J., & Woodward, T. S. (in press). Evidence affects hypothesis judgements more if accumulated gradually than if presented instantaneously. *Psychonomic Bulletin & Review*.
- Whitman, J., & Woodward, T. S. (submitted). Self-selection bias in hypothesis comparison. University of British Columbia.
- WHO (2004). *World Health Organization quality of life (WHOQOL) - BREF*. Geneva, Switzerland: World Health Organization.
- Woodward, T. S., Buchy, L., Moritz, S., & Liotti, M. (2007). A bias against disconfirmatory evidence is associated with delusion proneness in a nonclinical sample. *Schizophrenia Bulletin*, 33, 1023-1028.
- Woodward, T. S., Mizrahi, R., Menon, M., & Christensen, B. K. (2009). Correspondences between theory of mind, jumping to conclusions, neuropsychological measures and the symptoms of schizophrenia. *Psychiatry Research*, 170, 119-123.
- Woodward, T. S., Moritz, S., & Chen, E. Y. H. (2006a). The contribution of a cognitive bias against disconfirmatory evidence (BADE) to delusions: A study in an Asian sample with first episode schizophrenia spectrum disorders. *Schizophrenia Research*, 83, 297-298.
- Woodward, T. S., Moritz, S., Cuttler, C., & Whitman, J. C. (2006b). The contribution of a cognitive bias against disconfirmatory evidence (BADE) to delusions in schizophrenia. *Journal of Clinical and Experimental Neuropsychology*, 28, 605-617.

- Woodward, T. S., Moritz, S., Cuttler, C. C., & Whitman, J. (2004). A generalized cognitive deficit in integrating disconfirmatory evidence underlies delusion maintenance in schizophrenia. *Schizophrenia Research, 67*, 79.
- Woodward, T. S., Moritz, S., Menon, M., & Klinge, R. (2008). Belief inflexibility in schizophrenia. *Cognitive Neuropsychiatry, 13*, 267-277.
- World Health Organization (2011). Schizophrenia Retrieved December 2011
- Wright, J. C. (1962). Consistency and complexity of response sequences as a function of schedules of noncontingent reward. *Journal of Experimental Psychology, 63*, 601-609.
- Wykes, T., Steel, C., Everitt, B., & Tarrier, N. (2008). Cognitive Behavior Therapy for Schizophrenia: Effect Sizes, Clinical Models, and Methodological Rigor. *Schizophrenia Bulletin, 34*, 523-537.
- Young, H. F., & Bentall, R. P. (1997). Probabilistic reasoning in deluded, depressed and normal subjects: Effects of task difficulty and meaningful versus non-meaningful material. *Psychological Medicine, 27*, 455-465.
- Zimmermann, G., Favrod, J., Trieu, V. H., & Pomini, V. (2005). The effect of cognitive behavioral treatment on the positive symptoms of schizophrenia spectrum disorders: A meta-analysis. *Schizophrenia Research, 77*, 1-9.