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Measuring the Flexibility of Delusion-Like Beliefs in Non-Clinical Samples: Development and Validation of the Windsor Belief Flexibility Scale (WBFS)

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by

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ABSTRACT

This series of five studies examined the nature of belief flexibility for delusion-like beliefs in non-clinical samples. Findings in the literature show an overlap in psychotic symptoms between clinical and non-clinical populations. While studies about the flexibility of clinical delusions abound in the literature, there is a dearth of research pertaining to the flexibility of unusual delusion-like beliefs (i.e. beliefs that do not meet criteria for clinical significance). The aims of this dissertation were to: (1) develop and validate a new self-report measure, the Windsor Belief Flexibility Scale (WBFS), for measuring the flexibility of delusion-like beliefs in non-clinical samples, (2) to establish relationships between belief flexibility and reasoning processes already demonstrated to be related to delusional thought such as belief conviction, Jumping-to-Conclusions (JTC), and Bias Against Disconfirmatory Evidence (BADE), (3) to investigate the relationships between belief flexibility and these reasoning processes with affect, and (4) to compare the nature of belief flexibility for delusion-like beliefs with other belief domains (such as scientific, religious and political). The development of the measure is described in Chapter 2. Clark and Watson's (1995) recommendations for scale development were followed to generate a two part measure: (1) a pool of delusion-like beliefs, which were reduced using exploratory factor analytic techniques (EFA; Study 1), and replicated using confirmatory factor analysis (CFA; Study 2) and (2) a theoretically driven item pool for rating aspects of belief flexibility for selected delusion-like beliefs in Studies 3 (EFA) and 4 (CFA). The resulting model included two second-order factors of belief flexibility

and belief conviction, with the former composed of first-order factors of willingness to consider contradictory evidence and willingness to consider contradictory social feedback and the latter composed of unwillingness to doubt belief and intuitive reasoning**.** Convergent and divergent validity was explored by measuring relationships between the WBFS, its subscales, and related constructs (e.g., schizotypy, insight, cognitive flexibility, dichotomous thinking, and reasoning biases). In Study 5, the WBFS was used to investigate the generalization of a model of reasoning biases derived in clinical populations (So et al., 2012) to a general population sample. Results from this study replicated the distinction between conviction, belief flexibility and Jumping-to-Conclusions. The BADE was added to the model, and correlations with paranoia, worry, anxiety, and depression were explored. The BADE bias was positively associated with persecutory thoughts and anxiety and negatively associated with worry. No other significant or sizable associations were noted. Finally, using a partial invariance factor analytic method, belief flexibility and reliance on intuitive reasoning for different types of beliefs (e.g. political, religious and scientific beliefs) were examined. Implications for construct validity of the WBFS are discussed.

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CHAPTER 1

General Introduction

People hold a wide variety of beliefs ranging from simple explanations for every day events and experiences, to more nuanced social beliefs (e.g. religious, political) that are central to the formation and maintenance of identity. According to Domasio (2000), the purpose of beliefs is to provide meaning about ideas we hold about ourselves and our world. Some beliefs (e.g. religious beliefs) can be helpful in helping individuals cope with stressful situations (Paragment et al., 2012), while other beliefs (e.g. paranoid beliefs) can be harmful, creating distress for individuals (Peters, Joseph, & Garety, 1999). In the case of delusional beliefs, some beliefs are so distressing that the individual may require clinical intervention. In fact, research into the prevalence of delusions in non-clinical populations suggests that delusion-like beliefs may be held by as much as 25% of the general population (Peters et al., 1999). This is much higher than the prevalence of schizophrenia, the mental health condition characterized by clinically significant delusions and/or other unusual perceptual experiences, which is estimated at about 1% (Saha, Chant, Welham, & McGrath, 2005). This suggests that delusions likely exist on a continuum of clinical significance where only a small minority of beliefs evokes clinically significant symptoms such as subjective distress or behavioral dysfunction (Blackwood et al., 2001; Claridge, 1994; Van Os et al., 2008).

While the exact nature of clinically significant delusions is the subject of much debate (e.g. Mullen et al, 2014), there is some indication that subjective distress may be one of the only phenomenological features that distinguish them from other beliefs that are not clinically relevant (Peters et al., 1999). However, much remains to be learned

about the nature of delusion-like beliefs in non-clinical populations. The overarching purpose of this dissertation was to gain a better understanding of the features and phenomenology of delusion-like beliefs as they are distributed in the general population. Specifically, the aim was to provide a more robust conceptualization of belief flexibility when applied to delusion-like beliefs and to clarify the relationships between belief flexibility and other processes that may play a role in the development and maintenance of delusions.

Belief and Delusions

Despite the ubiquity of the term 'belief' in every day conversation as well as scientific discourse, it is somewhat surprising that there is little philosophical agreement about what a belief actually is. For example, while proponents of representationalism (e.g. Fodor, 1990; Dretske, 1998) agree that a belief is the state of having a representation (i.e. symbol) of a proposition stored in the mind, they disagree about the nature of the representation. Yet another school of thought, dispositionalism (e.g. Schwitzgebel, 2013), places greater emphasis on patterns of actual and potential behavior. In this group, disagreement exists between those who emphasize the importance of observable behavior as a marker of belief (e.g. Dennett, 1991) and those (e.g. Schwitzgebel, 2013) who allow private mental events that are not publically expressed in the range of behavioural dispositions that mark the existence of a belief. Finally, still others advocate eliminativism: the view that the common-sense view of how the mind works is fundamentally false and that mental state that signifies the presence of a belief does not actually exist (e.g. Churchland, 1981). These philosophers posit that this view is

supported by the very existence of subjective experiences that have been difficult to understand by psychology (e.g. delusions, dream states).

Even among the philosophers who do endorse the common-sense view of psychology, there is disagreement about whether delusions are belief states. The clinical definition of delusions accepted by psychologists and psychiatrist as firmly held beliefs that do not change in response to contradictory evidence (American Psychiatric Association, 2013). Thus, this view, which is most widely accepted by psychologists and psychiatrists conceives of delusions as irrational beliefs. The phenomenologist account of delusions (e.g. Gold & Hohwy, 2000) concedes that delusions encompass irrational beliefs, but argue that irrational beliefs are secondary to the subjective reality or mode of experience that involves shifts in familiarity or sense of reality. That is, they argue that it is not irrational reasoning about an anomalous experience per se that is central to delusions; rather it is the subjective experience of having a thought that feels foreign, that is in and of itself delusional. According to this view, delusions are qualitatively distinct from other belief states in that they do not possess a quality of 'experiential irrationality', and therefore are not continuous with other irrational beliefs.

Some philosophers go further to challenge the clinical definition of delusions as illogical inferences about evidence. For example, it has been argued that some delusions are not based on evidence at all. Campbell (2001) argues that a patient who looks at a row of marbles and becomes convinced that the world is going to end, does not appear to be using logical inference. Others argue that delusions do not interact with cognitive states and behavior the way that beliefs do (Bayne & Pacherie, 2005). For example, Breen and colleagues (2000) describe a patient who correctly believed that her husband had died

and been cremated four years earlier, but simultaneously held the belief that he was a patient in the same ward as her. Yet another view on delusions is that they are in fact cognitive hallucinations (Currie et al., 2000). This view conceptualizes delusions as imaginative states that are mislabeled as beliefs. In other words, delusions are conceptualized as metacognitive errors in monitoring mental states. Still other more radical conceptualizations characterize delusions as "empty speech acts that disguise themselves as beliefs" (Berrios, 1991), with the content being random fragments of information "trapped" in the moment the delusion is formed.

While consensus regarding the nature of delusions has proven elusive, many philosophers and clinicians agree that they share some similarities to beliefs. Beliefs have been conceptualized as a sensation of agreement with a thought (Ginsberg, 1972), as judgments of probability (Fishbein and Ajzen, 1975) and as propositional attitudes (Mullen and Gillet, 2014). Implicit in the current treatment approaches for delusions is that they are beliefs that can be challenged and revised. For example, cognitive behavioural approaches emphasize questioning the plausibility and consistency of patient's delusional beliefs (Chadwick & Trower, 1996). Some have made the argument that the more central question about delusions is not whether or not they are beliefs per se, but whether they are like non-delusional beliefs (e.g. the belief that gravity exists, or the belief that god exists) and if so where on a continuum and/or continuum of belief states they should be placed (Mullen and Gillet, 2014).

Some critics of the argument that delusions constitute a belief form, still acknowledge that some delusions are best understood as the result of disruptions in the belief process (e.g. Sass, 1994). According to these critics, while a delusion of

pathological jealousy can be conceptualized as an extreme form of a normative belief, it is more difficult to describe a bizarre delusion about aliens having removed the person's brain as continuous with any normative belief. As a result of this discrepancy, some authors have advocated the idea that there may be more than one kind of delusion. For example, Mullen (2003) suggests that some delusions are better understood as constituting part of a continuum with normative beliefs whereas others may best be conceptualized as completely distinct from normative beliefs.

If we accept the assumption that delusions are a form of belief (as is done for the purpose of the present dissertation), and also acknowledging that the content of a delusion is not necessarily what makes it delusional, it becomes important to delineate the features of a belief that render it a delusion. One way to achieve this is by comparing the different features of beliefs across the hypothesized continuum between normal functioning and clinically significant experiences.

The Continuum View of Psychosis

The notion of continuity in schizophrenia has been approached in two different ways. The fully dimensional view advanced by Claridge (1994) and Raine (1991), views dimensionality at the level of personality and individual differences such that the construct of schizotypy is conceptualized as a personality trait in the general population. In this view, symptoms associated with psychosis may be adaptive or detrimental depending on variations on other dimensions, for example intelligence. In contrast, the quasi-dimensional view advanced by Peters et al. (1999) and Linney et al. (1998) derives from the work of Meehl (1989) which posits "a dominant autosomal schizogene" that creates synaptic defects that give rise to schizotypy which is conceptualized as a

personality profile that is a precursor for the emergence of clinically significant psychosis. This model takes the 'abnormal' psychotic state as its reference point, and conceptualizes a continuum of psychosis ranging from aberrant personality characteristics observed in schizotypal personality (e.g. tendency to endorse magical thinking) to clinically significant delusions. A smaller proportion of the population is thought to comprise the quasi-dimensional continuum while the fully-dimensional continuum suggests that subclinical psychotic symptoms that impact thought and behavior exist across the full spectrum of the population.

Although it is still unclear which model best captures the true nature of the underlying psychosis continuum, most attempts to create measurement tools for assessing sub-clinical subjective experiences typically observed in psychosis, in otherwise healthy samples, ascribe to one model or the other. For example, the Community Assessment of Psychotic Experiences, (Stefanis et al., 2002) is consistent with the fully dimensional model, while the Peters Delusions Inventory (Peters, 1999) is based on the quasi-dimensional model. However, the extent to which these scales differ from each other is unknown and they are used fairly interchangeably in the literature.

Generally, individuals who score high on these measures have been shown to share a number of phenotypic characteristics with individuals diagnosed with schizophrenia, including cognitive-perceptual aberrations, interpersonal deficits and a degree of cognitive disorganization (Siever et al., 2002). For example, cognitive impairments in attention, reasoning, cognitive inhibition, verbal working memory, and recognition memory as well as differences in brain structure (e.g. grey matter reduction in certain brain regions) are present in individuals with schizotypal personality disorder,

albeit to a smaller extent than they are observed in schizophrenia (Cadenhead et al., 1999; Menon et al., 1995; Shenton et al., 1992). Children of and first degree relatives of people with psychotic disorders tend to demonstrate a lesser degree of cognitive impairments in several domains including verbal memory, executive functioning and attention (Owens & Johnstone, 2006; Sitskoom et al., 2004) and twin studies support a genetic link between schizophrenia and schizotypy (Kendler & Hewitt, 1992; Linney et al., 2003).

The continuum account suggests that delusion-like beliefs are much more prevalent in the general public than their clinically significant counterparts. For example, findings from the large British Psychiatric Morbidity Survey (Jenkins, 2003) indicated that approximately 9% of respondents reported experiencing 'thought insertion', a delusional belief that is closely associated with positive psychotic symptoms and Lincoln (2007) found that delusional beliefs (e.g., belief in telepathic communication; or a belief that there are no thoughts present in one's mind), were endorsed by 24% of the general population. These figures are much higher than the prevalence rates for diagnosed psychotic disorders (including schizophrenia), suggesting that only a small percentage of the beliefs on the continuum of healthy functioning and psychosis actually escalate to the level of clinically significance and most of the distribution of unusual beliefs are not associated with distress or disability (Johns and van Os, 2001; McGovern & Turkington, 2001; Van Os et al., 2008; Ward & Garety, 2017). Such a continuum is not based on one factor (e.g. degree of conviction for delusional beliefs) and people may differ in the frequency, intensity and number of symptoms that they present with at any given time (Perchy & Halligan, 2010).

Delusion-Like Beliefs

Given that delusions are considered to be a pathological belief form (Davies et al., 2001; Langdon & Coltheart, 2000), some researchers have turned their attention to studying delusion-like beliefs in the general public (e.g., Perchy & Halligan, 2010; Lincoln, 2007; Peters, Joseph & Garety, 1999; Peters et al., 2004; Verdoux et al., 1998). The convergence of findings from these studies suggests that while subclinical levels of psychotic symptoms do not signify the presence of mental illness, they may indicate a higher vulnerability to psychosis (Galbraith et al., 2014).

In this dissertation, the term 'delusion-like belief' refers to a belief with delusional content (i.e. more uncommon themes), but without the clinical distress associated with delusions. Such beliefs are often observed in individuals without clinical distress, who score high on measures of schizotypy. In contrast, fully developed delusions are hallmarks of schizophrenia and related disorders, and are characterized by clinically significant levels of distress.

Just like delusions, delusion-like beliefs can be conceptualized as multidimensional (Peters, 1999), and many studies have examined these beliefs with respect to levels of preoccupation, conviction, and distress. Lincoln (2007) found that levels of self-reported conviction and preoccupation for beliefs with delusional content were statistically similar across clinical and non-clinical samples and that the only factor that distinguished these groups was distress associated with the belief. That is, the only difference between clinically meaningful delusions and delusion-like beliefs may be the affective distress experienced by the individual, as a result of (equally) firmly held beliefs.

Investigations of individuals belonging to New Religious Movements (NRMs) such as Hari Krishna devotees and Druids also contribute to support a multidimensional view of delusion-like beliefs. One study revealed that individuals belonging to these groups endorse more delusion-like beliefs, which they tend to hold with a higher level of conviction compared to non-religious and Christian groups (Peters et al., 1999). However, these groups did not differ in terms of distress. When compared to delusional individuals, the NRM group and clinically deluded group were not distinguishable in their level of endorsement of delusional beliefs. They also showed similar levels of conviction about the delusion-like beliefs that they did endorse. However, individuals from the NRM groups were significantly less distressed and preoccupied by the delusion-like experiences that they endorsed compared to the clinically deluded group. There were no differences between religious and non-religious groups on any of the delusion measures.

Some researchers have focused on comparing and contrasting the phenomenology of clinical and non-clinical beliefs. For example, Jones (1999) compared two distinct classes of clinically significant beliefs (i.e. delusions present in psychosis, and overvalued ideas present in eating disorders) and non-clinical beliefs (i.e. extremist religious beliefs in a non-clinical sample). Participants were asked to rate their beliefs on a number of phenomenological features (e.g., conviction, personal importance, perceived truthfulness, acceptability, preoccupation, reliance on perceptual input vs. imagination, speed of formation). They also gathered ratings for a number of non-inferential beliefs about the sensory state of the perceiver (e.g. 'this is a chair' in response to a visual depiction of a

chair), and beliefs that require subjective evaluation (e.g. 'democracy is a superior form of political organization to oligarchy)'.

This study revealed that all belief types were rated at similar levels of personal importance. Religious beliefs in the general population sample and delusional beliefs of the sample with schizophrenia were held with equal conviction, and were assigned equally high levels of objective truthfulness. What distinguished delusions from religious beliefs were higher preoccupation, more rapid belief formation, greater reliance on perceptual input, and a lower degree of reliance on imagination. Delusions were also rated more similarly to religious beliefs when compared to overvalued ideas associated with eating disorders. Another important finding from this study was that the psychotic sample rated the descriptive statements (e.g. 'this is a chair') and delusional beliefs similarly on conviction, truthfulness, use of imagination and perceptual input. That is, delusions had the subjective sense of similar impact and certainty to actual observed events. These findings support the notion that the mere presence of atypical beliefs does not imply the presence of psychopathology, with distinctions between normative and delusional beliefs being driven by differences on phenomenological dimensions including greater preoccupation, more rapid formation, greater reliance on perceptual input, a lower degree of reliance on imagination, and levels of conviction and truthfulness that are unjustifiably high.

In addition to how a belief is held, a delusion-like belief likely possesses certain themes that are considered implausible. Based on the definition of delusion-like beliefs offered above, these beliefs should share themes similar to clinically significant delusions. One feature relevant to the phenomenological characteristics of delusion-like

beliefs is the general/cultural plausibility of the theme. This is an important feature, because a lack of social consensus about the validity of a belief signals that something may be awry in the belief formation and maintenance systems for a given individual. For example, in a culture where it is widely believed that people can communicate with dead loved ones, this belief does not necessarily signal delusional thought. However, when held by a person from a cultural background in which this is viewed as an atypical way of thinking, this belief may indicate that person may be losing touch with reality.

An example of a content theme that characterizes delusion-like beliefs is that of conspiracy theories. Conspiracies theories can be conceptualized as beliefs about systemic conspiracies that are held with conviction, despite the existence of more plausible explanations. Aaronovitch (2010) defines a conspiracist belief as "a belief that requires the acceptance of many unnecessary assumptions when simpler explanations are more plausible" (p.233). The literature on the formation and maintenance of conspiracist beliefs is limited. The most widely established finding from this small literature is that people who accept one conspiracy theory tend to endorse numerous other unrelated fictitious (Swami et al. 2010; 2011), and/or contradictory theories (Wood et al., 2012). Taken together, the existing evidence suggests that endorsement of conspiracy theories may not reflect processes derived from the logical evaluation of evidence and may instead result from a characteristic tendency to explain experiences and events in terms of conspiracy. Swami and colleagues (2011) named this trait 'conspiracist ideation'. Darwin and colleagues (2011) found that conspiracist ideation was related to schizotypy and paranoid ideation, but not to paranormal beliefs (Darwin, Neave, & Holmes, 2011).

In addition to content (i.e. uncommon theme of what is believed), it was decided that delusion-like beliefs likely possess certain phenomenological features related to what the belief means to the individual's sense of identity. Prior efforts to measure belief flexibility using delusional samples have focused on assessing the flexibility of the most personally meaningful delusion identified by individuals with clinically significant delusions (e.g. So et al., 2012). This approach is supported by evidence suggesting that a key difference between mystical religious beliefs and psychotic delusions is that the former is characterized by construction of meaning about where the self fits into the universe whereas clinical delusions emphasize meaning of personal experiences in relation to the self (Chadwick, 2001). Therefore, for delusion-like beliefs held by non-delusional individuals to be conceptually equivalent to the delusional beliefs held by individuals with clinical delusions, the delusion-like beliefs should be relevant to the person's sense of self.

Taken together, the literature supports the notion that a continuum of normative and unusual beliefs exists between normal functioning and clinically significant psychosis, and demonstrate that clinical and non-clinical delusional beliefs are not distinguished by the content of the belief, but by the way the belief is held on dimensions including distress, preoccupation, and personal meaningfulness.

Psychological Theories of Delusions

Several psychological theories of delusions have been proposed in the literature. Some theorists posit that delusions emerge as a result of attempts to make sense of aberrant perceptual experiences (Maher, 2005). Coltheart and colleagues (2011) proposed a two-factor model of delusions which implicates perceptual anomalies as the first factor,

and impairment in metacognitive reasoning processes involved in the monitoring and revision of belief as the second factor. This model suggests that while perceptual anomalies lead to generation of implausible hypotheses, it is the faulty belief monitoring and revision system that permits the overvaluation of unusual beliefs and prevents unusual beliefs from being rejected.

The threat anticipation model of delusion formation advanced by Freeman and colleagues (2002) also posits a central role for abnormal perceptual experiences. This model identifies external events such as interactions with other people, negative affect, and self/other schemas as primary precipitating factors in the formation of delusions. The threat anticipation model proposes that negative self-schemas (e.g. "I am weak") lead to biased construals of the self and others, while elevated anxiety leads to hyper-vigilance for threat. The combination of negative schemas and hyper-vigilance leaves the individual feeling vulnerable such that sinister explanations for aberrant perceptual experiences appear more plausible than they otherwise might. This theory is supported by evidence that anxiety is associated with delusions in clinical and non-clinical samples (Fowler et al., 2006) and that paranoia is associated with negative self-schemas (Smith et al., 2006), worry (Freeman et al., 2013), and depression (Galbraith et al., 2014). This model further posits roles for reasoning biases such as biased data-gathering (Freeman et al., 2008), and self-referential reasoning (Galbbraith et al., 2008) in the establishment and consolidation of delusional hypotheses.

Reasoning Processes Relevant to Delusions

As reviewed in the preceding sections**,** most contemporary models of psychosis (e.g. Morrison, 2001) contend that it is the ways in which individuals attempt to make

sense of and respond to aberrant perceptual experiences, that determines whether they develop clinically significant psychotic symptoms (Underwood et al., 2016; Garety & Hardy, 2017). That is, the ways in which people reason about their mental experience is central to whether anomalous experiences are appraised as sinister and distressing, and potentially result in clinically significant delusional symptoms. Several reasoning processes have been implicated in the formation and maintenance of delusions. In the following sections, the Jumping-to-Conclusions bias, belief flexibility, and the dual processing model of reasoning are discussed.

Jumping-to-Conclusions (JTC)

The most robust and widely replicated of the biases associated with delusional thinking is the Jumping-To-Conclusions (JTC) reasoning style. The JTC reasoning style refers to the tendency of individuals with psychosis to gather less information than is available when making decisions, the consequence of which is jumping to the wrong conclusion (Garety et al., 1991). The most widely used research method for quantifying JTC is the Probabilistic Reasoning Task, also known as the Beads Task (Huq et al., 1998). In the original version of the task, participants are shown two jars which contain beads of two different colours, in complementary ratios, for example 85:15 red to black vs. 85:15 black to red. In variants of this task, different stimuli are used in place of beads, different dimensions are used in place of color, and/or the ratio of the stimulus dimensions to one another is changed. The jars are hidden from view, the participant is told that beads will be drawn from only one of the two jars, and is asked to guess from which jar the beads are being drawn. The experimenter then presents beads one at a time, ostensibly from one of the jars, but the order of selection of beads is actually

predetermined. The variable of interest is the number of draws before a decision is made and the JTC bias is defined as making a decision after two draws or fewer (Garety et al., 2005).

Recent systematic reviews and meta-analyses have shown that individuals with psychosis consistently show the JTC data gathering bias, as they make decisions based on limited information (Dudley et al., 2016; Garety and Freeman, 2013; So et al., 2012). There is also some evidence for the specificity of JTC bias to delusional symptomology, with some research suggesting that JTC is linked to a higher probability of delusional symptoms in psychotic samples (So et al., 2012), and with other research showing that groups diagnosed with schizophrenia (with current delusions) showed a greater JTC bias than those without the diagnosis (Mclean et al., 2016). Furthermore, JTC bias has been observed in an attenuated form in individuals recovering from delusional disorders (Peters et al., 2006) and has been associated with delusional thinking in the general population (Freeman et al., 2008; Van Dael et al., 2006) and in high-risk individuals (e.g. relatives of psychotic individuals; Broome et al., 2007; Van Dael et al., 2006). There is also evidence that JTC co-varies with delusional severity over time (Woodward et al., 2009) and that the stability of JTC over time is associated with exacerbation of symptoms (Dudley et al., 2013). Other evidence suggests that training in reasoning can improve data gathering (Ross et al., 2011) and reduce delusional conviction (Mortiz et al., 2011; Waller et al., 2011). Taken together, the literature suggests that JTC may play a causal role in the formation and maintenance of delusions.

Belief Flexibility

Belief flexibility in the context of psychosis has been defined by Garety et al. (2005), as "a metacognitive process about thinking about one's own delusional beliefs, changing them in light of reflection and evidence and generating and considering alternatives" (p. 374). A review of the literature identified two existing general research methods for measuring belief flexibility. These included direct assessment of belief flexibility regarding delusions during clinical interviews, and using delusion-neutral tasks to assess tendencies to avoid the use of contradictory evidence when reasoning about or evaluating delusional beliefs.

The direct assessment method involves querying belief flexibility using structured clinical interviews including the Maudsley Assessment of Delusions Schedule (MADS; Wessley et al., 1993) and the Explanation of Experiences Assessment (EoE; Freeman et al., 2004). The responses on these interviews are dichotomously coded for the presence of three variables: Possibility of Being Mistaken (PM), Response to Hypothetical Contradiction (RTHC), and the ability to generate Alternative Explanation of Experiences (EoE). Using this method, belief flexibility is operationalized as being either present or absent with respect to a personally meaningful delusional belief. A lack of belief flexibility as measured by the variables above was shown to predict severity of psychotic symptoms (Garety et al., 1997) and was strongly related to delusional conviction in a sample of psychotic individuals who were followed for a year following relapse (So et al., 2012). Comparable studies that assess belief flexibility in general populations are scarce, and the only study that has attempted to compare the flexibility of personally meaningful beliefs in the general population with clinical populations was rife

with methodological problems (Colbert et al., 2010). For example, while the personally meaningful beliefs identified by the clinical group reflected delusions, the personally meaningful beliefs elicited from the non-clinical group appeared to capture statements of values, hopes, or goals for the future. Furthermore, the dichotomous coding of belief flexibility likely artificially disregards the possibility of variation in the degree to which different people may exhibit flexibility for delusional beliefs. Therefore, applying continuous multi-item measurement to belief flexibility is needed. These methodological issues are discussed in more detail in Chapter 3.

Another method for measuring belief flexibility (or lack thereof) which is not directly tied to delusional symptoms is the Bias Agianst Disconfirmatory Evidence (BADE; Moritz and Woodward, 2006). The BADE refers to whether people revise beliefs when presented with disconfirmatory evidence. This construct is measured using a delusion-neutral task. Though many versions of the BADE exist, they all share a similar general structure. Participants are presented with an ambiguous scenario, followed by the sequential presentation of three pieces of disambiguating information, one piece at a time. Subsequent to viewing each piece of information, participants are asked to rate the plausibility of a number of interpretations of the scenario being assessed. The same interpretations are presented across all three trials. They are categorized as true, absurd, and lure, and the lures are either neutral or emotionally evocative. In original versions of the task, small (or non-existent) reductions in ratings for lure items (i.e. initially plausible interpretations that become less likely as more information is provided) were operationalized as evidence of the BADE (Mortiz & Woodward, 2006). Due to methodological issues inherent in using difference scores in the calculation of the BADE,

multivariate methods of scoring have been developed, and have gained wider use (Bronstein and Cannon, 2017; Sanford et al., 2014; Speechley et al., 2012). These methodological implications are discussed further in Chapter 3.

The BADE has shown consistent positive associations with diagnoses of schizophrenia and severity of delusional symptoms (Eisenacher & Zinc, 2016; Speechley et al., 2012). It has also shown significant correlations with subclinical delusional ideation (Menon et al., 2013; Zawdzki et al, 2012). However, how the BADE is related to belief flexibility remains an unanswered empirical question.

Dual Process Models of Reasoning

Recently, dual process models of cognition (e.g. Kahneman, 2011; Evans & Stanovich, 2013) have gained attention as a framework for understanding the mechanisms that underlie the formation and maintenance of delusions. These models posit two processing streams that play distinct roles in judgment and decision making: a fast or heuristic, more intuitive stream (Stream 1), and a slower, more analytic stream (Stream 2). According to default-interventionist dual processing models (e.g. Evans & Stanovich, 2013), Stream 1 is the operational default which remains in charge unless overridden by the inhibitory intervention of the slower analytic Stream 2. The override function is triggered when more than one plausible explanation exists signaling that analytic evaluation is required. The slow analytic Stream 2 is posited to involve two types of processes: one that is characterized by a regulatory state of reflection that activates analytic thinking, and another that allows for disengagement of attention from current perceptual representations in order to engage in hypothetical/analytic thinking.

A growing body of evidence spurred by interest in dual process theories of reasoning (Kahneman, 2011; Evan& Stanovich, 2013) suggests that over-reliance on intuitive (i.e. rapid, instinctive, non-analytic) reasoning (referred to as Stream 1) and under-reliance on analytic (i.e. effortful, deliberate reasoning (referred to as Stream 2), may underlie the formation and/or maintenance of delusional beliefs (e.g. White & Mansell, 2009; Speechley et al., 2010; Speechley et al., 2013; Freeman et al., 2012; Balzan et al., 2013). For example, Speechley and colleagues (2013) argue that when presented with a decision-making task where only one obvious hypothesis presents itself, Streams 1 and 2 would converge on the same conclusion. In this case, Stream 1 can be relied upon to make accurate decisions. However, in the presence of more than one multiple potential correct decisions, the individual will experience a sense of conflict, which results in the activation of Stream 2's more effortful, algorithmic reasoning. They add that highly emotional states are likely to bias the reasoning system towards more reflexive, hastily made decisions indicative of Stream 1 operation (White & Mansel, 2009; Christopher & MacDonald, 2005). They posit that individuals with delusional thought encounter a 'dual stream modulation failure' wherein the sense of conflict fails to trigger Stream 2 processing, while highly emotional states bias the system toward Stream 1, such that erroneous explanations generated by System 1 go unchecked, and the delusional belief persists.

Research shows that the intensity of paranormal and superstitious beliefs has shown small positive associations with experiential reasoning while demonstrating small negative associations with rational reasoning (Aarnio and Lindeman, 2005, Freeman et al., 2012). Reliance on experiential reasoning has also been associated with paranoid

thinking in non-clinical populations, while a preference for rational thinking has been associated with fewer paranoid thoughts (Freeman et al., 2012). In a follow up study using a larger sample (Freeman et al., 2014), the inverse association between paranoia and rational reasoning was replicated but no associations were found between paranoia and experiential reasoning. Ward et al. (2017) showed that experiential reasoning was associated with severity of psychotic symptoms while higher levels of rational reasoning combined with the absence of JTC were protective against the development of need-for-care in individuals with psychosis. Taken together, these findings provide preliminary evidence for individual differences in analytic reasoning as a protective factor and individual differences in experiential reasoning as a risk factor for development of delusional thinking.

Application of this framework to reasoning biases involved in delusions suggest that JTC may reflect the activation of fast Stream 1 processes, while the ability to step back and consider the possibility of being mistaken (i.e. belief flexibility/BADE) is reflective of operation of Stream 2 (Ward and Garety, 2017) and that it may be important in determining whether delusional ideas develop into clinically significant delusions which result in impairment of functioning.

Present Investigation

The continuum view of psychosis suggests that many people in the general population hold delusion-like beliefs without associated impairment or the need for clinical intervention. Studying individuals who are prone to delusions can offer the opportunity to better understand the contribution of reasoning biases and other cognitive processes to the development of delusions. In order to allow for comparisons across the

psychosis continuum, consistency in measurement across populations is important. Thus, the primary aim of Chapter 2 was to develop and validate a measure of belief flexibility specific to a delusion-like belief which involves a broader conceptualization of belief flexibility as a multi dimensional construct. The aim of Chapter 3 was to use this instrument to replicate a model of reasoning biases originally developed with delusional individuals, using the newly developed and validated Windsor Belief Flexibility Scale in a non-clinical sample. A secondary aim of Chapter 3 was to explore the stability of belief flexibility across different domains of belief.

Overall, these studies help to clarify our understanding of the reasoning processes involved in the development of delusional thinking by refining the conceptualization and measurement of belief flexibility, and by providing a better understanding of the relationship between belief flexibility, belief conviction, and jumping-to-conclusions in non-clinical individuals.

CHAPTER 2

Measuring Belief Flexibility for Delusion-like Beliefs in the General Population

Introduction

The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders defines delusions as fixed beliefs that are not open to change, despite contradictory evidence (American Psychological Association 2013). However, evidence indicates that anywhere from 24-57% of individuals with diagnosed psychotic disorders are able to re-evaluate their delusional beliefs to some extent (Freeman et al., 2004; Garety et al., 2005; So et al., 2012). This phenomenon is referred to as belief flexibility. Ward and Garety (2017) define belief flexibility as the meta-cognitive skill of disengaging from a strongly held delusional belief so that other cognitive operations (e.g. considering possibility of being mistaken, integrating newer information, and generating other hypotheses), which are involved in decision making under situations of uncertainty, can be engaged.

Some studies have applied dual processing models of cognition, as proposed by Kahneman (2011) and others (e.g. Epstein, 1994) to conceptualize belief flexibility and other related reasoning biases. According to some models (e.g. Evans & Stanovich, 2013), Stream 1 is the default mode of operation unless inhibited by the slower analytic stream. The slower stream (Stream 2) is thought to consist of two levels of control: one that activates algorithmic thought and another level that when activated, disengages from present perceptual representations in order to engage in hypothetical/algorithmic thought (e.g. mental simulation).

Consistent with dual processing models, Pacini and Epstein (1999) developed The Rational Experiential Inventory (REI, Pacini and Epstein, 1999), a self-report

questionnaire that measures individual preferences for and enjoyment of conscious, analytical versus more affective, holistic approaches to problem solving. Positive correlations have been found between preference for experiential approaches on the REI and strength of paranormal, superstitious and paranoid beliefs, and inverse correlations have been reported between experiential preference and analytical reasoning (Aarnio and Lideman, 2005; Freeman et al., 2012). The data suggest that analytic reasoning may be protective against development of symptoms of paranoia, while reliance on intuitive reasoning may be associated with the development and strength of unusual beliefs across the psychosis continuum (Ward and Garety, 2017). Thus the elucidation of processes that influence belief flexibility necessitates attention to both experiential/intuitive as well as analytic processes.

Flexibility for delusional beliefs has been measured using various methods including clinical interviews about specific delusions (MADS, Wesseley at al., 1993; EoE, Freeman et al., 2004), and a delusion-neutral task assessing bias against disconfirmatory evidence (BADE, Moritz & Woodward, 2006). Two meta analyses have documented small to moderate relationships between belief flexibility as measured by BADE tasks and delusional severity as measured by clinician rated measures of psychotic symptoms (McLean, Mattiske, & Balzan, 2016; Eisenacher & Zink, 2016). A meta-analysis by Zhu and colleagues (2018) further showed that delusional conviction is associated with belief flexibility as measured by BADE tasks as well as the MADS interview. However, whether these findings hold for individuals in the less impaired end of the psychosis continuum is yet to be established.

The quasi-dimensional view of psychosis takes the psychotic state as its reference point and conceptualizes the psychosis continuum as varying degrees in the expression of symptoms, with schizotypy representing a trait that reflects the presence of attenuated psychotic symptoms. This view is supported by the overlap in psychotic symptoms between clinical and non-clinical populations (Freeman, 2006; Kelleher & Cannon, 2011; Taylor et al., 2014; Ward et al., 2017).

These studies show that between 24 to 30 percent of people in the population endorse delusional beliefs that meet diagnostic criteria (Freeman, 2007) with little if any associated distress or dysfunction. The presence of schizotypal traits can be measured using validated measures (e.g. PDI, Peters, 1999), and individuals who score high on measures of schizotypy without meeting diagnostic criteria for psychotic disorders share a number of sub-symptomatic phenotypic characteristics with individuals diagnosed with schizophrenia, including cognitive-perceptual aberrations, interpersonal deficits and cognitive disorganization (Siever et al., 2002).

There are few studies aimed at establishing belief flexibility across the psychosis continuum in the literature. This may partly be attributed to the fact that while it is not difficult to conceptualize and assess belief flexibility for delusions in individuals with psychotic illness (because there are target beliefs that can be elicited and assessed), it is arguably more difficult to elicit and measure delusion-like beliefs in non-clinical populations for whom target unusual beliefs are less obvious to identify. In non-clinical samples, it remains challenging to identify unusual beliefs that are conceptually equivalent to delusional beliefs in those with clinical delusions. To date, studies that have examined flexibility of unusual or delusion-like beliefs in the population have either

asked participants to rate neutral beliefs (e.g. rating scenarios on the BADE, Mortiz & Woodward, 2006; "the sun will rise tomorrow"; Colbert et al., 2010), or they have prompted non-delusional participants to provide personally meaningful beliefs that are not delusional in their content (e.g., "My kids will grow up and be happy"; "treat others as you'd like to be treated", "God exists"; Colbert et al., 2010). Both approaches fail to evaluate beliefs that are conceptually equivalent to personally meaningful delusional beliefs, as they are not sufficiently uncommon or distressing. They instead appear to be capturing statements of value, hopes, or goals for the future rather than the types of beliefs that reflect delusion-like content (e.g. paranoia, belief in telepathy etc) that result in distress and dysfunction, rendering the validity of the findings of such studies questionable.

The most commonly used methodology for assessing belief flexibility for clinical delusions involves a clinical interview which is based on the Maudsley Assessment of Delusions Schedule (MADS, Wessley et al., 1993) and the Explanation of Experiences Assessment (EoE) . The MADS and the EoE assess how people reason about delusional beliefs (e.g. Colbert et al., 2010; Garety et al., 1997; Khazaal et al., 2015) . Responses to are coded for the presence of three variables indicative of belief flexibility: (1) Possibility of Being Mistaken (PM), (2) Reaction to Hypothetical Contradiction (RTHC), and (3) generation of alternative explanations (So et al., 2012). A delusional belief is dichotomously rated as flexible if the person with the belief endorses any of these components.

While others have attempted to operationalize belief flexibility in non-clinical samples, the current study represents the first attempt to accomplish this construct in a

psychometrically validated self-report questionnaire format using multiple continuous items. Specifically, this set of studies aimed to develop and validate: (1) a self-report inventory of unusual delusion-like beliefs from which one or more personally meaningful beliefs can be selected, and (2) a self-report measure of belief flexibility that draws upon existing measures and dual processing models to establish factors that underlie flexibility for such beliefs in order to develop scale items.

Study 1

The first step undertaken in developing a self-report measure of belief flexibility related to delusion-like content involved generating a pool of unusual delusion-like beliefs to which items that measure belief flexibility can be anchored. To this end, the objective of Study 1 was to establish a set of unusual beliefs that commonly exist in the general population. A review of the literature indicated that the Peters Delusions Inventory (Peters et al., 1999) was one of the most well-established measures for assessing delusion-like beliefs and was selected as an indicator of the item pool's convergent validity. Therefore, it was decided that a new item pool of target beliefs be established. A literature review revealed relevant content in the areas of superstition, conspiracy theories, paranoia, and the paranormal (Eckbald and Chapman, 1983; Swami et al., 2010; Freeman et al., 2012; Tobacyk, 2004).

In Study 1, participants were randomly assigned to rate either the personal meaningfulness or perceived general consensus for a series of potential unusual delusion-like beliefs. This data was used to identify items characterized by high personal meaningfulness and low consensus, as these resemble delusional beliefs (which are characterized by high personal meaning and low general consensus). This is because

beliefs that are commonly held or those that are not personally meaningful are not sufficiently similar to delusional beliefs for the purposes of examining delusion-like beliefs.

Method

Participants. Participants were recruited from Amazon Mechanical Turk (MTurk). MTurk is an online labour market hosted by Amazon.com, which allows workers to complete tasks for monetary compensation. Eligibility for work is contingent on the quality of prior completed work and generally good task compliance. A total of 306 respondents completed the online survey, which took approximately 30 minutes and for which participants were provided a token of appreciation of $2.00 USD. Participants in the personal belief and general consensus conditions did not differ statistically on demographic characteristics. Demographics for the final sample were: $M_{age} =$ 34.69 (SD=9.84, Range: 19-70, Median = 33.2), 49% male, employment status (61% full time, 14% part time, 13% self-employed, 12% unemployed), education (12% graduate or professional, 47% university degree, 25% some post-secondary, 15% high school diploma, 1% some secondary), race/ethnicity (73% Caucasian, 6% Asian, 7% African-American, 4% Hispanic, 3% Biracial / mixed race, 8% Other or prefer not to answer). With respect to mental health diagnoses, 3% endorsed a prior or current diagnosis of Obsessive-Compulsive Disorder, 2% eating disorder, and 1% psychotic disorder. Given that unusual dysfunctional beliefs (e.g. obsessions in OCD; overvalued ideas in eating disorders) are central to these diagnoses, these participants were removed from the dataset.

Measures

Development of the Windsor Belief Flexibility Scale (WBFS): Part 1, Target Unusual Beliefs. The initial item pool of unusual beliefs consisted of 80 dichotomous yes/no items drawn from existing instruments that queried unusual delusion-like beliefs. Items reflecting lack of control, paranoia, and astrology were included from the Cardiff Belief Questionnaire (Perchy & Halligan, 2010). Items tapping belief in conspiracy theories were drawn from the Generic Conspiracy Beliefs Scale (Brotherton et al., 2013). Items assessing belief in phenomena that violate principles of science such as witchcraft, superstition, extraordinary life forms, spiritual beliefs and precognition were included from the Revised Paranormal Beliefs Scale (Tobacyk, 2004). The authors edited, deleted and added to the item pool, resulting in a pool of 55 items that were evaluated for the study. A validity check item was included that requested participants to provide an answer of 'yes'. All participants who failed to provide this response (N = 7) were removed from the dataset. See Appendix A for all target belief items tested.

Procedure. Eligible participants viewed a description of the study on MTurk. Interested participants followed a link that determined eligibility. MTurk workers who had completed a study in the lab previously were not eligible. If eligible, participants were referred to the online survey where they viewed a consent form. If they agreed to participate, they completed a demographics questionnaire and were subsequently presented with the 55 delusion-like beliefs, one item at a time in a randomized order, and were asked to indicate whether or not they believed each statement in a two-alternative forced-choice (yes/no) format.

Participants were then re-presented with the subset of beliefs that they endorsed (as 'Yes'), and responded to follow-up questions. Those assigned to the personal meaningfulness condition (n=148), rated each endorsed belief using the item, "Please indicate how meaningful this belief is to how you see yourself in relation to other people" (anchored 1 'very unimportant' to 7 'very important'). Those assigned to the consensus condition (n=158) rated each endorsed belief using the item "Please indicate to what extent people from your shared cultural background would hold this belief" (anchored 1 'nobody other than me', and 7 'everyone from my cultural background').

Results

Preliminary Analyses. Descriptive data were analyzed using IBM SPSS 23 and Mplus Version 7 software (Muthén & Muthén, 2012). Initially, the tetrachoric correlations for some item pairs could not be estimated due to infrequent item endorsement (<1% of the sample), and as a result, five items were removed. The endorsement rate for the 50 retained items was 21% on average (SD=16.8), and 35 items were endorsed by less than 25% of the sample.

Exploratory Factor Analysis. Mplus Version 7 software (Muthén & Muthén, 2012) was used to conduct an exploratory principle axis factor analysis on the yes/no responses to delusion-like beliefs to reduce the item pool. Factors were extracted using the weighted least squares means and variance adjusted method (WLSMV) and using an oblique rotation method (Geomin), allowing factors to correlate. Given the dichotomous nature of the data, tetrachoric correlations were used to estimate the model (Jöreskog, 1994). An inspection of frequencies indicated that univariate normality was violated for

almost all items. However, given the relative robustness of EFA parameter estimates to violations of normality, the data was not transformed for analysis.

Several issues were considered in determining how many factors to extract. Given that the items were adapted from three different questionnaires, it was decided that a minimum of 3 factors should be examined. An examination of the scree-plot and the Kaiser-Guttman criterion (eigenvalue > 1.0) indicated an initial nine-factor solution. Models ranging between three and nine factors were considered. Examination of the simple structure suggested that the six-factor solution represented the most optimal fit to the data. This solution explained 73% of item variance following rotation. An inspection of the residual error variance indicated that eight items had uniqueness values above .5, signifying that 50% or more of the variance in these items was not accounted for by the model. These items were excluded from the final item pool.

Remaining items with loadings of 0.5 or above, low cross loadings, and either high personal meaningfulness ratings (defined by mean ratings greater than 4) or low perceived general consensus (defined by mean ratings smaller than 4) were retained in the final item pool, resulting in 34 items (see Table 1). The final model included six factors with the following latent variables: (1) delusional psychopathology (e.g. loss of control over thoughts and actions, delusions of reference, perceived duplication of place and time; α= 0.67), (2) government conspiracies (α = 0.82), (3) psychic-related phenomena (α= 0.86), (4) alien contact (α= 0.66), (5) supernatural entities (α = 0.55), and (6) astrology and urban legends (α=0 .45). Inter-factor correlations are provided in Table 2, and ranged from -0.03 (government conspiracy / astrology and urban legends) to 0.48

Table 1.

Study 1, EFA Factor Loadings, Personal Meaningfulness and General Consensus scores

Table 2.

Item	Factor Loading	Endorsement Rate	Personal Meaningfulness (SD)	General Consensus (SD)
Factor 1: Psychopathology				
You are not in control of your own actions?	0.85	14.4%	4.11(1.41)	3.47(1.50)
Your thoughts aren't fully under your own control?	0.85	12.1%	4.30(1.74)	3.87(1.92)
People say or do things that contain special messages for you?	0.56	14.4%	4.45(1.47)	4.22(1.60)
Certain places are at two locations at the same time?	0.54	5.9%	4.16 (2.16)	4.30(2.36)
Factor 2: Government Conspiracies				
The government permits or perpetrates acts of violence on its own soil, disguising its involvement?	0.94	29.4%	2.90(1.09)	2.93(1.05)
Certain significant events have been the result of the activity of a small group who secretly manipulate world events?	0.87	30.1%	3.36(1.25)	3.29(1.17)
The government uses people as patsies or scapegoats to hide its involvement in criminal activity?	0.84	49.7%	3.61(1.36)	3.43(1.27)
The government is involved in the murder of innocent citizens or well-known public figures?	0.81	52.3%	4.18(1.38)	4.33(1.28)
A small secret group of people is responsible for making all major world decisions such as going to war?	0.80	21.9%	4.88(1.26)	4.76(1.21)
A lot of important information is deliberately concealed from the public out of self-interest?	0.79	73.2%	4.75(1.69)	4.50(1.50)
Technology with mind control capacities is used on people without their knowledge?	0.69	9.2%	4.86(1.35)	4.92(1.38)
New and advanced technology which would harm current industry is being suppressed?	0.67	51%	3.41(1.29)	3.53(1.92)
The spread of certain viruses and/or diseases is the result of the deliberate, concealed effort of some organization?	0.67	24.2%	2.96(1.60)	2.71(0.98)
Experiments involving new drugs or technologies are routinely carried out on the public without their knowledge or consent?	0.54	28.1%	4.21(1.41)	5.02(1.13)
Groups of scientists manipulate, fabricate, or suppress evidence in order to deceive the public?	0.54	42.5%	4.69(1.80)	4.66(1.06)
Factor 3: Psychic Related Phenomena				
Psychokinesis, the movement of objects through psychic powers does exist?	0.98	8.5%	4.31(1.78)	4.80(1.80)
Some individuals are able to levitate (lift) objects through mental force?	0.98	7.5%	4.52(1.50)	4.90(1.44)
A person's thoughts can influence the movement of a physical object?	0.96	8.2%	4.52(1.61)	5.0(1.28)
Some psychics can accurately predict the future?	0.92	18.6%	3.25(1.15)	2.90(0.80)
Some people have an unexplained ability to predict the future?	0.89	24.5%	3.21(1.29)	2.88(0.95)
During altered states such as sleep or trances, the spirit can leave the body?	0.74	20.9%	3.11(1.25)	2.74(1.08)
Mind reading is possible?	0.73	14.7%	4.78(1.38)	5.05(1.21)
Your mind or soul can leave your body and travel (astral projection)?	0.68	21.6%	4.88(1.31)	5.16(1.22)
Reincarnation does occur?	0.58	22.5%	3.17(1.76)	3.61(1.51)
Some people communicate with the dead?	0.57	31.7%	4.54(1.36)	4.88(1.14)
Factor 4: Alien Contact				
Evidence of alien contact is being concealed from the public?	0.77	26.1%	3.14(1.42)	3.46(1.17)
Secret organizations communicate with extraterrestrials but keep this fact from the public?	0.76	10.8%	4.86(1.06)	5.06(1.11)
Some UFO sightings and rumors are planned or stages in order to distract the public from real alien contact?	0.71	10.8%	4.15(1.60)	2.93(1.03)
Factor 5: Supernatural Entities				
There is a devil?	0.98	34.6%	4.01(1.81)	2.78(0.96)
Some people are possessed by evil spirits?	0.70	23.5%	3.15(1.31)	3.05(1.21)
Black magic really exists?	0.55	15.7%	3.17(1.22)	2.89(0.93)
Factor 6: Astrology/Urban Legends				
The horoscope accurately tells a person's future?	0.74	4.2%	3.29(1.13)	3.40(1.08)
Astrology is a way to accurately predict the future?	0.60	6.2%	4.53(1.50)	4.36(1.57)
The Loch Ness Monster of Scotland exists?	0-.56	8.8%	4.22(1.67)	5.13(1.18)

(psychic related phenomena / supernatural entities). An inspection of the endorsement rates provided in Table 1 shows that astrology and urban legends and psychopathology factors contained the least commonly endorsed items, while the most commonly endorsed items belonged to the government conspiracies factor.

Study 1 - Factor Correlations from Exploratory Factor Analysis

	Psycho-pathology	Conspiracies	Psychic Related Phenomena	Alien Contact	Supernatural Entities
Conspiracies	0.20				
Psychic Related Phenomena	0.35*	0.43*			
Alien Contact	0.14	0.17	0.34*		
Supernatural Entities	0.28	0.26*	0.48*	0.39*	
Astrology and Urban Legends	0.05	-0.03	-0.01	0.12	0.04

Note: * indicates statistically significant correlations ($p<.05$).

On average, items for most factors were rated as somewhat important, with an overall M=3.91 (SD=0.32). The perceived general consensus ratings indicated relative implausibility (M=3.5, SD=0.87), with items related to psychokinesis and astrology/urban legends identified as least plausible and those related to belief in supernatural entities as the most plausible.

Study 1 Discussion

The purpose of Study 1 was to establish an item of unusual delusion-like beliefs that could be used as targets for rating belief flexibility in non-clinical samples. The result was a set of statements, most of which were endorsed as believed by less than 25% of the sample. The beliefs retained in the measure were rated as moderately important

and somewhat implausible, providing support for conceptual equivalence with delusional beliefs. The measure includes beliefs in six domains: psychopathology, government conspiracies, psychic related phenomena, alien contact, supernatural entities, as well as astrology and urban legends.

While this analysis indicated a well-fitting model, EFA solutions are specific to the data set from which they are derived. Therefore, a replication was required to improve confidence in the factor structure.

Study 2

The purpose of Study 2 was to replicate the factor structure of the item pool obtained in Study 1, using confirmatory factor analytic (CFA) techniques in an independent sample.

Methods

Participants. A total of 413 Amazon Turk workers were recruited, with 320 retained for the CFA analysis. A total of 51 participants were removed from the data due to providing incomplete data or choosing to withdraw participation, 15 were removed for responding incorrectly to the embedded validity item, 10 were removed due to the mental health screen, and 17 were removed during data screening for statistical outliers.

Demographic characteristics for the final sample were: M_{age} = 35.68 (SD = 11.62, range 18 to 69, Median = 33.5); 50% female, 49% male and 1% prefer not to answer; education: less than 1% completed 1-10 years of education, 11% completed high school, 26% completed some post-secondary education, 48% had a university or college degree, and 14% completed graduate or professional school; employment: 63% full-time, 12% part-time, 10% unemployed, and 14% self-employed; racial/ethnic 72% Caucasian, 9%

African-American, 6% Asian, 6% Hispanic, 2% multiracial, and 2% other. With respect to mental health, 11% reported a past diagnosis of OCD, 3% reported a past diagnosis of a psychotic disorder, and 2% reported a past diagnosis of an eating disorder.

Materials and Measures

Windsor Belief Flexibility Scale, Target Beliefs. Participants completed the 34-item version of the questionnaire developed in Study 1. The internal reliability of the total scale was excellent in Study 2 (α=0.97). The reliability of the subscales were consistent with Study 1: psychopathology (α=0.58), astrology/urban legends (α=0.62), supernatural entities (α=0.68) , alien contact (α=0.80), government conspiracies (α=0.88), and psychic-related phenomena (α=0.88).

Peters Delusions Inventory (Peters et al., 1999). The PDI is a measure of delusion-prone schizotypy – a construct associated with a heightened tendency towards delusional thinking. The version of the PDI used here presents participants with 21 delusional beliefs. Participants are asked to rate distress (i.e. how upsetting they find the belief), preoccupation (i.e. how much time they spend thinking about the belief), and conviction (i.e. how confident they are that the belief is true) on 5-point scales. Higher scores on the PDI suggest elevated delusion proneness. The PDI has good psychometric properties including good internal consistency (α = .82; α = .79 in the current sample) and test-retest reliability (Spearman's r ranging from .78 - .81). The PDI was administered to examine relationships between delusion prone schizotypy and endorsement of delusion-like beliefs on the target belief section of the WBFS.

Procedure. The procedure was identical to Study 1 except as noted. All participants completed the 34-item questionnaire of delusion-like beliefs, and rated personal meaningfulness for each endorsed belief. Participants also completed the PDI.

Results

Preliminary Analyses. Descriptive data was analyzed using IBM SPSS 23. The mean proportion of participants who endorsed each belief item was approximately 24% (SD=15; Range=6-75%). Most (63%) of the beliefs were endorsed by 25% or less of the sample, which was consistent with estimates of schizotypy in the general population and in line with the findings of Study 1. The average Personal Meaningfulness rating across items in the current sample was 4.73 (SD=1.2), which was somewhat higher than the ratings in Study 1, though the standard distribution is also much larger in the current sample, resulting in an overlapping distribution of scores across the two studies. Beliefs that were given ratings of 5 or above on personal meaningfulness included conspiracy theories involving concealment of information from the public, government involvement in acts of terrorism on its own soil, and political involvement of secret societies in major world decisions. Other beliefs rated high on meaningfulness include belief in the devil, and belief in reincarnation.

Confirmatory Factor Analysis. Mplus version 7 software (Muthén & Muthén, 2012) was used to conduct the CFA. A Confirmatory Factor Analysis (CFA) was conducted in order to confirm the factor structure of the target beliefs derived in Study 1. While the unobserved latent variables in model the CFA were assumed to be continuous in nature, the observed indicators were in fact dichotomous (YES/NO to existence of belief). Therefore, the CFA was computed using tetrachoric correlations to measure

associations between underlying latent variables (Jöreskog, 1994). The six factors identified in Study 1 were fit to the data. Latent variables were estimated using the

Table 3.

Study 2, CFA Factor Loadings, target unusual beliefs.

Item	Factor Loading
Factor 1 – Psychopathology	
You are not in control of your own actions?	0.72
Your thoughts aren't fully under your own control?	0.58
People say or do things that contain special messages for you?	0.72
Certain places are at two locations at the same time?	0.64
Factor 2: Government Conspiracies	
The government permits or perpetrates acts of violence on its own soil, disguising its involvement?	0.87
Certain significant events have been the result of the activity of a small group who secretly manipulate world events?	0.94
The government uses people as patsies or scapegoats to hide its involvement in criminal activity?	0.81
The government is involved in the murder of innocent citizens or well known public figures?	0.86
A small secret group of people is responsible for making all major world decisions such as going to war?	0.78
A lot of important information is deliberately concealed from the public out of self-interest?	0.74
Technology with mind control capacities is used on people without their knowledge?	0.76
New and advanced technology which would harm current industry is being suppressed?	0.61
The spread of certain viruses and/or diseases is the result of the deliberate, concealed effort of some organization?	0.76
Experiments involving new drugs or technologies are routinely carried out on the public without their knowledge or consent?	0.84
Groups of scientists manipulate, fabricate, or suppress evidence in order to deceive the public?	0.73
Factor 3: Psychic Related Phenomena	
Psychokinesis, the movement of objects through psychic powers does exist?	0.93
Some individuals are able to levitate (lift) objects through mental force?	0.93
A person's thoughts can influence the movement of a physical object?	0.95
Some psychics can accurately predict the future?	0.91
Some people have an unexplained ability to predict thefuture?	0.87
During altered states such as sleep or trances, the spirit can leave the body?	0.92
Mind reading is possible?	0.80
Your mind or soul can leave your body and travel (astral projection)?	0.94
Reincarnation does occur?	0.72
Some people communicate with the dead?	0.82
Factor 4: Alien Contact	
Evidence of alien contact is being concealed from the public?	0.93
Secret organizations communicate with extraterrestrials but keep this fact from the public?	0.97
Some UFO sightings and rumors are planned or stages in order to distract the public from real alien contact?	0.91
Factor 5: Supernatural Entities	
There is a devil?	0.51
Some people are possessed by evil spirits?	0.83
Black magic really exists?	0.96
Factor 6: Astrology/Urban Legends	
The horoscope accurately tells a person's future?	0.71
Astrology is a way to accurately predict the future?	0.72
The Loch Ness Monster of Scotland exists?	0.67

Note: All loadings are statistically different from zero.

WLSMV method. The variance was adjusted to 1.0, and the LVs were permitted to correlate (See Table 4 for correlations).

A review of fit indices indicate that the model fit the data reasonably well (X^2 = 789.48, df = 511, p <.001; CFI = 0.96; TLI = 0.956; RMSEA =0 .041(CI=0.036-0.047); SRMR = 0.056). See Table 3 for factor loadings. A review of inter-factor correlations indicates several statistically significant correlations ranging from the weak to the moderately strong ranges (Table 4).

Table 4.

Study 2, Factor Correlations from CFA, target unusual beliefs

	Psycho-pathology	Conspiracies	Psychic Related Phenomena	Alien Contact	Supernatural Entities
Conspiracies	0.34**				
Psychic Related Phenomena	0.19**	0.32**			
Alien Contact	0.24**	0.43**	0.54**		
Supernatural Entities	0.07	0.16**	0.30**	0.21**	
Astrology and Urban Legends	0.25**	0.31**	0.49**	0.48**	0.18**

Note: ** indicates statistically significant correlations (p<.01).

The highest correlations were observed between psychic phenomena and alien contact (r=0.54). Likewise, astrology/urban legends showed similarly high correlations with alien contact (r=0.48) and psychic phenomena (r=0.49). This is in stark contrast to Study 1, where astrology/urban legends were uncorrelated with other factors, and few inter-factor correlations were observed.

Validity Analyses. In order to explore the construct validity of WBFS target beliefs, the relationships with the PDI were examined. The mean PDI score was 9.94

(SD=10.54) for distress, 10.21 for preoccupation (SD=10.28), 13.22 for conviction (SD=12.00), and 37.08 (SD=35.11) PDI mean total score. Belief factor scores were generated for each person, which were then correlated with the PDI. Correlations were moderately strong and ranged between 0.37 (distress and alien contact) and 0.57 between (delusional psychopathology and PDI distress score; see Table 5). This suggests that the higher individual scores on a measure of delusion-prone schizotypy, the more likely they are to endorse beliefs on the WBFS target beliefs scale.

Table 5.

Study2, Correlations between WBFS target belief factor scores and PDI scales.

	PDI Scale			
Factor	Distress	Preoccupation	Conviction	Total
F1 Psychopathology	0.57 [.48-.63]	0.53 [.45-.61]	0.50 [.41-.58]	0.54[.46-.62]
F2 Conspiracies	0.46[.37-.54]	0.52[.40-.57]	0.55[.42-.59]	0.53[.41-.58]
F3 Psychic Abilities	0.44[.35-.52]	0.53[.40-.56]	0.53[.44-.61]	0.54[.41-.58]
F4 Alien Contact	0.37[.25-.43]	0.42[.30-.47]	0.43[.30-.46]	0.42[.29-.46]
F5 Supernatural Entities	0.40[.32-.50]	0.51[.39-.56]	0.55[.44-.60]	0.50[.40-.56]
F6 Astrology & Urban Legends	0.44[.31-.48]	0.51[.33-.52]	0.51[.35-.58]	0.50[.34-.53]

Note: 95% Confidence Intervals are indicated in brackets; PDI – Peters Delusion Inventory.

Study 2 Discussion

The findings from Study 2 confirmed the six-factor structure for the WBFS target beliefs scale that emerged in Study 1. Factor scores were significantly correlated with scores on a validated measure of delusion-prone schizotypy. The target beliefs also demonstrated personal meaningfulness in the neutral to somewhat personally meaningful range, and were rated as generally uncommon with regards to cultural consensus. Taken

together, these findings represent a significant improvement over previous attempts to generate personally meaningful beliefs in non clinical samples (e.g. Colbert et al., 2010) with respect to construct validity.

In summary, the results of Studies 1 and 2 indicate success in establishing a pool of personally meaningful and infrequently held target beliefs. These items can be used to identify unusual personally meaningful target beliefs which can next be assessed for flexibility.

Study 3

The purpose of Study 3 was to establish a set of items to query dimensions of belief flexibility when applied to one or more of the target beliefs established in Studies 1 and 2. A pool of potential items was generated based on a conceptual analysis of belief flexibility, and an EFA was performed to reduce the item pool and to examine its factor structure.

Based on the dual process model of reasoning, an item pool intended to capture three processes thought to influence belief formation and flexibility was generated: 1) effortful analytic, 2) rapid, intuitive, and, 3) affective. In order to explore construct validity for the resulting belief flexibility items, the relationships between the resulting scale and the PDI were examined.

Method

Participants. A total of 345 Amazon Turk workers were recruited, with 203 retained for analysis. A total of 89 participants completed less than 20% of the questionnaire and were removed, 17 chose to withdraw prior to completing, 15 were removed due to the mental health screening criteria, and 16 were removed during data

screening. Participants in the final sample (N=197) ranged in age between 20 and 67 years (M_{age} = 33.21, SD=8.93, Median = 32.9), with 53% identifying as female, 46% as male and 1% either identifying as 'other' or not responding. In terms of educational attainment, less than 1% reported completing 1-10 years of education, 12% completed high school, 29% completed some post-secondary education, 47% completed a university or college degree, and 12% completed graduate or professional school. The majority was employed with 59% working full-time, 12% part-time, 14% unemployed, and 15% self-employed. With respect to ethnoracial identity, 71% identified as Caucasian, 7% identified as African-American, 6% identified as Asian, 6% identified as Hispanic, 3% identified as multiracial, 1% identified as "other" and 6% refused to answer.

Measures

Development of Windsor Belief Flexibility Scale, Part 2, belief rating items. An initial pool of items was generated by the authors. A total of 24 items were generated based on the following processes posited by the dual processing framework. Specifically, the following 6 factors were theorized to underlie belief flexibility ratings: (1) willingness to consider contradictory evidence (7 items), (2) willingness to consider contrary social feedback (5 items), (3) intuitive reasoning (4 items), (4) reliance on confirmatory evidence (4 items), (5) negative affective response to belief revision (2 items), and (6) affective valence of belief (2 items). Factors (1) and (2) were conceptualized as slow analytic processes, while factors (3) and (4) were conceptualized as rapid intuitive processes. Factors (5) and (6) were conceptualized as rapid responses that are specific to affective processes. See Figure 1 for a visual depiction of the hypothesized factor

structure. These 24 items were presented as follow-up queries about the target delusion-like belief identified as most meaningful by the participant.

Peters Delusions Inventory (Peters et al., 1999). This measure was administered in Study 2 above.

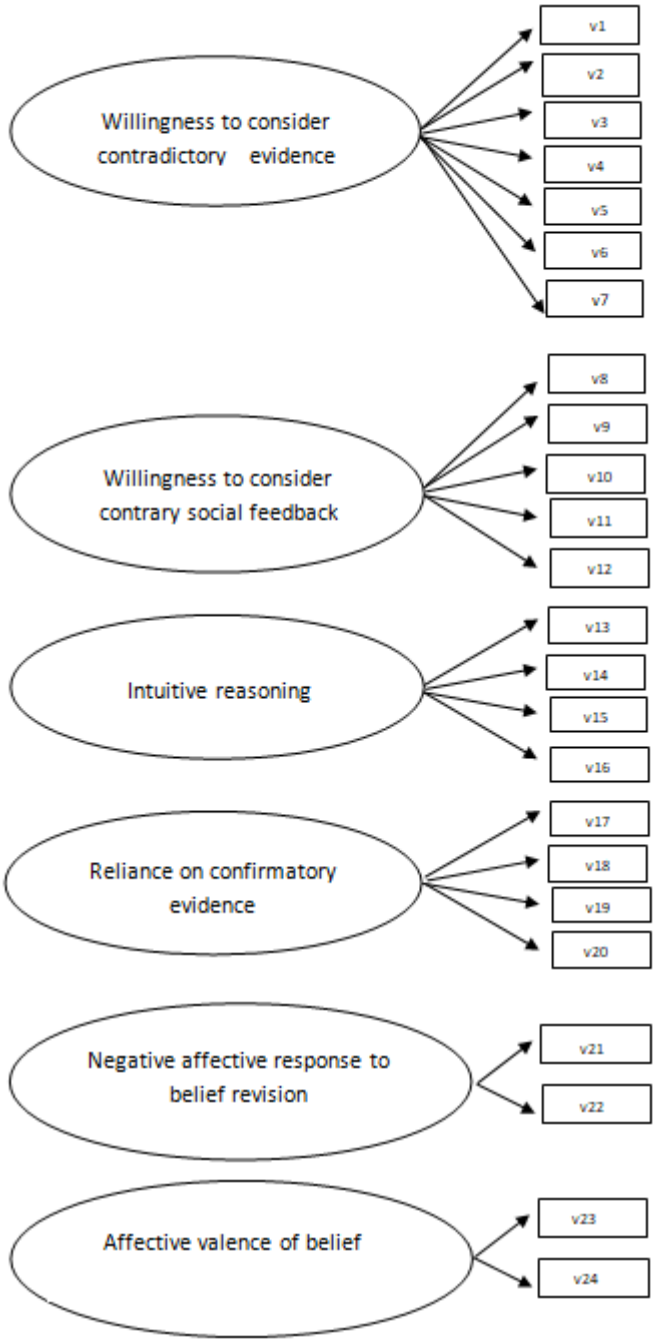
Procedure. Eligible participants viewed information about the study on Mechanical Turk. Interested participants followed a link to an online survey, where they were presented with a consent form. If they agreed to participate, they completed the demographics questionnaire. Participants then completed WBFS target beliefs scale, and were asked to indicate whether or not they believed each statement in a two-alternative forced-choice format. Participants were then shown the items they had endorsed as statements they believed and were asked to select the one that they considered most personally meaningful. Participants then rated the chosen belief using the new WBFS belief rating scales. Three of the items were negatively worded and a validity item was embedded in the questionnaire that requested participants respond with a response of 'yes'. Participants responded to the items on a 7-point likert-scale, ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). Participants also completed the PDI to establish the association between belief flexibility and schizotypy. The order of presentation of the measures was counterbalanced. Participants received $2.00 US as a token of appreciation for their participation.

Results

Endorsement of Most Personally Important Beliefs. Overall, 22% of participants selected the belief that the government is deliberately concealing information from the public out of self interest as their most personally meaningful belief, 12.8%

Figure 1.

Hypothesized WBFS Factor Structure. Items comprising each factor (v1-v24) are reproduced in Table 6.



selected belief in the devil, 10.8% selected belief that new technology is being suppressed, 8.8% selected belief in reincarnation, and 4.9% selected belief that that people communicate with the dead. All other items were selected at least once, but selection remained below 5% for these items.

Exploratory Factor Analysis. An exploratory factor analysis (EFA) was conducted on the belief flexibility items using the principle axis factoring extraction method. Only 3% of the data was missing (at random), and given that exclusion of the data did not impact EFA results, participants with missing data were retained. Inspection of histograms indicated that while the distribution for several items was skewed, no bimodal distributions were noted. The item correlation matrix was inspected to ensure factorability and to check for singularity. No items were fully correlated and the highest correlation was 0.89. Correlations between items ranged from 0.1 to 0.7. The data was checked for sampling adequacy and spherecity. Based on Kaiser's (1974) recommendations, the value for KMO was in the upper end of the good range (KMO=0.746), indicating that the pattern of correlations was relatively compact and appropriate for factor analysis. Bartlett's test of spherecity indicated that the R-matrix was not an identity matrix. Six multivariate outliers were identified using Leverage values three times greater than the mean leverage value. Their inclusion impacted interpretation of factor structure. Therefore, they were excluded from subsequent analyses, leading to a sample size of 197.

Based on the inspection of the eigenvalues and theoretical expectations, two to six factor solutions were examined. A total of seven items with very low communalities and/or low factor loadings were removed from subsequent analyses. See Table 6 for

Table 6.

Study 3, Information on EFA Factor loadings, item Skew and Kurtosis and dropped items

Item	Factor	Factor loading	Skew	Kurtosis	Item dropped / reason(s) for dropping
I can imagine changing my mind about this belief. (v1)	1	0.734	0.53	-0.88	N/A
I can visualize the kind of evidence and/or circumstances that would change my mind about this belief. (v2)	1	0.752	0.48	-0.90	N/A
I could be persuaded to change my mind about this belief. (v3)	1	0.836	0.43	-1.01	N/A
I can think of alternate explanations for the experiences that led me to hold this belief. (v4)	1	0.634	-0.01	-1.13	N/A
If someone I trusted disagreed with me about this belief, I might change my mind. (v8)	1	0.846	0.70	-0.50	N/A
If enough people disagreed with me about this belief, I might change my mind. (v9)	1	0.846	0.64	-0.59	N/A
If a person who cares about me disagreed with this belief, I might change my mind. (v10)	1	0.844	0.76	-0.46	N/A
When I think about this belief, I feel good. (v23)	2	0.896	0.64	-0.83	N/A
When I think about this belief, I feel bad. (v24)	2	-0.821	-0.29	-1.35	N/A
The thought of changing my mind about this belief is upsetting to me.(v21)	3	0753	0.45	-1.07	N/A
I get uneasy when thinking about questioning this belief.(v22)	3	0.696	0.96	-0.12	N/A
I don't need objective evidence to know this belief is true.(v13)	4	0.805	-0.10	-1.17	N/A
I have a gut feeling that this belief is true. (v14)	4	0.559	-0.95	0.38	N/A
I did not need to think too much about this belief to know that it's true. (v15)	4	0.781	-0.41	-0.98	N/A
I can vividly remember an experience that supports this belief.(v17)	5	0.886	-0.32	-1.04	N/A
I can think of evidence from personal experience that supports this belief. (v18)	5	0.539	0.10	-1.25	N/A
I can vividly imagine evidence that supports this belief. (v19)	5	0.591	-0.67	-0.51	N/A
If people disagree with me about this belief, I might let them think I don't believe it anymore, but still hold that belief.(v11)	3	0.183	0.89	-0.98	Dropped; low communiality
I can remember a time when I did not hold this belief. (v5)	4	-0.516	0.34	-0.45	Dropped; low communiality
In the past month, I have looked for evidence that contradicts this belief. (load < .5) (v6)	3	-0.263	-0.45	-1.83	Dropped; Loading < .5
I can vividly imagine evidence that supports this belief. (load < .5) (v20)	5	0.311	0.29	-1.16	Dropped; Loading < .5
I believe that this belief is factual. (load < .5) (v7)	4	0.446	-0.10	-0.44	Dropped; Loading < .5
I formed this belief very gradually, over time. (load < .5) (v16)	3	0.381	0.65	-1.40	Dropped; Loading < .5
Most people from my cultural background, also hold this belief. (load < .5) (v12)	1	0.165	0.78	-1.12	Dropped; Loading < .5

removed items. This left 17 items in the factor analysis and based on an inspection of the Scree plot and theoretical considerations involving the dual processing model as outlined above, models with two-, three-, four-, five-, and six-factor models were examined.

Factors were extracted using the principal axis method. Given that the factors of are likely to be correlated, an oblique rotation method was used. Of the orthogonal rotation methods, two methods that are highly effective at optimizing simple structure, namely oblimin, and promax with a varimax prerotation, were selected. The EFA was performed for two to six factors using both rotation methods. A comparison of the simple structure matrices suggested that the five-factor solution was most optimal regardless of the rotation method. To decide between them, we compared the hyperplane count of the reference structure matrices for these solutions. That is, we tabulated the proportion of loadings in the reference structure with values less than or equal to ±0.1 with the idea that the solution with the highest hyperplane count provides the least cross loadings, resulting in the most interpretable solution. While the oblimin solution had a hyperplane count of 51%, the promax solution yielded a hyperplane count of 56%. Thus, the promax solution was selected as yielding the most interpretable factor structure and the subsequent analyses were based on this solution.

The five-factor model explained 64% of the overall variance in the items. The factors were named: (F1) willingness to consider contradictory evidence (7 items), (F2) affective valence of belief (2 items), (F3) negative affective response to belief revision (2 items), (F4) intuitive reasoning (3 items), and (F5) reliance on confirmatory evidence (3 items). The cross-loadings in factor structure were clarified using hyperplane count, and

the pattern matrix structure was retained. See Table 6 above for items, and factor loadings. The internal reliability of the items was in the acceptable range (alpha = 0.66).

The factor correlations showed a small to moderate inverse correlation between willingness to consider contradictory evidence and intuitive reasoning. No other statistically significant correlations were noted (See Table 7).

Table 7.

Study 3- Factor Correlations

	F1	F2	F3	F4
F1 Willingness to Consider Contradictory Evidence				
F2 Affective Valence of Belief	0.06			
F3 Negative Affective Response to Belief Revision	-0.06	-0.12		
F4 Intuitive Reasoning	-0.37*	0.13	0.14	
F5 Reliance on Confirmatory Evidence	-0.08	0.16	0.12	0.06

Note: * indicates statistically significant correlations ($p<.05$)

In order to examine the relationship between these factors and delusion-prone schizotypy, factor scores were generated and Pearson correlations with the PDI were calculated (Table 8). The only factor that was consistently correlated with delusion-proneness was negative affective response to belief revision. However, reliance on confirmatory evidence also demonstrated some weak correlations in the positive direction with preoccupation and conviction ratings.

Table 8.

Study 3, Correlation of EFA Factor Scores with PDI

	PDI Distress	PDI Preoccupation	PDI Conviction
Willingness to consider contradictory evidence	0.11	0.11	-0.06
Affective valence of belief	0.16	0.16	0.12
Negative affective response to belief revision	0.31*	0.29*	0.27*
Intuitive reasoning	0.08	0.08	0.17
Reliance on confirmatory evidence	0.16	0.22*	0.23*

Note: PDI = Peters Delusions Inventory
* indicates statistically significant correlations ($p<.05$)

Study 3 Discussion

The goal of Study 3 was to develop a multi-factorial measure of belief flexibility that could be applied to studying personally important but unusual beliefs. Consistent with the theorized structure, the exploratory factor analysis indicated five factors corresponding to the hypothesized analytic and intuitive processes. However, contrary to expectations, items related to willingness to consider contradictory evidence and those related to contrary social feedback collapsed onto the same factor. This suggests that both of these constructs reflect slow processes that are involved in analytic evaluation. That is, this finding is consistent with the hypothesis that both of these factors reflect slow processes involved in belief flexibility.

Interestingly, the only factor to show a correlation with all subscales of the PDI was negative affective response to belief revision. Also, reliance on confirmatory evidence correlated weakly with conviction and preoccupation about delusional beliefs. This suggests that reliance on confirmatory evidence may help maintain a disposition

towards delusion-proneness in the non-clinical population. The factor correlations suggested that intuitive reasoning is inversely related to willingness to consider contradictory evidence. This is consistent with the hypothesis that items from willingness to consider contradictory evidence are reflective of reliance on slow analytic processes, while those belonging to intuitive reasoning are indicative of reliance on the default operation of the fast, intuitive stream.

The findings of Study 3 indicate a few other necessary revisions to the WBFS. Given that EFA solutions are often unstable across samples, a replication of the model identified in Study 3 under more stringent CFA conditions is desirable. However, two out of the five factors that emerged from the EFA analysis (i.e. affective valence of belief, and negative affective reaction to belief revision) were composed of two indicators. While this did not affect model identification in EFA models, more stringent CFA models typically require at least three items per latent variable in order to provide model estimates. Therefore, more items capturing F2 and F3 per Table 6 should be generated.

Another interesting addition to the WBFS includes the construct of conviction. In samples comprised of individuals diagnosed with clinically significant delusions, reasoning biases including JTC and low belief flexibility have been shown to correlate strongly with delusional conviction (e.g. Freeman et al., 2008; Colbert et al., 2010), raising the possibility that perhaps these reasoning biases are indistinguishable from belief conviction (So et al., 2012). However, using a longitudinal factor analytic design, So and colleagues (2012) showed that in clinical samples, belief flexibility, JTC and delusional conviction are indeed distinct but interrelated processes, with belief flexibility showing moderately large inverse correlations with conviction, and smaller inverse

correlations with JTC. Whether or not such a factor structure holds in non-clinical populations remains an empirical question. However, as with belief flexibility, studies that measure the strength of delusional conviction use a direct assessment interview method (e.g. So et al., 2012), which suggests that the WBFS should be augmented to include items that explicitly measure the related construct of belief conviction.

Study 4

As noted above, the original model that emerged from the EFA analysis in Study 3 included two factors with less than three indicators, violating the rule of thumb for avoiding empirical under-identification in CFA techniques. Therefore, it was necessary to generate more items to potentially capture each of the domains in order to perform CFA on the full model. One goal of Study 4 was to include additional items related to the factors that emerged in Study 3 as well as items that measured confidence/conviction in belief, and to test theorized models using CFA. This study also sought to validate the finalized model by examining the relationships of the factors with measures of divergent and convergent constructs.

Conviction in belief was conceptualized as a second-order latent variable comprised of items related to intuitive reasoning, and those capturing a new first-order latent variable capturing the unwillingness to doubt belief.

Method

Participants. A total of 420 participants were recruited from MTurk for Study 4. Of these 358 endorsed at last one unusual belief from the WBFS belief item pool and answered the belief flexibility questions for the belief identified as most personally meaningful. Demographic characteristics for the final sample were M_{age} = 33.5

(SD=10.21, range 18 to 62, Median = 32.1); 52% male, 47% female, 1% not identified or did not respond. Regarding highest level of education attained, most (47%) had completed post-secondary education, 29% reported having some and/or in the process of completing post-secondary education, 13% had received a high school diploma, 9% attended graduate or professional school, less than 1% reported 1-10 years of education as the highest level attained and 1% did not answer the question. Most of the sample was employed full-time (67%), 8% part-time, 12% unemployed, and 11% self-employed. For racial/ethinic identity, 76% identified as Caucasian, 8% as African American, 4% as Asian, 4% as Hispanic, 2% as mixed, 4% other or chose not to answer. Regarding mental health diagnoses, 10% reported having been diagnosed or treated for OCD, 3% reported a history of past diagnosis or treatment for an eating disorder, and 3% endorsed a past history of a psychotic disorder. These participants were removed from the dataset.

Procedure. Procedures were the same as Study 3, except as noted. For each endorsed belief, participants were asked to respond to a revised version of the WBFS, reproduced in Appendix B. The items were presented on a 7-point Likert scale ranging from 1 – Strongly Disagree to 7-Strongly Agree. In order to assess the validity of the measure, participants also completed a number of measures that capture other related constructs discussed below. Participants received a token of $3.00 US Dollars in appreciation for their participation.

Measures. Participants completed a revised version of the WBFS which included the 17 items retained from Study 3, with an additional 9 items. The additional items included 3 items capturing the unwillingness to doubt belief: (“I cannot imagine being wrong about this belief”; “I am certain about this belief”; “There is at least a small chance

I could be wrong about this belief" – Reverse coded), 2 items capturing negative affective response to belief revision: ("If I changed this belief, my life would have to change in important ways"; "It is hard for me to listen to people talk about things that contradict my belief"), and 4 items that measure affective valence of belief: ("I feel comforted when I think about this belief"; " feel safe when I think about this belief"; "I feel powerless when I think about this belief"; "I feel scared when I think about this belief"). All items administered in Study 4 are located in Appendix B.

Peters Delusions Inventory (Peters et al., 1999). This measure was administered the same as in the preceding studies.

Cognitive Flexibility Inventory (CFI, Dennis & Van der Wal, 2010). The CFI was used to establish convergent and divergent validity of the belief flexibility measure. This self-report instrument measures the type of belief flexibility that is required for individuals to successfully challenge and modify maladaptive thoughts. This scale contains 20 items and shows a reliable two-factor structure and good psychometric properties (α =0 .93). The CFI includes two sub-scales, 1) Alternatives (i.e. the ability to identify multiple explanations for events and human behavior and to generate multiple alternative solutions to difficult problems), and 2) Control (i.e. the tendency to perceive difficult situations as controllable). It was hypothesized that the Alternatives would converge with analytic processes, while Control should not be related to belief flexibility excepting possibly with negative affective response to belief revision.

Beck Cognitive Insight Scale (BCIS, Beck et al., 2004). The BCIS was used to establish convergent validity. This measure assesses the ability to examine and correct thoughts and beliefs. The BCIS is a 15 item self-report questionnaire that measures

cognitive insight on 4-point Likert scales that has been validated for use with clinical (including psychotic) and non-clinical populations (Beck et al., 2004). The BCIS consists of two subscales: 1) self-reflectiveness which assesses introspection; and, 2) self-certainty which assesses overconfidence in decisions and judgments. Cognitive insight is defined as the difference between self-reflectiveness and self-certainty scores (Beck et al., 2004). The internal consistency of this measure was acceptable in the current data (α =0 .67). It was expected that self-reflectiveness and self-certainty would correspond strongly with the WBFS analytic and intuitive processes, while correlations with affective subscales would be weaker.

Dysfunctional Attitudes Scale (DAS, Weissman & Beck, 1978). The DAS was included to establish convergent validity. The DAS was developed to measure dichotomous thinking in depressed individuals, but has also been used to show that dichotomous thinking is negatively linked to belief flexibility in psychotic individuals (Garety et al., 2005). The DAS is a 40 item self-report questionnaire that measures depressive cognitive schemas on 7-point Likert-style scales, and operationalizes dichotomous thinking as the total number of extreme responses (scores of 1 or 7). The reliability of the measure in the current sample was excellent (α=0.99). It was expected that dichotomous thinking would correlate negatively with analytic processing and would be more strongly related to intuitive and affective processes.

Dissociative Experiences Scale (DES, Bernstein & Putnam, 1986). The DES, a self-report questionnaire that quantifies the level of dissociative symptoms, was used to establish divergent validity. This measure is a 28 item-self-report questionnaire rated on a

1-100 visual analogue scale, including items that target the phenomena of amnesia, absorption, depersonalization and derealization (current α= 0.96).

Creative Experiences Questionnaire (CEQ; Merckelbach et al., 2001). The CEQ is a 25-item dichotomous (True/False) self-report questionnaire that is used to measure fantasy proneness: a propensity toward an imaginative internal life (e.g. daydreaming). The CEQ is closely linked to hypnotic susceptibility, absorption, and paranormal experiences. It was used as a measure of divergent validity (current alpha = 0.84).

Attributions Style Questionnaire (ASQ; Dykema et al., 1996).The ASQ is a self-report questionnaire that assesses explanatory styles for bad events and good events using scores on three different dimensions: internal versus external, stable versus unstable, and global versus specific causes. The ASQ contains 12 hypothetical scenarios which respondents are asked to imagine experiencing. Six of the scenarios are positive (e.g., "you get a raise") and the other six are negative (e.g., "you meet a friend who acts hostilely towards you"). For each question, respondents are asked to write down what they believe to be the cause of the situation, and then answer questions about the stability/instability, internality/externality and global/specificity of their attributions using 7-point Likert-scales. The ASQ showed good internal reliability in the present sample (α = 0.70). The ASQ was used to establish divergent validity.

Social Desirability Scale- 17 (SDS-17; Stober, 2001). The SDS-17, a 16-item measure of social desirability: a construct that refers to the tendency to give biased responses that may be distorted to provide an overly positive self-description in order to make a good impression on others. The SDS-17 was included to establish divergent validity. The internal reliability of the SDS-17 in the current data was good (α =0 .70).

Data Analysis. Confirmatory Factor Analyses were conducted with 'R 3.3.3' software using the Lavaan package for Structural Equation Modelling (Rosseel, 2012) to test the latent structure of the WBFS. All models were specified by restricting the loading of the first indicator on each factor to 1 and parameters were estimated using the Maximum Likelihood method. The Lavaan package manages missing data by providing case-wise (or full-information) maximum likelihood estimation.

Results

WBFS Target Beliefs. Of the beliefs identified as most meaningful, 20.9% of the 358 participants whose responses were submitted to the CFA identified the belief that the government purposely conceals information from others as most personally meaningful, while 20% selected the belief in the devil. Approximately 11% chose the belief that new technology is being suppressed to avoid harm to current industry, and 7% chose the belief in reincarnation as most meaningful. All other items were selected at least once, but selection remained below 5% for these items.

Data Screening. A total of 13 participants were identified as potential multivariate outliers as indicated by leverage values exceeding 0.25. These participants were excluded from all subsequent analyses. The data were also screened for missing values. Missing data only affected 2% of the sample in a completely random pattern (MCAR), and participants with missing data were retained using full-information maximum likelihood estimation. The data was inspected for univariate normality using histograms. The distribution of responses for all items was non-normal in terms of both skewness and kurtosis. The Shapiro-Wilks tests of normality were conducted on each of the questionnaire items and all of them indicated non-normal distributions. Consistent

with these results, Mardia's test of multivariate normality was conducted using R's 'mvn' package. Results indicated significant skewness (γˆ1.p, p = 397.6, p <.001) and kurtosis (γˆ2.p, p = 2018.23, p < .001). Given the notable degree of multivariate non-normality, the Satorra-Bentler corrections were applied to all fit indices.

Models. A number of models were tested using CFA. First, the augmented version of the model that emerged from Study 3 was tested (Table 9, Model A). This model included the following factors: (1) willingness to consider contradictory evidence and social feedback, (2) affective valence of belief, (3) negative affective response to belief revision, (4) intuitive reasoning, and (5) reliance on confirmatory evidence. Two of the factors in this model (i.e. Affective valence of belief and negative affective response to belief revision) were expanded to include more items.

Given the theoretical expectation that willingness to consider contradictory evidence and willingness to consider contrary social feedback are distinct factors, a 6-factor model (Table 9, Model B) with the following factor structure was tested: (1) willingness to consider contradictory evidence, (2) willingness to consider contrary social feedback, (3) affective valence of belief, (4) negative affective response to belief revision, (5) intuitive reasoning, and (6) reliance on confirmatory evidence.

Another theoretically justifiable modification to this model involved the separation of the positive vs. negative affective valence of belief (Table 9, Model C). This is because some of the items on this model reflected feelings of safety and comfort, while others capture feelings of powerlessness and fear. Therefore, we tested a version of the model that included the following 7 factors: (1) willingness to consider contradictory evidence, (2) willingness to consider contrary social feedback, (3) positive affective

valence of belief, (4) negative affective valence of belief, (5) negative affective response to belief revision, (6) intuitive reasoning, and (7) reliance on confirmatory evidence.

Another model tested included a new factor called "unwillingness to doubt belief". This eight-factor model (Table 9, Model D) included all 7 factors in Model C, in addition to the new factor. The items comprising 'unwillingness to doubt belief' are outlined in Table 10. This model was theoretically motivated, with the aim of creating a 'conviction' factor. Model F in Table 9, added two second-order latent variables of belief flexibility and conviction to the eight-factor model, with belief flexibility encompassing willingness to consider contradictory evidence and willingness to consider contrary social feedback, and conviction was comprised of unwillingness to doubt and intuitive reasoning. See Figure 2 for a visual depiction of this model. Model E in Table 9 refers to a model that includes only belief flexibility and conviction and their constituent first-order factors (i.e. the top half of Figure 2).

Confirmatory Factor Analysis. A review of the model fit indices in Table 9 suggested that the five-factor model (Model A) was not a good fit to the data. Review of the modification indices suggested that the largest residual variances involved the items hypothesized to belong to the willingness to consider contrary social feedback with each other. Separating the willingness to consider contradictory evidence into two distinct factors improved model fit (Model B), but continued to result in a poorly fitting model. When this model was further modified to include two distinct factors of positive vs. negative affective valence (Model C), the fit improved. The addition of the unwillingness to doubt belief factor did not improve upon Model C, but also provided a good fit to the data (Model D). Inspection of item loadings (Table 10) indicated that all

items loaded strongly onto their respective theorized latent variables for Model D. Correlations between latent variables for the eight-factor model are provided in Table 11.

Table 9.

Study 4, Summary of CFA Fit Indices

Model	X^2	df	CFI	TLI	RMSEA	RMSEA CI	SRMR	AIC
Model A	764.51	220	0.83	0.81	0.10	[.09-.10]	0.10	26173.63
Model B	555.04	215	0.90	0.88	0.08	[.07-.09]	0.09	25937.81
Model C	358.70	209	0.95	0.95	0.05	[.04-.06]	0.06	25918.73
Model D	456.60	271	0.95	0.94	0.06	[.05-.06]	0.06	26892.34
Model E	113.71*	60	0.98	0.97	0.05	[.04-.07]	0.05	1457.32
Model F	574.74	280	0.93	0.92	0.06	[.05-.06]	0.07	27316.35

Note: k=number of factors in the mode; LVs=latent variables

An inspection of the factor correlation matrix (Table 11) showed large inverse correlations between that the unwillingness to doubt belief with both the willingness to consider contradictory evidence and with the willingness to consider social feedback. It also showed large positive correlations with intuitive reasoning, moderate positive correlations with both reliance on confirmatory evidence, and negative affective response to belief revision. The two factors depicting the positive and negative affective valence of belief were only weakly related to the non-affective factors in the model.

Second-Order Factor Structure. Based on this pattern of correlations, it was hypothesized that some of the factors from Model D represented indicators of two second-order latent variables: belief flexibility and belief conviction. Specifically, it was hypothesized that the willingness to consider contradictory evidence and the willingness to consider contrary social feedback were indicators of belief flexibility, while intuitive reasoning and unwillingness to doubt belief represent indicators of conviction. Based on

Table 10.

Study 4, Item Loadings for the Eight-Factor CFA Model

Item	F1	F2	F3	F4	F5	F6	F7	F8
Willingness to consider contradictory evidence (α= .89)								
I can imagine changing my mind about this belief.	.80							
I can visualize the kind of evidence and/or circumstances that would change my mind about this belief.	.75							
I could be persuaded to change my mind about this belief.	.92							
I can think of alternate explanations for the experiences that led me to hold this belief.	.69							
Willingness to consider contrary social feedback (α= .94)								
If someone I trusted disagreed with me about this belief, I might change my mind.		.89						
If enough people disagreed with me about this belief, I might change my mind.		.94						
If a person who cares about me disagreed with this belief, I might change my mind.		.94						
Unwillingness to Doubt Belief (α= .89)								
I cannot imagine being wrong about this belief.			.71					
There is at least a small chance that I could be wrong about this belief.*			-.77					
I am certain about this belief.			.75					
Intuitive reasoning (α= .72)								
I don't need objective evidence to know this belief is true.				.82				
I have a gut feeling that this belief is true.				.50				
I did not need to think too much about this belief to know that it's true.				.71				
Reliance on confirmatory evidence (α= .79)								
I can vividly remember an experience that supports this belief.					.78			
I can think of evidence from personal experience that supports this belief.					.74			
I can vividly imagine evidence that supports this belief.					.71			
Negative affective reaction to belief revision (α= .75)								
The thought of changing my mind about this belief is upsetting to me.						.80		
I get uneasy when thinking about questioning this belief.						.77		
If I changed this belief, my life would have to change in important ways.						.57		
It is hard for me to listen to people talk about things that contradict my belief.						.58		
Positive affective valence of belief (α= .90)								
When I think about this belief, I feel good.						.	.88	
I feel comforted when I think about this belief.							.89	
I feel safe when I think about this belief.*							.88	
Negative affective valence of belief (α= .77)								
When I think about this belief, I feel bad.								.82
I feel powerless when I think about this belief.								.62
I feel scared when I think about this belief.								.77

Table 11.

Study 4. Factor Correlations for the Eight-Factor CFA Model

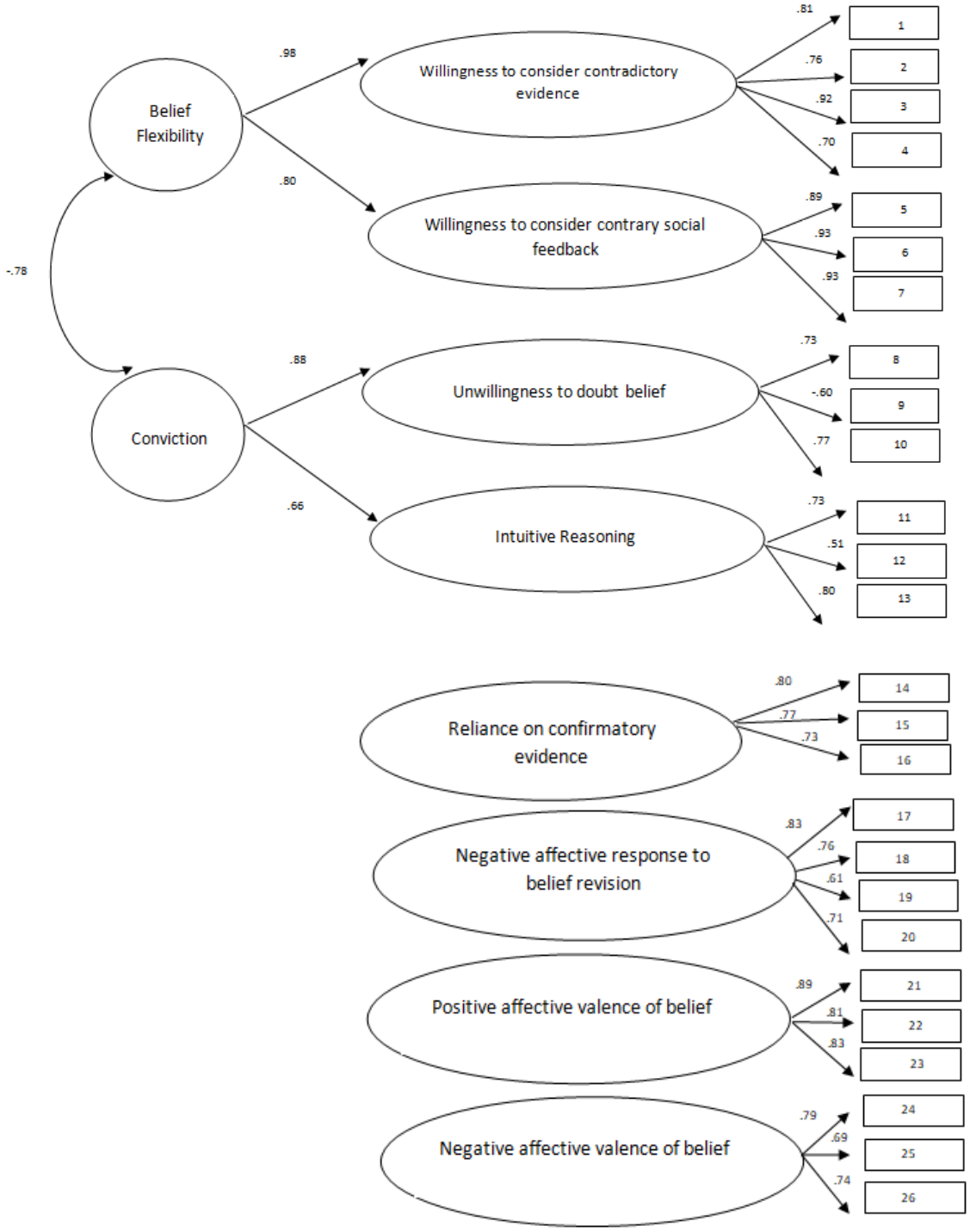
	ConEv	Social	Intuitive	NegAfRev	ConfEv	PosVal	NegVal
Social	0.80**						
Intuitive	-0.53**	-0.41**					
NegAfRev	-0.17	0.02	0.34**				
ConfEv	-0.24**	-0.23**	0.04	0.24**			
PosVal	0.19	0.19	0.28**	0.26**	0.05		
NegVal	0.08	0.19	-0.07	0.29**	-0.02	-0.52**	
NoDoubt	-0.75**	-0.59**	0.55**	0.37**	0.45**	-0.04	-0.02

Note. ConEv=willingness to consider contradictory evidence , Social=willingness to consider contrary social feedback, Intuitive=intuitive reasoning, NegAfRev=negative affective response to belief revision, ConfEv=reliance on internally generated evidence, PosVal=Positive affective valence of belief, NegVal=negative affective valence of belief,NoDoubt=unwillingness to doubt belief

findings from previous modeling research in delusional populations (So et al., 2012), conviction and belief flexibility were expected to show a moderate inverse correlation. A second-order CFA including the latent variable of belief flexibility and belief conviction, in addition to the other factors (i.e. negative affective response to belief revision, reliance on internally generated evidence, positive affective valence of belief, and negative affective valence of belief) was conducted (Model F), with the factor loading of the first indicator for each latent variable fixed to 1.0. Though an inspection of the chi square, TLI, and CFI suggested a reduction in model fit, the SRMR and the RMSEA values were within recommended ranges (Table 9). Also, examination of factor loadings suggests that all items loaded strongly and significantly onto their respective latent variables (See Figure 2). Therefore, given its congruency with theorized models

Figure 2.

Study 4, Factor Structure for Second-Order Model (Model F)



and acceptable model fit indices, this second-order model was retained. This decision was further supported by the excellent model fit provided by a second-order model including only the latent variables of belief flexibility and belief conviction and their corresponding factors (Model E, Table 9).

Table 12.

Study 4, Correlations between First and Second-Order Variables

	BF	CONV	ConfEV	NegAfRev	NegVal
Conviction	-0.84				
Reliance on confirmatory evidence	-0.23*	0.48*			
Negative affective response to belief revision	-0.12	0.43*	0.26*		
Negative affective valence of belief	0.07	0.05	0.01	0.23*	
Positive affective valence of belief	0.17	0 .04	0.08	0.28*	-0.64*

Note: BF=belief flexibility; CONV=conviction; ConEv=reliance on confirmatory evidence; NegAfRev= negative affective response to belief revision; NegVal=negative affective valence of belief; PosVal=positive affective
valence of belief

Correlations between latent variables from this model are outlined in Table 12. The largest correlation was observed between the second-order latent variables of belief flexibility and belief conviction. These two constructs showed a strong inverse correlation. Belief conviction showed significant correlations of moderate size in the positive direction with negative affective response to belief revision and with reliance on confirmatory evidence. Notably, reliance on confirmatory evidence demonstrated significant associations with other latent variables including a small negative correlation with belief flexibility and a small positive correlation with negative affective response to belief revision. Significant correlations were also observed between all of the three factors that captured affective reactions.

Validity Analyses. In order to better assess the validity of first-order variables, scores on validity measures were entered as correlations added to the eight-factor model (Table 9, Model D). Correlations are presented in Table 13.

Table 13.

Correlation of Validity Measures with WBFS Factors

Measure	Scale	ContEv	Social	NoDoubt	Intuitive	ConfEv	NegAfRev	PosVal	NegVal
PDI	Distress	-0.23	0.07	0.21	-0.40*	-0.14	-0.38	-0.21	0.27
	Preoccupation	-0.13	0.05	-0.23	0.15	0.07	0.63*	0.32*	-0.19
	Conviction	-0.16	-0.27*	-0.07	0.37*	0.26	-0.12	-0.14	-0.18
CFI	Alternatives	-0.05	-0.04	-0.07	-0.12	0.15	-0.11	0.01	-0.08
	Control	0.06	0.06	0.02	-0.15	0.01>	-0.11	-0.04	0.01
BCIS	Self-Reflectiveness	0.33**	0.24**	-0.54**	-025**	-0.32*	-0.19*	-0.20*	0.19*
	Self-Certainty	-0.20*	-0.17*	0.32**	0.22*	0.05	0.17	0.07	-0.04
DAS	Extreme Responding	-0.08	0.11	0.25*	0.08	0.15	0.13	0.01	0.20*
DES	Total	0 .07	0.08	0.01	0.01	0 .13	0.14	0.14	0.06
CEQ	Total	0.11	0.09	0.06	-0.04	0.06	0.16	0.11	0.17
SDS	Total	0.07	0.02	0.02	0.05	0.05	0.04	0.11	-0.02
ASQ	Internality	-0.03	0.01	-0.03	0.13	-0.05	0.06	0.10	-0.02
	Stability	-0.01	-0.05	-0.05	0.03	0.05	0.10	-0.08	0.11
	Globality	0.03	0.03	-0.03	0.02	-0.03	0.05	0.09	0.01>

Notes. ContEv=willingness to consider contradictory evidence, Social=willingness to consider contrary social feedback from credible sources, NoDoubt=unwillingness to doubt belief, Intuitive=intuitive reasoning, ConfEv=reliance on confirmatory evidence, NegAfRev=negative affective response to belief revision, PosVal=positive affective valence of belief, NegVal=negative affective valence of belief * indicates statistically significant correlations at $p < .05$ and ** indicates statistically significant correlations at $p<.01$).

As expected, all WBFS factors showed at least a weak relationship with some aspect of delusion-prone schizotypy as measured by the PDI, with the strongest association between WBFS negative affective response to belief revision and PDI preoccupation (r =0 .63). BCIS self-reflectiveness showed significant correlations with all of the eight factors, the strongest correlation being with unwillingness to doubt (r = -0.54) and the lowest with negative affective valence of belief (r = 0.19). BCIS Self-

certainty correlated positively with unwillingness to doubt belief and intuitive reasoning, and negatively with willingness to consider contrary social feedback. Contrary to expectations, the CFI and its sub-scales were unrelated to the WBFS. However, the CFI and its subscales demonstrated moderate correlations with Social Desirability (*r*s ranged from 0.28 to 0.40), while the WBFS was not related to social desirability (*r*s ranged from .002 for experiential reasoning to 0.13 for openness to social feedback).

DAS Dichotomous thinking showed a small positive correlation with unwillingness to doubt belief, suggesting that lower levels of doubt are slightly predictive of a greater tendency to provide extreme responses to statements reflective of dysfunctional depressogenic attitudes. Dichotomous thinking showed a small positive correlation with negative affective valence of belief, suggesting that a tendency to experience negative emotions about unusual beliefs is associated with more extreme or dichotomous thinking. In line with predictions, dissociation, fantasy proneness, attribution style, and social desirability were unrelated to the WBFS demonstrating divergent validity for the WBFS.

The correlations between these variables and the second-order latent variables of belief flexibility and conviction were also examined. Results of these analyses showed that conviction is moderately associated with self-certainty (r =0.47) and self-reflection (r = -0.54) on the BCIS, and distress on the PDI (r = 0.34). Conviction on the WBFS was also weakly but significantly associated with PDI preoccupation (r = -0.26), and PDI conviction (r = 0.23) scores. Belief Flexibility was moderately associated with self-reflection (r = 0.30) and self-certainty (r =.-0.27) on the BCIS and conviction (r = -0.18)

on the PDI. No other significant correlations were observed and all other correlations were negligible in size ($r \geq 0.10$).

Study 4 Discussion

The factor structure of the WBFS was tested using a confirmatory factor analytic method. Results of the initial CFA indicated that the construct of belief flexibility for unusual delusion-like beliefs is best conceptualized as consisting of a global unwillingness to consider contradictory evidence, including social feedback. Results further indicate that the related construct of belief conviction for delusion-like beliefs can be conceptualized as a result of reliance on intuitive reasoning and a lack of willingness to doubt the veracity of the belief. Consistent with findings in clinical samples of individuals with psychosis (e.g. So et al., 2012), these results suggest that belief flexibility and conviction are distinguishable constructs, with a strong correlation in the negative direction.

In addition to belief flexibility and conviction (and their constituent factors), this study confirmed that the WBFS also assesses reliance on confirmatory evidence, negative affective response to belief revision, positive affective valence of belief, and negative affective valence of belief. Examination of factor correlations suggests that the tendency to rely on confirmatory evidence is negatively correlated with belief flexibility, and positively correlated with conviction and negative affective reaction to belief revision. All three affective factors were also significantly correlated with each other. This pattern of correlations suggests that the tendency to access confirmatory evidence is associated with the processes such as subjective experience of intuitive certainty and with difficult affective reactions to the possibility of belief revision, which are likely associated with

the functions of Steam 1. Furthermore, this tendency was negatively correlated with belief flexibility, a meta-cognitive process that is best conceptualized as indicative of Stream 2 functioning. This suggests that reliance on confirmatory evidence may be a rapid cognitive response to delusion-like belief that accompanies an experiential sense of certainty, and that the willingness to consider contradictory evidence which requires more cognitive processing, may be associated with a slight reduction of this tendency.

With respect to the validity analyses, a few interesting patterns were noted. All of the first and second-order factors showed significant correlations with the self-reflectiveness subscale on the BCIS. In line with expectations, BCIS self-reflectiveness showed a moderately strong positive correlation with belief flexibility, while demonstrating a moderately strong inverse correlation with both conviction and reliance on confirmatory evidence. This suggests that the strength of conviction in a belief is predicted by lower levels of self-reflectiveness, while higher levels of self-reflectiveness can predict the degree of belief flexibility. Further it shows that reliance on confirmatory evidence is associated with less self-reflectiveness. This pattern of findings is consistent with the idea that slow cognitive processes (e.g. self-reflection) are more related to belief flexibility than they are to the rapid/intuitive processes associated with conviction. This is also consistent with the pattern of correlations observed with the BCIS self-certainty subscale, which showed significant positive correlations with intuitive reasoning and unwillingness to doubt belief, and a negative correlation with the willingness to consider contradictory evidence. This suggests that as certainty increases, people are less willing to consider revising or actually revise their unusual beliefs, and is consistent with the inverse correlation observed between belief flexibility and conviction on the WBFS.

The DAS, a measure of dichotomous thinking, showed a positive correlation with unwillingness to doubt and an inverse correlation with intuitive reasoning. This suggests that doubt is associated with a response style characterized by less extreme conviction ratings, while reliance on intuitive reasoning is associated with more extreme conviction ratings. This pattern of findings further supports the hypothesis that belief flexibility is reflective of slow effortful analytic processes while conviction is reflective of faster, less reflective, more automatic heuristic processes.

General Discussion

These studies sought to develop and validate a self-report measure of belief flexibility for delusion-like beliefs in the general population. Collectively, these findings offer evidence for the validity and reliability of the WBFS as a measure of belief flexibility and related processes, providing psychometrically improved measures for assessing belief flexibility and conviction for delusion-like beliefs in the general population. While this program of research focused on establishing validity of the measurement model for WBFS, additional research into other psychometric properties such as test-retest reliability is warranted.

The current relationships between the latent variable of belief flexibility and conviction for delusion-like beliefs in the general population are consistent with the findings of So and colleagues (2012) who demonstrated that delusional belief flexibility and conviction are distinct but inversely related constructs. The tendency to rely on confirmatory evidence, such as thinking of knowledge/memories from personal experience was highly related to belief conviction. This suggests that judgments about confidence in unusual beliefs are supported by access to internally generated

confirmatory evidence. Furthermore, according to this research, affective features of the belief are not significantly related to the flexibility of delusion-like beliefs.

It has been suggested that some reasoning biases (e.g. the JTC) are a result of the hypersalience of the match between current hypothesis and current evidence (Speechley et al., 2010). That is, whatever hypothesis is appealing enough (due to a match between confirmatory evidence- including internal /affective experiences - and current belief), it is accepted because the slow and deliberate analytic stream of reasoning is not engaged. In line with this position, intuitive reasoning was inversely related to unwillingness to doubt belief, indicating reliance on subjective, heuristic processing is associated with a reduced tendency to doubt personally significant unusual beliefs. The findings also indicated that reliance on confirmatory evidence is associated with lower doubt, and lower willingness to consider contradictory evidence and social feedback. This suggests that accessing confirmatory evidence may reflect reliance on heuristics, which is more indicative of a failure to engage effortful self-reflective processes. Likewise, relationships between negative affect, intuitive reasoning and extreme responding suggested the operation of rapid intuitive/affective processes on dichotomous thinking.

Limitations and future directions. While this study is the first to develop a continuous self-report measure of belief flexibility for delusion-like beliefs in the general population, the generalizability of findings is limited by several methodological shortcomings. One set of major limitations are related to test construction. Some items in the WBFS are double barreled and could use further simplification. Furthermore, while conviction is conceptualized as a higher-order construct, it would be instructive to create a simpler first-order factor, tapping the strength/certainty of the belief more directly. As it

stands, some of the items from the willingness to consider external evidence and unwillingness to doubt share some overlap in item construction which is problematic for construct validity.

A second set of limitations is related to generalizability. This model was not tested on individuals in delusions. In order to make assertions about reasoning processes that impact formation and maintenance of clinically significant delusions, it will be important to administer the WBFS to people with varying degrees of delusional psychopathology. Furthermore, given that delusional beliefs were selected partly based on cultural implausibility and Turk participants were mainly recruited from the US, how this model generalizes to other cultures is an imperative question. Also, most of the beliefs endorsed as highly personally meaningful, came from the same two categories (conspiracy theories, and belief in the supernatural), limiting the generalizablity of its factor structure to other types of beliefs. Furthermore, the finding that government conspiracies were identified most frequently as the most meaningful belief with respect to the way people understand themselves in relation to others, raises questions about the appropriateness of our procedure for identifying a target belief. This is an issue that deserves further attention in future studies. With a sufficiently large sample, it would be interesting to compare the latent structure of WBFS for each of the delusion-like belief domains established in Studies 1 and 2. It would also be informative to test the structure of the WBFS on more neutral and/or commonly held beliefs. This would help elucidate the nature of belief flexibility as being specific to particular unusual beliefs vs. as a general reasoning style that people may apply when evaluating propositions. This study is

also lacking a test-retest reliability component, which will be important in establishing the stability of scores over time.

Another important direction for future research would be to test the relationship between belief flexibility and other established measures that capture related reasoning biases. For example, Jumping-to-Conclusions (JTC) or the tendency to make decisions based on limited amounts of data, and the Bias Against Disconfirmatory Evidence (BADE) are two commonly investigated reasoning biases (e.g. So et al., 2012; So & Kwok, 2015) and have been demonstrated to have associations with belief flexibility. It has been suggested that a tendency to accept implausible hypotheses as more likely than they are (referred to as the Liberal Acceptance Bias), limits the quality of evidence required for belief formation, and that reliance on confirmatory evidence including mood and/or other internal states makes implausible scenarios more tenable. Concurrent with these processes, the BADE leads to the dismissal of contradictory evidence, and the JTC bias serves to limit the quantity of evidence required for the formation of beliefs. The JTC bias has been thought to be impacted by the hypersalience of evidence/hypothesis match, referring to the tendency to evaluate the match between current belief and confirmatory evidence (e.g. congruence of mood with the valence of the belief) as particularly significant. This process is representative of the operation of rapid intuitive Stream 1 processes. The BADE in contrast, involves analytic evaluation of evidence, and is thought to be representative of slow analytic Stream 2 processes. Using this framework, it would be useful to assess how the factors that comprise the fast vs. slow processes on the WBFS are related to JTC and the BADE.

Furthermore, worrying and paranoia have been shown to relate significantly to reasoning biases (Ward & Garety, 2017). While the WBFS included some scales that assess affective factors, it would be important to examine the contribution of state and trait affective processes to latent variables in WBFS.

Finally, this study is limited by its cross-sectional nature. Longitudinal studies can help gain a better understanding of how belief flexibility may interact with these other factors to maintain or change vulnerability to psychosis across the psychosis continuum. For example, it would be interesting to investigate whether measuring belief flexibility for some delusion-like beliefs is more predictive of future psychosis than others and/or whether the extent of reliance on intuitive reasoning or confirmatory evidence changes with the progression of psychotic symptomology. It would also be interesting to investigate whether accumulation of external feedback over time, has an impact on belief flexibility scores.

CHAPTER 3

Examining the factor structure of reasoning biases in the general population

Introduction

Recent approaches to understanding delusions emphasize the centrality of cognitive biases to the development and maintenance of delusions (e.g. Freeman, 2007; Garety & Freeman, 1999; van der Gaag, 2006).While cognitive impairments in domains such as executive functioning and working memory are ubiquitous in schizophrenia (O'Carroll, 2000), the cognitive biases discussed here reflect aberrations in the reasoning process, affecting the acquisition, processing, and appraisal of information (Mortiz et al., 2008). The reasoning biases that are repeatedly highlighted in the literature and used as targets of therapeutic intervention include the Jumping-to-Conclusions (JTC) bias (i.e. tendency to rely on limited data in decision making), and a lack of belief flexibility (i.e. failure to acknowledge that they may be mistaken and to consider the possibility of alternative explanations).

Jumping to Conclusions (JTC)

Perhaps the most robust and widely replicated of the biases contributing to delusional thinking is the Jumping-To-Conclusions (JTC) reasoning style. The JTC reasoning style refers to the tendency of individuals to gather less information than is available when making decisions, the consequence of which is jumping to wrong conclusions (Garety et al., 1991).

A frequently used method for quantifying JTC has been the Probabilistic Reasoning Task, also known as the Beads Task (Huq et al., 1998). In the many variants of this task, participants assess the probability of an event, using empirical evidence. In

the original version of the task, participants are shown two jars which contain beads of two different colours, in complementary ratios, for example 85:15 red to black vs. 85:15 black to red. In other variants of this task, different stimuli are used in place of beads, different dimensions are used in place of color, and/or the ratio of one stimulus dimension to the other is changed. The jars are then hidden from view, the participant is told that beads will be drawn from only one of the two jars and is asked to guess from which jar the beads are being drawn. The experimenter then draws beads one at a time, ostensibly from one of the jars, but the order of selection of beads is actually predetermined. The idea is that if delusions are associated with the JTC bias, then delusional individuals should require fewer draws for making a decision. The presence of such a decision making style characterized by limited data gathering has been reported in 40% to 70% of delusional individuals (Glockner & Moritz, 2009). The Beads Task (including its computerized variants that use the same, or other stimuli meant to aid comprehension) is not the only paradigm that is used to measure JTC. Others have used more socially relevant material (Dudley, Young, John, & Over, 1997; Menon, Pomarol-Clotet, McKenna, & McCarthy, 2006; Warman, Lysaker, Martin, Davis, & Haudenschield, 2007) and have shown that delusional individuals tend to make hasty decisions with regard to all types of material.

Investigations of JTC in non-clinical samples have yielded mixed results. Some studies report hastier decision-making to be positively associated with increasing delusion proneness (Freeman, Purgh, & Garety., 2008; White & Mansell., 2009), whereas other studies have not replicated this finding (Rodier et al., 2011; Warman et al., 2007). Studies that took the more robust approach of comparing groups of individuals with

delusions, individuals with higher delusion proneness, and individuals with lower delusion proneness on JTC, have similarly yielded mixed results. Van Dael and colleagues (2006) found a pattern of results that suggest a gradation of JTC bias across groups. Specifically, they found that the patient group had the highest proportion of decisions with a definite rating after seeing only one bead on the beads task, followed by the delusion-prone group, and then the non-delusion prone group. Balzan and colleagues (2012) found a similar gradation across groups, but the difference in JTC was not significant between their two non-clinical groups. Other researchers found that the JTC bias was present only in clinical groups and that it was not observed in non-clinical groups (Freeman et al., 2010; Warman et al., 2007). In fact, both of these studies found that the delusion-prone individuals gathered more data than their non-delusion prone counterparts, though this difference did not reach statistical significance in either investigation.

The discrepancy in these findings may be attributable to differences in methodology. One noteworthy difference is that while the studies that found gradation across groups used 85:15 and 90:10 ratio of bead colors for the Beads Task, the studies that did not find a similar pattern of gradation used the more difficult version of the task where the ratio of colors was 60:40. So and Kwok (2015) set out to address these methodological differences that may have contributed to the discrepancy in these findings. They found that on both versions of the task (i.e. 85:15 and 60:40 color ratio), the JTC bias was stronger in individuals with delusions, followed by the non-delusion-prone group and then the delusion-prone group. The authors speculated that relationship between JTC and severity of or predisposition to delusions may be non-linear, or that the

JTC bias as measured by the Beads Task can only reliably distinguish the risk of delusions when the JTC becomes so pronounced that a decision is made after only one or two draws.

The JTC bias has been conceptualized as a predisposing factor for the development of delusions by facilitating the liberal acceptance of delusional ideas (Fine et al., 2007; Freeman et al., 2014; Garety et al., 2013). Recently, the research has turned to the question of whether the JTC is specific to delusions or whether it is a more general feature of psychotic illnesses. While a narrative review of 61 studies of JTC suggested that JTC is specific to delusions (Garety and Freeman, 2013), in a recent meta-analysis, So et al. (2016) concluded that they were unable to make a determination about this question due to a lack of sufficiently powered studies that compared individuals with schizophrenia with vs. without delusions. In another meta-analysis, Dudley and colleagues (2016) found that the odds of JTC in individuals with psychosis was 4 to 6 times higher than in healthy participants and those with non psychotic mental illnesses, and showed that JTC was associated with a greater probability of delusions in psychotic populations. Another meta-analysis (McClean et al., 2016) showed that individuals with schizophrenia with current delusions showed more JTC than those diagnosed with schizophrenia without current delusions.

The JTC bias is likely influenced by the widely established confirmation bias: the tendency to obtain confirmatory evidence for pre-existing beliefs, expectations or hypotheses (Nickerson, 1998) and the previously discussed Bias Against Disconfirmatory Evidence (BADE): the tendency to not attend to or discard evidence that is contradictory to one's initial belief (Freeman et al., 2002; Garety et al., 2001). So and colleagues (2012)

suggested that the style of limited data gathering characterized by JTC diminishes the willingness to consider alternate explanations, thereby strengthening or maintaining delusional explanations. This account highlights the role that belief flexibility, or lack thereof, plays in the development and maintenance of delusions.

The nature and interrelationships among these processes is not well understood in at-risk populations. However, as already noted above, So and Kwok (2015) suggested that the relationship between JTC and delusion proneness may not be linear, so that non-clinical individuals who are not delusion prone jump to conclusions more quickly in this task than delusion-prone individuals. That is, JTC may not be as strongly related to delusional severity in non-clinical samples. Therefore, it is conceivable that the relationship between belief conviction, flexibility, and JTC may be different in non-psychotic than in psychotic samples. There is also some indication that JTC may be specific to delusion subtypes, as Menon and colleagues (2013) failed to replicate a JTC bias in people with delusions of reference. They suggested that, unlike paranoid delusions which are driven by beliefs or thoughts about the self and others, delusions of reference, (i.e. the experience of feeling that an external stimulus is directly about them), are driven more by the *experience* of self-referentiality. This is consistent with research showing that JTC is related to abnormal beliefs but not to abnormal experiences such as the presence of hallucinatory symptoms (Lawrence & Peters, 2004).

Belief Flexibility

The fifth edition of the Diagnostic and Statistical Manual of Mental defines delusions as fixed beliefs that are not open to change, despite contradictory evidence (American Psychological Association, 2013). A lack of belief flexibility can predict

outcome in psychosis (Garety et al., 1997) and has been implicated in maintaining delusional conviction over time. Though much remains to be learned about its precise role in the development and maintenance of delusions, there is some support in the literature for the utility of belief flexibility as a promising therapeutic target (Waller et al., 2011; Garety et al., 2014). Garety and colleagues (2014) showed that a brief computerized intervention targeting JTC and belief flexibility was associated with significant reductions in state paranoia in individuals with psychotic delusions. More importantly, they found that the reduction in paranoia was mediated by changes in belief flexibility but not changes in JTC, indicating a causal relationship between belief flexibility and paranoia.

Ward and Garety (2017) identified three areas of investigation that take different approaches to the measurement of belief flexibility for delusional beliefs. These include: 1) direct assessment of belief flexibility regarding delusions using an interview format, 2) using delusion-neutral tasks to assess the tendency not to use contradictory evidence, and 3) dual process models of reasoning.

Direct Assessment. The earliest research on belief flexibility was spurred by psychological theories about decision making under conditions of uncertainty (e.g. Fischhoff and Beythmarom, 1983; Hemsley and Garety, 1986). This work led to the development of the Maudsley Assessment of Delusions Schedule (MADS, Wesseley et al., 1993), an assessment tool designed for comprehensive clinical assessment of delusions and the ways in which people reason about their psychotic experiences. The MADS is a standardized semi-structured interview that addresses seven aspects of delusional experience namely conviction, belief maintenance factors, affect relating to

chosen belief, action, preoccupation, systemization, and insight. Using the MADS, the full range of delusions currently being experienced by a person is elicited and then a principal belief (i.e. a belief that is reported by the patient to be of particular importance to them) is established (e.g. for one person, the belief that he or she is being followed by the CIA may be particularly salient). This principle belief then becomes the focus of the rest of the interview. The belief maintenance section of the MADS taps into evidence for the delusion, and two of its items (i.e. PM and RTHC) have been previously used to measure belief flexibility. The evidence for the delusion cited by the patient is discussed and they are asked whether it is possible that they are mistaken about their belief (PM). The interviewer then asks how they would react in a hypothetical situation where some new evidence was generated against their delusion (RTHC). The answers to these questions are dichotomously coded (yes/no) and a positive response to either inquiry is taken as evidence of belief flexibility.

Another measure previously used in the measurement of belief flexibility is the Explanation of Experiences Assessment (EoE; Freeman et al., 2004). The EoE is a structured interview that assesses whether people can come up with alternative explanations for the evidence cited for their delusions (i.e. AE). Once a person's evidence for their primary delusional belief (i.e. the most personally meaningful delusion) is identified, they are asked "Can you think of any other explanations that you have described? Are there any reasons other than [paraphrase evidence for delusional belief] that could possibly account for these experiences even if you think they are unlikely?" Whether the patient is able to generate any alternative explanation is dichotomously coded (yes/no) and is taken as evidence of belief flexibility. The PM, RTHC, and AE

have been shown to be internally consistent yielding a stable factor when combined together as a scale in factor analytic research (So et al., 2012).

The literature using this direct assessment of delusions suggests that approximately 50% of individuals with psychosis deny any possibility of being mistaken about their delusional belief. That is, they respond negatively to the PM item of the MADS (So et al., 2012) while 25% are able to generate alternate explanations (AE) on the EoE (Freeman et al., 2004). AE has also been found to correlate positively with anomalous experiences and negatively with JTC (Freeman et al., 2004). Research also suggests that belief flexibility may be influenced by affective processes, as belief inflexibility is more strongly associated with grandiose than with persecutory delusions (Garety et al., 2013).

Research into the difference between clinically significant delusions and delusion-like beliefs has identified subjective distress as a main distinguishing factor (Peters et al., 1999). However, studies of belief flexibility in non-clinical samples are scarce. The one study that precedes this dissertation is rife with methodological issues, such that belief flexibility has not been adequately considered as a factor that may be able to distinguish the role of clinically significant vs. non-significant delusional beliefs. The study that did measure belief flexibility in a non-clinical sample did not in fact measure belief in delusional content. Colbert and colleagues (2010) compared belief flexibility across three groups: individuals with current delusions, individuals with delusions who are currently in remission, and non-clinical controls. They compared belief flexibility for a standard belief (i.e. the belief that the sun will rise tomorrow) with a personally meaning belief. For the currently delusion group, the personally meaningful belief was the most salient

current delusion elicited during a clinical assessment. For the remitted and non-clinical groups, the personally meaningful belief was a belief that they held that was important to them and how they understood the world (examples from their study included, "Treat others as you would like to be treated"; "My parents love me"; "My kids will grow up and be happy"). They found that personally meaningful beliefs, whether delusional or not, were held with the same conviction across groups but that the two clinical groups showed less flexibility than the non-clinical control group on the standard belief that the sun will rise. They concluded that belief inflexibility may be a characteristic thinking style of individuals with delusions rather than being specific to the delusional content.

However, the interpretability of these findings is limited by a few factors. First, the belief that 'the sun will rise tomorrow' was assumed to represent a belief that was less personally meaningful than other beliefs targeted in this study. However, the participants never rated the personal meaningfulness of this belief. Second, assuming that this belief does represent a personally unimportant belief, in order to conclude that a lack of belief flexibility is a general thinking style, it must first be demonstrated that this level of rigidity is observed in personally meaningful beliefs that may not be delusional in content (e.g. beliefs for unobservable entities or phenomena). Furthermore, the extent to which the personally meaningful beliefs generated by the non-clinical and remitted groups are comparable is questionable. The personally meaningful beliefs provided by the remitted group (e.g. belief that my parents love me) appear qualitatively distinct from the content of delusional beliefs (e.g. paranoia, belief in telepathy etc), suggesting that perhaps asking about personally meaningful beliefs in this way is not the most suitable method of prompting for delusion-like beliefs. Finally, the ability to entertain alternatives to the

belief that the sun will rise tomorrow may not be capturing belief flexibility at all. It may actually be capturing skepticism, the philosophical position than certainty in any form of knowledge is impossible (De Rose, 1995). Hence a new strategy was developed for eliciting personally meaningful delusion-like beliefs during the development of the WBFS.

The conventional approaches to measuring belief flexibility also face some serious conceptual challenges. For example, given the evidence that the features of delusion-like beliefs are continuous, conceptualizing belief flexibility as a dichotomous categorical variable is not empirically justified as it contributes to the loss of valuable information regarding its intensity and fluctuation. After all, the possibility of being mistaken may be acknowledged and endorsed to varying degrees so that belief flexibility may fluctuate in time for the same delusion and within the same individual. Furthermore, there is some indication that the different items comprising the construct (e.g. possibility of being mistaken, ability to generate alternative explanations) are not always consistent with each other (e.g. Garety et al., 2014). For example, it is possible that someone acknowledges the possibility of being mistaken, but is unable to generate alternative explanations. Is this person's belief flexibility equal to an individual who can both acknowledge possibility of being mistaken and is capable of generating alternate explanations for their experience? The existing approaches to measuring belief flexibility ignore the difference between these two cases and lump both into the group of 'belief flexibility – present'. Whether operationalizing belief flexibility as a continuous variable would change our understanding of the construct or its relationship to other constructs (e.g. cognitive biases) is an empirical question.

Indirect Assessment: Bias Agianst Disconfirmatory Evidence (BADE; Moritz and Woodward, 2006). The BADE is a construct that captures the ability to modify one's belief when presented with disconfirmatory information, and is measured using a delusion-neutral task. The BADE task was developed because the MADS and EoE relied on direct assessment of delusional symptomology such that it was not possible to measure the belief flexibility bias without measuring the symptom itself. The BADE task was developed to provide a method for measurement of the belief flexibility bias that is separate from the symptom itself, much like the beads task helps to measure JTC without the need for a direct clinical assessment (Woodward et al., 2006).

While the BADE task has been subject to many modifications over time, all of its variations share a general structure. Participants are presented with an ambiguous scenario (either pictorially or verbally) and are presented with three pieces of disambiguating information sequentially, one piece at a time. Subsequent to receiving each piece of information, they are asked to rate the plausibility of a number of interpretations (which remain the same across trials). These interpretations are categorized as true, absurd, and lure, and lures can either be neutral or emotionally evocative. Different aspects of belief flexibility are measured using the amount of change in plausibility ratings as more information about the scenario is provided. Traditionally, a smaller change in ratings of the lure items (i.e. interpretations that are initially plausible but become less likely as more information is provided) was operationalized as evidence of the BADE (Mortiz & Woodward, 2006). Another univariate scoring method, computes the BADE as the adjustment of the lure interpretations as a ratio of the increase in the true statements (Zadowski et al., 2012).

The BADE has consistently shown positive associations with a diagnosis of schizophrenia and severity of delusional symptoms (Eisenacher, 2016; Moritz et al., 2010; Speechley et al., 2012). It has also shown significant correlations with subclinical delusional ideation (Menon et al., 2013; Zawdzki et al, 2012). However, there exists a significant degree of variability in task administration and scoring, making comparisons across studies more difficult. For example, in addition to the pictorial (Woodward et al., 2006) vs. sentence (Woodward et al., 2008) presentation of scenarios, the number of scenarios, the number of interpretations offered for each scenario, and the language of interpretation have all been varied across studies (Speechley et al., 2012).

Computation of the BADE scores have also varied across studies. While the most widely used method for calculating the BADE involves the computation of a change score for lure interpretations across trials, in response to calls in the literature for more reliable scoring methods, some researchers have begun using multivariate analyses to represent the BADE as a set of two scores: Evidence Integration Impairment (EII), and Conservatism also referred to as Positive Response Bias (PRB) (Bronstein and Cannon, 2017; Sanford et al., 2014; Speechley e t al., 2012). The former reflects the degree to which disambiguating evidence impacts conviction, and the latter captures a low willingness to rate interpretations with high certainty, even when such a practice would be justified.

Sanford and colleagues (2014) calculated EII as Absurd 1 + Absurd 2+ Absurd 3 + Lure A3 + Lure B3 – True 3, with each component of the equation representing the average plausibility rating provided for each item category at the specified trial, and letters A and B referring to neutral and emotional lures respectively. For example, Lure

A3 refers to average plausibility rating for the neutral lure interpretation after being presented with the third piece of disambiguating information. Based on this computation, flexibility can be understood as the ability to reject implausible items (i.e. absurd interpretations at any point during the task) and change one's plausibility ratings for true and lure items based on incoming information.

A more recent study by Bronstein and Cannon (2017) used confirmatory factor analysis to revise the equation for EII, eliminating the last component of this equation so that the True 3 rating is dropped from the equation. Conservitism/PBR is operationalized as Lure A1+Lure B1 + LureA2+LureB2+True1+True2. Only EII was found to discriminate between delusional individuals and other groups (Sanford et al., 2014). Given that EII includes absurd as well as lure ratings, it appears that the BADE measured in this way is consistent with a general tendency to accept implausible hypotheses as highly plausible, also referred to as the Liberal Acceptance bias (Moritz et al., 2009).

Relationships to Delusional Conviction

Both JTC bias and a lack of belief flexibility have been associated with levels of delusional conviction in psychosis (Colbert et al., 2010; Freeman et al., 2004; 2008). Given the strength and consistency of these findings, So and colleagues (2012) investigated the question of whether these biases are truly distinguishable from delusional conviction and found that using a factor analytic design, the three constructs form three separate factors, suggesting that they are indeed conceptually independent.

So and colleagues (2012) investigated the relationship between these constructs over a period of 12 months, in a longitudinal cohort of people receiving treatment for psychosis who had experienced a relapse. Using exploratory factor analysis, they showed

that delusional conviction, JTC, and belief flexibility formed independent latent factors (Figure 3). However, they noted that method variance may have inflated the relationships between the variables that constituted each factor. They also found that while JTC and belief flexibility did not change over time, that there was some evidence for a decline in delusional conviction, and that belief flexibility was most predictive of future improvements in delusional conviction over the course of 12 months.

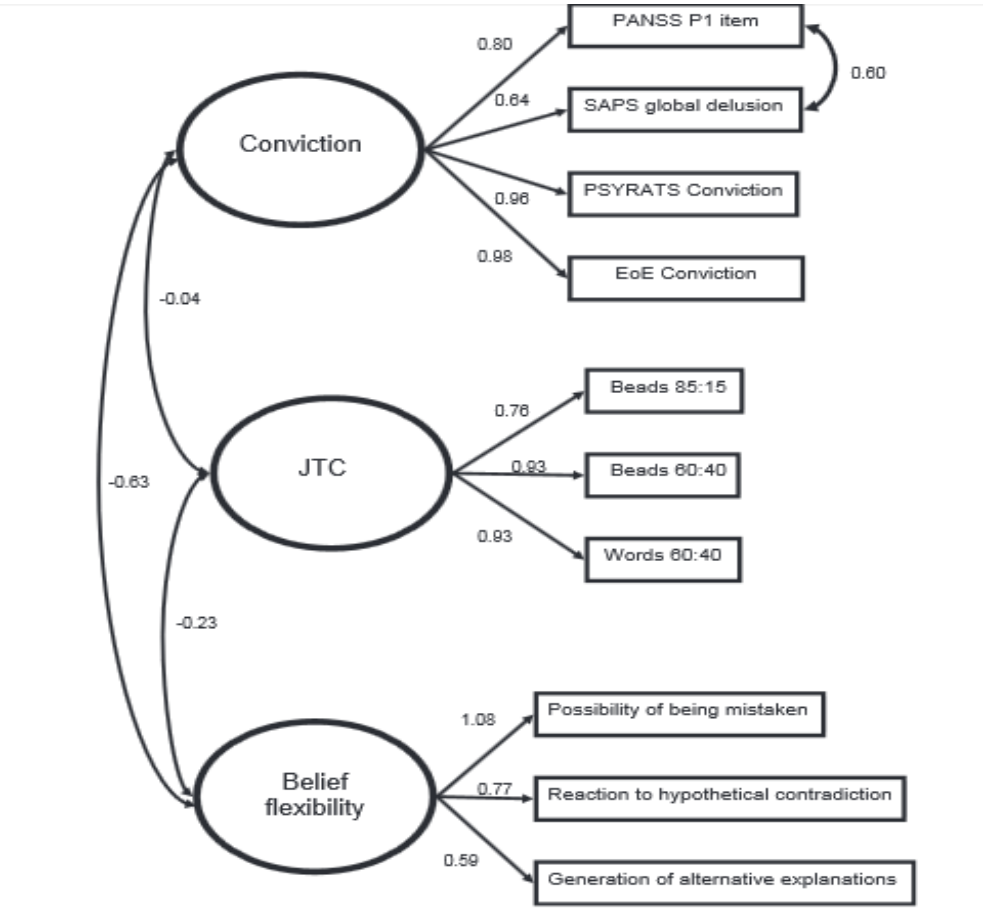
The only study of belief flexibility that included a non-clinical group showed a strong negative association between belief flexibility and belief conviction in this group (Colbert et al., 2010). Though the findings related to the relationship between JTC and conviction were equivocal (see Freeman et al., 2008 but see Rodier et al., 2011), the results presented in Chapter 2 above show that conviction for delusion-like beliefs can be measured in the general population. These findings also show that WBFS conviction is distinct from WBFS flexibility, and that it is correlated positively with PDI conviction and inversely with PDI preoccupation. However, how belief flexibility and conviction measured using the WBFS relate to BADE and JTC (i.e. tasks not directly related to the belief assessed for the WBFS) has not yet been addressed. Examining these relationships is one of the aims of the current investigation.

Delusional Reasoning and Affect

As discussed in Chapter 1, the Dual Stream Modulation Theory suggests that delusional beliefs are in part a result of a lack of activation of the slower analytic reasoning stream, such that the conclusions reached by the rapid intuitive stream go unchecked (Speechley et al., 2013). Speechley and colleagues (2013) also proposed another component in their model: what they termed the accentuated emotional modulation (AEM) process, wherein

Figure 3.

A Model of Belief Conviction, Jumping-to-Conclusions (JTC), and Belief Flexibility in Delusional Individuals. So et al. (2012).



the affective valence and intensity of affect experienced as associated with information increases reliance on intuitive Stream 1 processing. However, many studies have failed to show that emotionally laden content increases reliance on reasoning biases (Menon et al., 2006; Galbraith et al., 2010) and a meta-analysis found that emotional material was not associated with amplification of the JTC (Fine et al., 2007).

However, the stimuli used in these studies may not have been sufficiently emotionally evocative, as another line of investigation has found JTC to be predicted by the use of self-referrent emotional stimuli in both delusion-prone and deluded individuals (Warman and Martin, 2006; Warman et al., 2007). Dudley and Over (2003) evoked Evans and Over's concept of epistemic utility (1996) – the value that people place on gaining truths vs. avoiding falsehoods – to explain why emotionally laden material may not always elicit reasoning biases. Specifically, they argue that people without delusions have a tendency to place more value on confirmatory evidence for statements that predict danger (de Jong et al., 1997), as the cost of believing such statements may promote survival. They argue that individuals with delusions judge confirmatory strategies to have more utility such that they apply a danger-confirming strategy to situations where it is not warranted. In other words, people with delusions are biased towards confirmatory evidence. Though this usually does not pose a problem (e.g. with neutral materials and/or insufficiently personal or evocative materials), when one is sufficiently emotionally activated, this strategy may lead to errors (e.g. the belief that one is the subject of harm by others based on an interpersonal situation that makes one feel rejected).

This theory is consistent with findings which show that studies that use paranoid or persecutory beliefs and/or introduce stress as a variable, have been more successful in eliciting the JTC. For example, individuals in a stress-inducing condition rated their confidence in the beads task as higher than those in a control condition (Keefe and Warman, 2011). Likewise, Ellet and colleagues (2008) found that individuals with persecutory delusions who were exposed to a stressful urban environment were more likely to show JTC than those who were exposed to a mindfulness intervention. Mortiz

and colleagues (2009) showed that individuals with delusions who were exposed to anxiety-provoking music were more likely to exhibit JTC bias than those who were not. Lincoln et al. (2010) showed that an experimental manipulation that increased anxiety exacerbated state paranoia; an effect that was partially mediated by JTC.

Results for positive mood manipulation has been mixed, with some studies suggesting that increasing positive mood leads to increased data gathering on the beads task in non-clinical populations (Lee et al., 2011). A study of bipolar individuals showed that positive mood was associated with resistance to advice in decision making tasks (Mansell and Lam, 2006). While research on positive mood and grandiose delusions is scarce, there is some indication that JTC is more strongly associated with grandiose than persecutory delusions (Garety et al., 2013).

Study 5

The primary contribution of this program of research has been to gain a better understanding of the nature of cognitive biases in non-clinical samples by attempting to improve the measurement of belief flexibility for unusual delusion-like beliefs, and to replicate the model tested by So et al. (2012) depicted in Figure 3. The Windsor Belief Flexibility Scale (WBFS) was developed to measure belief flexibility, belief conviction, and the conceptually related processes of reliance on confirmatory evidence, negative affective reaction to belief revision, and positive and negative valence of belief. In this study, participants rated their most salient personal belief using the WBFS, and then completed three versions of the probabilistic reasoning task to measure JTC bias. A version of the BADE task was also used to see how this reasoning bias might be related to belief flexibility and JTC given their conceptual overlap.

Furthermore, given that anxiety, depression, and worry have been linked to paranoia and subclinical delusional ideation (Freeman & Garety, 2014) and emotional state can impact on reasoning processes (Bentall et al., 2009), self-report measures of depression, anxiety, paranoia, and worry were also administered.

Method

Participants. Participants were recruited from Mechanical Turk (MTurk). A total of 392 respondents completed the online survey, which took approximately 45 minutes and for which they were provided a token of appreciation of $2.50 USD. MTurk workers who had completed a prior WBFS study were unable to access the study.

Demographics for the final sample were: $M_{age} =$ 35.84 (SD=10.48, Range: 20-72, Median = 33.3), 47% male, employment status (64% full time, 21% part time, 5% self-employed, 10% unemployed), education (12% graduate or professional, 41% university degree, 22% some post-secondary, 20% high school diploma, 5% some secondary), race/ethnicity (70% Caucasian, 8% Asian, 10% African-American, 4% Hispanic, 3% Biracial / mixed race, 5% Other or prefer not to answer). With respect to mental health diagnoses, 4% endorsed a prior or current diagnosis of Obsessive-Compulsive Disorder, 3% eating disorder, and 3% psychotic disorder. Consistent with the preceding studies, these participants were removed from the dataset, leaving a total of 357 participants in the final sample.

Procedure. MTurk workers viewed information about the study on MTurk. Interested participants followed a link that determined eligibility. If eligible, they were provided with a link to the online survey. Participants were presented with a consent form. If they agreed to participate, they completed the demographics questionnaire

followed by the WBFS, the Green et al. Paranoid Thoughts Scale (GPTS), the Penn State Worry Questionnaire (PSWQ), the Beck Anxiety Inventory (BAI), and the Beck Depression Inventory (BDI). Finally, participants also completed three versions of the probabilistic reasoning (JTC) task as well as the BADE task. All of the measures and tasks were presented in a randomized order.

Measures

Windsor Belief Flexibility Scale (WBFS). The WBFS is a 26-item self-report questionnaire developed and validated in Chapter 2. The WBFS has an eight-factor structure that includes the following subscales: (1) willingness to consider contradictory evidence, (2) willingness to consider contrary social feedback, (3) unwillingness to doubt belief, (4) intuitive reasoning, (5) reliance on confirmatory evidence, (6) negative affective response to belief revision, (7) negative affective valence of belief, and (8) positive affective response to belief. Factors 1 and 2 constitute the second-order latent variable of belief flexibility and Factors 3 and 4 create the second order latent variable of conviction. The WBFS was primarily used to measure the central dependent variables of belief flexibility and conviction for delusion-like beliefs.

Participants also completed a subset of ten WBFS items (comprising Factors 1,2 and 4) in relation to three additional beliefs (religious, political, and scientific). Specifically, participants were asked to indicate whether they believe that human causes significantly contribute to global warming, that democracy is the best system of government that humans share a common ancestor with apes, that electrons exist, and that god exists. These additional beliefs were included in order to investigate whether belief flexibility is a trait-like construct that generalizes across belief types and/or

whether it is specific to the belief being tested, and to explore whether reliance on intuition vs. analysis varies across beliefs.

The Bias Against Disconfirmatory Evidence (BADE) (Woodward and Moritz, 2006). The BADE task is a measure that utilizes non-delusional beliefs with the specific aim of measuring belief flexibility when people are presented with evidence that is contradictory to initial conclusions (Buchy et al., 2007). The version of the BADE task used here included 35 delusion-neutral scenarios, 20 of which are designed to measure the BADE, and the rest are control trials designed to obscure the nature of the task. Each trial consists of three successive statements which serve to disambiguate the scenario. The 20 trials that measure the BADE contain one true interpretation, one lure interpretation, and one absurd interpretation (See Appendix C for an example of a trial). The lure interpretation initially appears equally or more plausible than the true interpretation, but as more information is revealed, it becomes less plausible. The true interpretation appears implausible initially but as more information is revealed about the scenario, it becomes the most plausible interpretation. The absurd interpretation remains implausible across all statements. Participants were asked to rate the plausibility of each interpretation independently after the presentation of each disambiguating statement. The BADE was operationalized using the multivariate method of operationalization developed by Bronstein and Cannon (2017); as a set of two factors: Evidence Integration Impairment (Absurd1+Absurd2+Absurd3+L ure3) and Positive Response Bias as Lure 1+Lure 2+ +True1+True2. The univariate method of calculating the BADE as the difference between Lure 3 and Lure 1 was considered, but the multivariate method provided a better fit to the data and was used in the analysis.

Jumping to Conclusions (JTC, Huq et al., 1991). JTC bias was measured using three different variations of the probabilistic reasoning task. In the first version, participants were presented with computerized versions of the beads task, adapted from Balzan et al. (2012). Participants were presented with a picture of two containers full of red and black beads (85% red, 15% black for container A, and vice versa for container B). They were told that the computer would randomly select beads from the same container during the task and participants were to determine from which jar the beads were being drawn. Participants were told that they could ask for as many beads as they wished in order to make the decision as to from which jar the beads came. After each trial, participants were given the option to make a decision or to request another bead. The second variation of this task involved the same procedure except with a more ambiguous colour ratio for the beads (i.e. 60:40). The third version of this task followed the same structure, but used emotionally salient, self-referent materials in place of the beads (Dudley et al., 1997). Specifically, participants were told that they would see words that came from a survey of the opinion of two groups of 100 about an individual. They were presented with these words one at a time. Participants were told that one group made 60 positive and 40 negative comments while the reverse was true for the other group. Participants were asked to decide from which survey the words were drawn. The dependent variable was the pieces of information requested before making a decision (Draws to Decision).

Peters Delusions Inventory (Peters et al., 1999). This measure was administered the same as in the preceding chapters.

Green et al. Paranoid Thought Scale (GPTS, Green et al., 2008). The GPTS was the first multi-dimensional measure of persecutory ideas developed for use in both non-clinical and patient populations. The measure seeks to capture the range of persecutory beliefs that are present in the continuum of normal functioning and psychopathology, by assessing in a self-report format ideas of persecution (i.e. paranoid beliefs that reflect the idea that harm is going to occur or is occurring, with the assumption that a persecutor has the intention to cause harm) and ideas of social reference (i.e. paranoid beliefs which reflect the idea that harm is going to occur or is occurring without the assumption that a persecutor has the intention to cause harm). Participants are asked to think about the last month and to indicate the extent of these feelings from 1 (not at all) to 5 (totally) for each statement. Using a principal component exploratory factor analytic approach, two 16 item factors were extracted, indicating ideas of social reference (e.g. 'I was frustrated by people laughing at me') and ideas of persecution (e.g. "It was difficult to stop thinking about people wanting to make me feel bad").

The GPTS showed good psychometric properties. Specifically, it showed adequate internal consistency with alpha values ranging from .68 to .95 for the total score and subscales. Test-retest reliability at two weeks follow-up showed strong consistency, with intra-class correlation coefficients ranging from .81 to .88 for total scores and subscales. Regarding construct validity, GPTS showed strong correlations with other measures of paranoia (Spearman's rho = .71-.81) and moderate correlations with other measures of delusion-proneness (Spearman's rho = .39 - .43). The GPTS was also able to discriminate between delusional and non-clinical groups and it also showed good

sensitivity to clinical change, with reductions in GTPS scores correlating significantly with improvements in assessments of psychosis.

Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger and Borkovec, 1990). The PSWQ is a well-established measure of trait worry that has been widely used in clinical and non-clinical populations. It consists of 16 items that assess pathological aspects of worrying such as uncontrollability of thinking. Each item is rated on a 5-point scale, with higher scores indicating a greater tendency to worry. The PSWQ has very good psychometric properties, with internal consistency and test-reliability resulting in intra-class correlations in the .92-.95 range (Meyer et al., 1990). The PSWQ correlates with other measures of worry such as the Worry Domains Questionnaire (Tallis, Eyesnck, & Mathews, 1992) and the Anxious Thoughts Inventory (Startup & Erikson, 2006) and is able to reliably distinguish Generalized Anxiety Disorder (GAD) from other mental health problems (Brown et al., 1992). This measure also predicts the frequency and duration of worry episodes in daily life (Verkuil et al., 2007).

Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988). The BAI is a 21-item self-report inventory which measures clinical levels of anxiety. It possesses high internal consistency, (α = .92) and test–retest reliability (r = .75). The BAI accurately discriminates anxious clinical groups (e.g. GAD, panic disorder, etc.) from non-anxious clinical groups (major depression, dysthymic disorder etc) and correlates moderately with the Hamilton Anxiety Rating Scale (r = .51).The BAI places an emphasis on physiological aspects of anxiety, with 15 items measuring physical symptoms. This makes the BAI a good complement to the PSWQ, which focuses mainly

on the more cognitive and affective components of anxiety such as excessive worry. High scores on this scale may indicate heightened levels of clinically significant anxiety.

The Beck Depression Inventory-II (BDI-II; Beck, Steer, Ball, & Ranieri, 1996). The BDI-II is a 21-item self-report measure of depressive symptomatology. Participants respond on a 4-point scale ranging from 0 (absence of symptom; e.g., "I do not feel sad") to 3 (severe presence of symptom; e.g., "I am so sad or unhappy that I can't stand it"). Higher scores indicate greater severity of depressive symptoms. The BDI-II has demonstrated excellent internal consistency with alphas ranging from .92 to .93 (Beck et al., 1996). This instrument also demonstrates acceptable levels of convergent validity with other measures of depression (r = .77), anxiety (r = .71), and self-esteem (r = -.64) (Osman et al., 1997).

Results

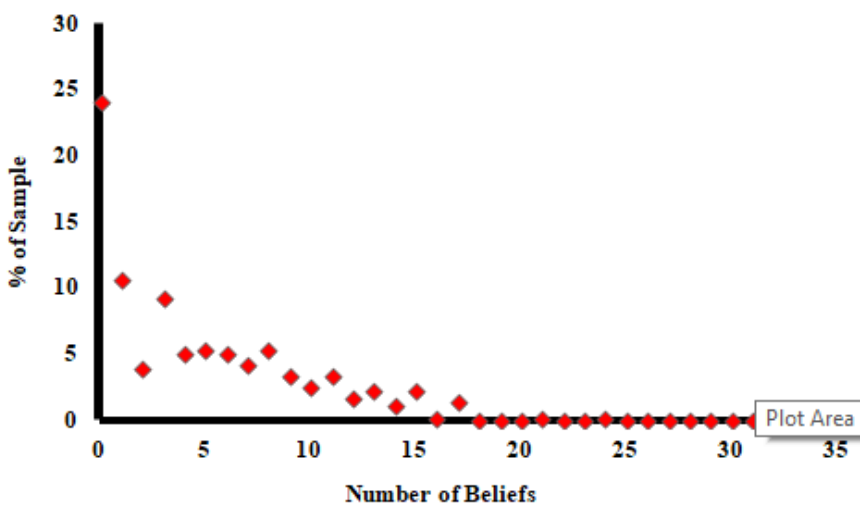
WBFS Target Beliefs. Overall, 16.9% of the 358 participants whose responses were submitted to the CFA identified the belief that the government purposely conceals information from others as most meaningful. Similarly, 13% selected the belief in the devil, 7.7% chose the belief that new technology is being suppressed to avoid harm to current industry, 6.9% selected the belief that some people can communicate with the dead, 5.8% chose the belief in reincarnation, and 5% chose the belief that evidence of alien contact is being concealed from the public as most meaningful. All other items were selected at least once, and selection remained below 5% for all other items. This pattern of response selection was consistent with findings from Chapter 2 with the exceptions that communication with the dead and concealment of alien contact were selected more frequently in the present sample.

With respect to non-delusional beliefs, 218 participants endorsed believing in human contribution to global warming, 180 endorsed believing in democracy, and 194 endorsed believing that humans share an ancestor with apes. A total of 243 participants endorsed believing in the existence of electrons, 246 endorsed believing in the existence of genes, and 128 reported believing in the existence of god.

A total of 24% of the overall sample did not endorse any of the WBFS target beliefs, while 11% endorsed one belief, 4% endorsed two, and 9% endorsed three of the beliefs. Less than 5% of the sample endorsed four or more of the target beliefs (Figure 4).

Figure 4.

Study 5, Frequency distribution for the number of endorsed beliefs



Structural Equation Modeling. In order to test the model that emerged from So and colleagues' (2012) factor analysis (which indicated that belief flexibility, belief conviction and Jumping to Conclusions are distinct but related factors), a CFA was performed using the 6 items from the WBFS that form the latent variable of conviction, the 7 items from the WBFS that form belief flexibility latent variable, and the total

number of draws to decision (DTD) on the three variations of the JTC task which were used to form a JTC factor. Given that a greater number of draws to decision reflects more gathering of data by participants, DTD was expected to load negatively onto the latent factor of JTC. The model reflecting belief flexibility, conviction and JTC was a good fit to the data (Table 14).

In order to investigate the possibility that belief flexibility and conviction may be tapping the same underlying construct, a model that collapsed BF and conviction was tested, which failed to converge. Therefore, models with additional latent variables were tested. Specifically, in addition to the JTC and belief flexibility, this model included Evidence Integration Impairment (EII) and Positive Response Bias (PRB) components of the BADE task. The model that included the PRB failed to converge, while the model that included the EII was a good fit to the data (Table 14). The correlations between the latent variables indicted that belief flexibility was negatively correlated with conviction (r = -0.682, p<.001), jumping to conclusions (r = -0.54, p<.001), and positively correlated with EII (r = 0.280, p<.001). The only other significant correlation was found between conviction and jumping-to-conclusions (r=0.28, p<.001).

In order to test the hypothesis that the EII and belief flexibility as measured by the WBFS were in fact tapping the same general construct of liberal acceptance of evidence, a model that included a higher-order EII component with belief flexibility was tested. While the fit indices suggested a good fit to the model (Table 14), an inspection of the factor loadings indicated that EII did not load significantly onto the higher order factor of liberal acceptance (loading=0.179, p=.129), and an examination of the AIC scores supported this decision. Therefore, it was concluded that the best fitting model to the data

involves 4 factors: belief flexibility, conviction, JTC, and EII. Refer to Figure 5 for a visual depiction of this model.

Table 14.

Study 5, Model Fit Indices

Model	X^2	**df**	**CFI**	**TLI**	**RMSEA**	**RMSEA CI**	**SRMR**	**AIC**
a)BF, Conviction, JTC	121.33	97	0.99	0.98	0.036	[.004-.055]	0.052	23858.77
b)BF, Conviction, JTC,EII	221.15*	160	0.98	0.97	0.044	[.029-.058]	0.059	2448.90
c) BF+EII, Conviction, JTC	222.12*	161	0.98	0.97	0.044	[.029-.057]	0.060	2994.05

Note: * indicates statistical significance at $p<.01$ level.

Relationship with Affect. Using the model established above, the relationship between belief flexibility, conviction, jumping to conclusions, and evidence integration impairment with measures of paranoia/persecutory ideation, delusion- proneness, anxiety, worry, and depression was explored by including these variables as correlates in the model. The correlations between these measures with each other are presented in Table 15. Most scales/subscales showed small to large correlations with each other. Notably, the PDI distress subscale was unrelated to all other covariates.

Table 15.

Study 5, Correlations between Measures of Affect

Measure	Scale	PDI-D	PDI-P	PDI-C	GPTS-S	GPTS-P	PSWQ	BAI
PDI	Distress (D)							
	Preoccupation(P)	0.07						
	Conviction (C)	0.10	0 .96**					
GPTS	Social Reference (S)	0.10	0.52**	0.49**				
	Persecution (P)	0.08	0.50**	0.48**	0.91**			
PSWQ	Total	0.03	0.26**	0.25**	0.44**	0.33**		
BAI	Total	0.08	0.42**	0.41**	0.73**	0.68**	0.56**	
BDI	Total	0.07	0.37**	0.39**	0.66**	0.59**	0.56**	0.84**

Table 16 depicts the correlations between latent constructs and the affective measures. Belief flexibility showed large inverse correlations with PDI conviction, and a moderate positive association with PDI preoccupation, suggesting that the more one admits to considering contradictory evidence on the WBFS, the less convinced they are of delusional beliefs, and the more time they spend thinking about them. The EII showed a similar pattern of correlations, while conviction (as measured by WBFS) and the JTC, showed the opposite pattern of correlations with the PDI. The same pattern of correlations emerged when the model was re-run by substituting the univariate BADE

Table 16.

Correlation of Latent Variables with Measures of Affect

Measure	Scale	Belief Flexibility	Conviction	JTC	EII
PDI	Distress	0 .08	0.03	-0.05	-0.06
	Preoccupation	0.68**	-0.60**	-0.41*	0.66*
	Conviction	-0.81**	0.77**	0.42*	-0.62**
GPTS	Social Reference	0.17	0.12	0.11	0.09
	Persecution	0.18	-0.08	0.07	0.30**
PSWQ	Total	0.03	-0.10	-0.06	-0.22**
BAI	Total	0.05	0.10	-0.04	0.24*
BDI	Total	-0.11	-0.10	0.09	-0.06

Note: PDI=Peters Delusions Inventory, GTPS=Green et al. Paranoid Thoughts Scale, PSWQ=Penn State Worry Questionnaire, BAI=Beck Anxiety Inventory, BDI=Beck Depression Inventory

difference score for the EII. This lends further evidence to the hypothesis that JTC as measured by draws to decision and conviction on WBFS may be reflective of more rapid, intuitive processes which involve less preoccupation with thoughts and beliefs, while the EII and belief flexibility are slower, more analytic processes that do involve more time devoted to the belief.

Interestingly, the only construct that demonstrated associations with the affective covariates was EII, which showed positive associations with persecutory ideation and anxiety, and a negative association with worrying. This suggests that the tendency to rate unlikely scenarios as likely despite the presence of disconfirmatory evidence is associated with greater tendency to experience the somatic aspects of anxiety, greater vulnerability to persecutory beliefs, and a lower tendency to worry. Substituting the univariate computations of the BADE for the EII yielded the same pattern of correlations.

The preoccupation, conviction, and distress scores for the persecutory and social reference subscales on the GTPS were also introduced as covariates, and did not correlate with the latent constructs in the model. The largest correlation was found between JTC and persecutory preoccupation (r=-0.27, p=.202), followed by JTC and persecutory conviction (r=0.22, p=.25), and EII and persecutory conviction (r= -0.21, p=.25). Though the results are not statistically significant, the size and direction of the correlations is consistent with the hypothesis that JTC and conviction are related to more rapid reasoning processes as indicated by their positive correlation with each other, and the JTC's inverse correlation with preoccupation, while EII is more correlated with analytic processes as indicated by its positive correlation with preoccupation. That said, the results are not statistically significant, the effect size is small, and such an interpretation calls for replication in an independent sample.

The relationship of the first order factors on the WBFS that did not constitute higher-order variables were explored in relation to conviction, belief flexibility, EII, and JTC (Table 17). Most notably, this suggests a strong relationship between reliance on

confirmatory evidence and the affective reactions to belief revision with belief conviction.

Measurement Invariance Analysis. In order to test the hypothesis that different types of beliefs may recruit different reasoning processes (specifically slow vs. rapid), participants' responses for the religious, political, and scientific beliefs were analyzed. Seven different beliefs were included in this analysis and compared to the personally meaningful delusion-like beliefs rated in the previous section.

Measurement Invariance (MI) testing involves a series of sequential model comparisons. When MI is achieved, it can be concluded that the same underlying construct is being measured across groups or across time. In this case, the question being answered is to what extent the model derived from data in Chapter 2, holds for different groups (i.e. belief types). The procedure outlined by Vandenberg and Lance (2000) was followed and model fit indices are provided in Table 18.

At each comparison step, equality constraints are added consecutively and each model served as the basis of comparison for the preceding model. In the first step (i.e. configural invariance), the same model is fit to all groups (belief types in this case) simultaneously and the hypothesis that the same items load onto the same factors across groups is tested. The configural model yielded a good global fit, indicating that different belief types would yield the same factor structure for the construct of belief flexibility on the WBFS. In the next step (i.e. weak/metric invariance) factor loadings were constrained to be equal across belief types. That is, the optimal model would have to produce the same factor loadings for all belief types. Imposing the equality constraints decreased the

Figure 5.

Study 5, Model of Reasoning Processes

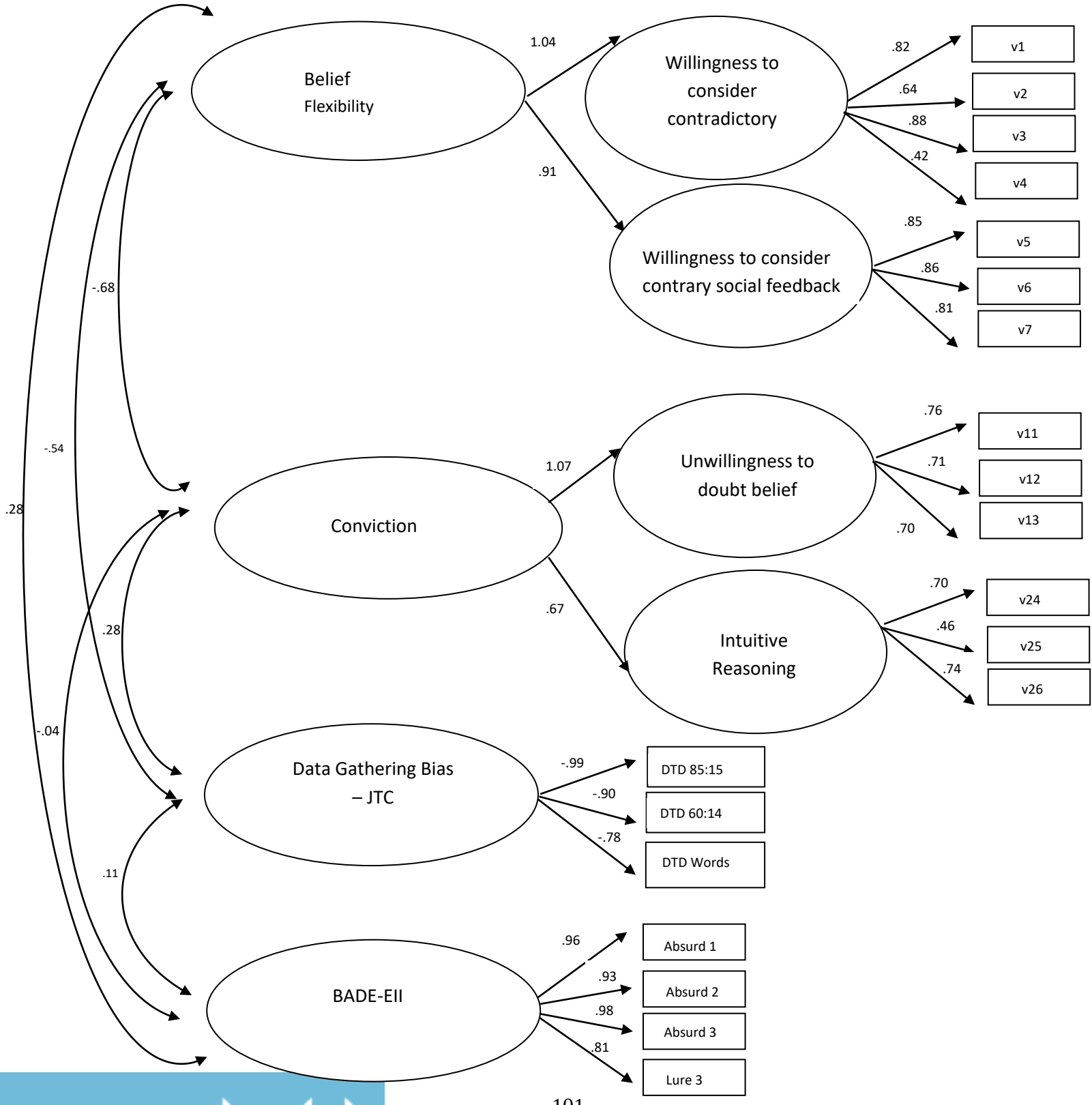


Table 17.

Correlations between WBFS First-Order Factors and Other Reasoning Processes

Scale	Belief Flexibility	Conviction	JTC	EII
Reliance on confirmatory evidence	-0.27**	0.58**	-0.03	0.07
Negative affective response to belief revision	-0.09	0.57**	-0.05	0.29**
Negative Affective Valence of belief	0.26**	0.01	0.11	0.22**
Positive affective valence of belief	0.12	0.12	0.03	0.20**

model fit, suggesting that factor loadings may not be equal for different belief types. To determine if the decrease in model fit was meaningful, recommendations by Cheung and Rensvold, (2002) to evaluate the amount of change in the CFI index were followed. Given the chi square's sensitivity to sample size, Chen (2007) recommends that for smaller sample sizes (i.e. 300 per group or smaller), Δ CFI of .005 and a Δ RMSEA of .01 be used as evaluation criteria. Per these criteria, the hypothesis of metric invariance was accepted in the current data, indicating that items loaded similarly onto their factors across all belief types. Next, intercepts were constrained to be equal across groups to test for strong/scalar invariance. The assumption of strong/scalar invariance suggests that the Likert scale is being used the same way to answer questions for different belief types. This model yielded a poor fit to the data across groups as Δ CFI > .005. Therefore, partial measurement invariance was tested to explore whether allowing the intercepts for some of the WBFS items to vary would result in scalar invariance.

To test partial invariance, first mis-specified items were identified via modification indices so that they could be allowed to vary between groups. This revealed four items with large modification indices: "I did not need to think too much about this belief to know that it's true", "I have a gut feeling that this belief is true", "I can think of alternate explanations for the experiences that led me to hold this belief" and "I can visualize the kind of evidence or circumstances that would change my mind about this belief". This indicates scores on these items systemically varied across belief types independently of changes in the latent constructs to which each belong (i.e. willingness to consider contradictory evidence, and intuitive reasoning). Releasing the constraints on the intercept estimates for these four items resulted in a better-fitting model, and ΔCFI of .001, meeting criteria for the establishment of partial scalar/strong invariance (Table 18).

Given that partial scalar invariance has been established, latent means could now be compared. To examine differences among latent means, the latent mean for delusion-like beliefs was used as a reference group by restricting the mean to zero, following which the latent means for the other beliefs were freely estimated and tested for significant differences. In other words, delusion-like beliefs were used as a reference group and the remaining latent means for the other beliefs were estimated in relation to it.

As compared to the self-selected personally meaningful delusion-like beliefs, comparison of latent means revealed lower mean ratings for willingness to consider contradictory evidence for the belief in god ($z=-5.29$, $p<.001$) , genes ($z=--9.08$, $p<.001$),electrons ($z=-6.231$, $p<.001$), evolutionary theory ($z=-4.795$, $p<.001$) and global warming ($z=-3.213$, $p<.001$). In contrast, no differences were observed with the belief in

democracy (z=-.266, p=.790). With respect to the willingness to consider contrary social feedback, lower means were noted for the belief in god (z=-4.006, p=.005), genes (z=-7.841, p<.001), electrons (z=-4.962, p<.001), evolutionary theory (z=-4.972, p<.001),

Table 18.

Study 5. Invariance Testing Model Fit Indices

Model	***X*²*(df)***	**P(ΔX²)**	**CFI**	**RMSEA**	**Decision**
Baseline model	440.16(224)	NA	0.976	0.069	Accept
Configural Invariance (indicating equal factor structure across groups)					
Metric Invariance (Indicating equal factor loadings across groups)	500.85(266)	.03*	0.974	0.066	Accept
Scalar Invariance (Indicating equal intercepts for all variables across groups)	672.19(308)	<.001**	0.959	0.076	Reject
Partial Scalar Invariance (Indicating equal intercepts for some but not all variables across groups)	526.34(284)	.11	0.973	0.065	Accept

and global warming (z=-3.611, p<.001). Again, belief in democracy did not show significant differences from delusion-like beliefs in the willingness to consider contrary social feedback (z=-.651, p=.515). With respect to intuitive reasoning, belief in electrons (z=-3.878, p<.001) and evolutionary theory (z=-1.914, p=.056), showed lower means, while belief in god showed a higher mean (z=4.03, p<.001). No differences in intuitive reasoning were observed between delusion like beliefs and the belief in genes (z=-1.752, p=.080), global warming (z=-.854, p=.393), or democracy (z=-.578, p=.564).

Given the indication in the literature that belief in god is predicted from an intuitive reasoning style (Shenhav et al., 2011), this analysis was re-run using belief in god as the referent belief. This showed that belief in democracy involved higher willingness to consider contradictory evidence (z = 4.63, p<=.001), higher willingness to

consider contrary social feedback (z=3.241, p<.001) and a lower level of intuitive reasoning (z=-4.200, p<.001). Belief in global warming only showed higher scores on willingness to consider contradictory evidence (z=2.562, p=.01) and intuitive reasoning (z=-4.479, p<.001). The other beliefs tested only showed differences in one factor, with genes (z=-5.205, p<.001), electrons (z=-6.855, p<.001) and evolution (z=-5.915, p<.001) all showing lower levels of reliance on intuitive reasoning.

Study 5 Discussion

In this study, the WBFS was used to test a model of reasoning processes of belief flexibility and conviction for delusion-like beliefs in a non-clinical sample, as related to reasoning biases including evidence integration impairment (EII) and data gathering bias (JTC). Relationships with other WBFS subscales (i.e. tendency to rely on confirmatory evidence, negative affective response to belief revision, positive affective valence of belief, and negative affective valence of belief) were also explored. The relationship of the components of this model with worry, paranoia, anxiety, and depression were examined, and the generalization of the resulting model and extent of reliance on analytic vs intuitive processes for different types of beliefs (including political, scientific, and religious beliefs) were explored.

Taken together, this study shows that belief flexibility and conviction for delusion-like beliefs in the general population are distinct constructs which are inversely and strongly interrelated. This is consistent with So and colleagues' (2012) findings which showed a similar pattern of findings within clinical samples. Consistent with this model, our findings also showed that belief flexibility and conviction are both distinguishable from the data gathering bias (commonly referred to as the JTC bias). This

finding is also supported by the observation that of the 10% of participants who rated their confidence in their endorsed unusual delusion-like belief as very high (7/7 on the response scale), 65.7% indicated that they could imagine changing their mind about their belief, suggesting that it is possible to be very certain about a belief while remaining very open to the possibility of belief revision. Furthermore, the correlation of JTC with belief flexibility (r = -.54) was almost double the size of its correlation with conviction (r = .28), suggesting that these constructs are based in distinct underlying processes.

Another important finding was that the evidence integration impairment factor of the BADE, which shares a lot of conceptual overlap with the construct of belief flexibility, was also found to be empirically distinct from belief flexibility, conviction, and JTC. The fact that EII and belief flexibility were positively correlated suggests that perhaps the willingness to consider contradictory evidence and contrary social feedback are indicative of a general willingness to rate unlikely scenarios as plausible. That is, the WBFS belief flexibility items may not be measuring the willingness to consider the quality of contradictory evidence. Rather, these findings suggest that it may be measuring the Liberal Acceptance Bias – the tendency to evaluate implausible information as plausible. With the liberal acceptance bias in operation, weak counter factual arguments can lead to the justification of implausible hypotheses. That is, scoring high on belief flexibility may reflect a tendency to be *too* open to contradictory evidence. That is, perhaps what is being captured is a tendency to accept too much contradictory evidence as plausible, such that the quality of evidence in relation to other available evidence is not taken into account. Based on this finding, one would expect positive correlations between

belief flexibility and/or the EII and delusion proneness and with paranoid and persecutory beliefs.

Results showed moderately strong relationship between EII and WBFS both showed a significant positive correlation with PDI preoccupation and a significant inverse correlation with PDI conviction, suggesting that both measures capture the tendency to spend time considering contradictory evidence, resulting in lower conviction levels. While this is consistent with the construct of WBFS belief flexibility, the inverse correlation between EII and PDI conviction is surprising. However, unlike WBFS belief flexibility, EII also showed a moderately strong significant positive correlation with persecutory beliefs. Taken together, this suggests that the EII captures a *disregard* for disconfirmatory evidence in determining plausibility ratings is more strongly related to persecutory beliefs while the willingness to spend cognitive resources on *considering or evaluating* disconfirmatory evidence could result in acceptance or dismissal of the evidence, and was not significantly related to persecutory beliefs. That said, the direction of the correlation between WBFS and persecutory beliefs was in the positive direction. Therefore, the relationship between WBFS, EII and persecutory beliefs requires further clarification.

The relationships between these constructs and other WBFS subscales were explored. With respect to reliance on confirmatory evidence, and affective aspects of the belief, some similarities with the findings in Chapter 2 were noted. Specifically, reliance on confirmatory evidence showed moderately large correlations with conviction in both studies (r=0.48 and 0.58, respectively) and small inverse correlations with belief flexibility (r=-0.23 and -0.27, respectively). Conviction also showed moderately large

correlations with negative affective response to belief revision in both studies (r=0.43 and 0.57, respectively). Belief flexibility's association with negative affective response to belief revision was noted in Study 5, but was not observed in Study 4 where EII and JTC were not included in the model.

With respect to the PDI, while belief flexibility, conviction, JTC, and EII were correlated with preoccupation and conviction suggesting a relationship with delusion-prone schizotypy, no correlations were observed with distress on the PDI in this study, suggesting that these reasoning processes may not be related to distress. With respect to other affective factors discussed above, the only significant correlations were found with the EII. Specifically, EII was positively associated with persecutory beliefs and anxiety, and negatively associated with worry. This suggests that while belief flexibility as measured using a self-report questionnaire such as the WBFS may not show relationships with affective variables measured, the closely related construct of evidence integration impairment when measured using a performance based measure and operationalized as the tendency to rate implausible explanations as highly plausible despite contradictory evidence, is related to a heightened sense of anxiety and a higher tendency to experience persecutory beliefs.

Interestingly, EII correlated negatively with worrying, suggesting that the higher one tends to rate absurd and/or unlikely explanations despite evidence to the contrary, the less one worries, despite reports of heightened anxiety symptoms. This positive association with anxiety is consistent with the position that in the context of feeling anxious, the occurrence of ambiguous internal sensations or feelings may lead to the endorsement of odd or delusional ideas through a sense of 'things not seeming right'

(Freeman, 2008). Freeman (2008; 2012) has suggested that worrying may be in part responsible for the initial generation of implausible interpretations of information, and in conjunction with elevated anxiety, depression, and/or insomnia, can result in the endorsement of paranoid beliefs. Therefore, the finding of a negative association between anxiety and worry is surprising and requires replication.

In the current study, JTC was associated with delusional conviction and preoccupation on the PDI, and with the persecutory conviction subscale of the GTPS. This suggests a role for hasty decision making/limited data gathering in delusional thinking in non-clinical populations. This is also consistent with the hypothesis that JTC is a reflection of rapid Stream 1 processes and that such reliance on rapid processing results in higher levels of conviction and less time devoted to analysis of the evidence that supports beliefs. These findings are also consistent with previous studies that show associations between JTC and psychotic paranoia in the general population (e.g. Moritz et al., 2012) and run counter to studies that have proposed non-linear relationships between JTC and schizotypy in non-clinical populations (e.g. So and Kwok, 2015).

A major difference between our findings and that of So et al.'s (2012) involves the correlation of JTC with the other measured constructs. Specifically, the pattern of correlations between JTC and belief conviction and flexibility was found to be much greater in the current non-clinical sample, suggesting that the contribution of this reasoning style to belief conviction decreases when delusion-like beliefs are clinically significant. However, this interpretation is limited by a few methodological factors. For example, in the study using clinical samples (So et al., 2012), belief flexibility was measured using categorical indicators derived from a semi-structured clinical interview

and conviction was measured using several clinician rating scales and an item on the EoE that asked participants to rate their conviction on a 100-point scale. Furthermore, in the current study, JTC was not operationalized as the presence of a decision after only one or two trials. Rather, the number of draws-to-decision was used to measure data gathering style. In fact, there were not enough participants to perform a meaningful CFA on only those participants who made a decision after only one or two trials. Furthermore, in the present study, items from the WBFS were used to measure both belief flexibility and belief conviction. Secondly, the target beliefs rated for this study were mostly comprised of beliefs in government conspiracies and spiritual beliefs. Therefore, the possibility that the strength of the correlation in the current study is due to methodological choices cannot be ruled out. However, examination of measurement invariance across types of beliefs rated indicated that the measurement structure of the WBFS held across different beliefs.

Another important direction for future research involves a re-evaluation of the WBFS target belief pool. An examination of the number of beliefs endorsed by participants (Figure 4) revealed that 75% of the sample endorsed at least one delusion-like beliefs. This is counter to the findings in the literature and calls the validity of some of the items in the final item pool (e.g. beliefs in conspiracy theory or belief in the devil) as representations of delusion-like beliefs into question. Validating a version of the WBFS with fewer target beliefs is important in establishing this measure as pertinent to the psychosis continuum.

Future studies would also benefit from an exploration of how performance on validated tests of executive functioning may be related to these constructs. The literature

indicates that executive function deficits could play a role in the formation and/or maintenance of delusions. Studies of neurocognition across the psychosis continuum suggest that the cognitive profiles of those at risk for psychosis are impaired in verbal executive and verbal memory while individuals in the early and late initial prodromal state demonstrated additional attentional deficits in a graded manner (Pukrop et al., 2006). Delusion-proneness has also been negatively associated with performance on the Stroop task (Orem & Bedswell, 2010) implicating executive dysfunction in the development of delusions. Other studies have shown that JTC is associated with executive functioning deficits in clinical, and non-clinical and at-risk samples (Falcone et al., 2014; Garety et al., 2013; Ochoa et al., 2014). With respect to the BADE, studies have shown associations with executive functioning, vigilance and working memory in clinical samples (Eifler et al., 2014; Riccaboni et al., 2012) and that the BADE is distinct from cognitive set-shifting (Mortiz et al., 2010). Thus, clarifying the relationship between executive functioning and the BADE, JTC, and WBFS in a large sample of the general population using structure equation modeling methods could help generate an understanding of how executive functioning is related to reasoning processes, before the onset of cognitive decline associated with first episode psychosis.

While existing research suggests that JTC bias is associated with delusions above and beyond cognitive impairments including working memory deficits, the design of the present study could benefit from the inclusion of a clinical comparison group to clarify interpretation. Specifically, the extent to which people rely on intuition vs. external evidence may be different for clinical and non-clinical samples. It would also be

interesting to explore whether different types of delusions (E.g. paranoid vs. grandiose) show differences on the WBFS.

Results also showed that unusual delusion-like beliefs differ from other belief types with respect to the extent of reliance on fast and slow reasoning processes. Specifically, the belief in god, genes, electrons, evolutionary theory and human contribution to global warming, were all associated with lower willingness to consider contradictory evidence or to consider contrary social feedback. While it is striking that scientific beliefs showed less flexibility to revision relative to delusion-like beliefs such as conspiracy theories, these results become less surprising if belief flexibility on the WBFS is conceptualized as a tendency to accept contradictory information too easily. That is, delusion-like beliefs may be associated with a greater tendency to evaluate evidence as plausible regardless of its quality, while people may be more selective with the types or qualities of evidence, they use to update scientific beliefs. This may be because people feel less well versed in science than in delusion-like beliefs which may have initially formed based in firsthand experiences. With respect to reliance on intuitive reasoning, belief in god showed higher scores while belief in electrons and belief in evolution showed lower scores relative to delusion-like beliefs. Overall, the findings show that belief flexibility can vary depending on the type of belief being measured and raises questions about whether or not belief flexibility on the WBFS is a type of reasoning bias (i.e. liberal acceptance) as opposed to a reasoning style that is protective. Future research that examines within-individual variation in belief flexibility across multiple beliefs will help to elucidate the relationships.

Interestingly, the belief in man's contribution to global warming was not significantly different than the delusion-like belief on any of the latent variables. This might be because while the delusion-like belief chosen came from many different categories, the beliefs that were most commonly endorsed had a political component. Specifically, a quarter of the sample chose government conspiracies (i.e. the belief that information is being deliberately concealed from the public and the belief that new technology is being suppressed to avoid harm to current industry). Therefore, any differences between the delusion-like belief and other belief types is confounded by the fact that the current sample was somewhat heterogeneous in the type of belief selected, with an overrepresentation of beliefs related to political conspiracies. In the future, it will be important to monitor the number of beliefs selected from each category so that a comparable number of belief types are selected.

When belief in god was used as the referent belief, the results showed that delusion-like beliefs, belief in democracy, and belief in human contribution to global warming were each characterized by greater willingness to consider contradictory or social evidence, and less reliance on intuitive reasoning. In contrast, the belief in genes, electrons, or evolution only showed differences from religious beliefs in lower reliance on intuition. These results suggest that all beliefs measured relied less on intuitive knowledge than belief in god, and indicate that the factors that result in belief in more scientific concepts were no different than those that result in belief in god, in terms of the willingness to consider contrary evidence. This is consistent with Shtulman's (2013) findings that scientific and supernatural beliefs could not be differentiated in terms of the participants' ability to justify and/or revise their beliefs.

Overall, the findings of this study replicated the factor structure previously established by So et al. (2012) of reasoning processes including belief flexibility, conviction, jumping to conclusions, and evidence integration impairments, in a non-clinical general population, and suggested that only evidence integration impairment is associated with affective variables including paranoia, anxiety, and worry. While it is possible that in the non-clinical population, belief flexibility and conviction are unrelated to these affective factors, further investigation of the WBFS in terms of its correlations with state and trait affect is warranted. This study also showed that delusion-like beliefs differ from other belief types with respect to the openness to belief revision and intuitive reasoning, suggesting that belief flexibility is not a trait-like tendency that exists within individuals, and that it tends to remain specific to the belief being measured. Beliefs are mental constructs that vary in the degree to which their supporting evidence is open to reinterpretation, updating and revision, Longitudinal and/or experimental studies that involve manipulation of affective state could help to elucidate the extent to which reasoning processes that contribute to belief flexibility may be influenced by affective variables.

CHAPTER 4

General Discussion

The overarching goal of this dissertation was to develop a broader understanding of the nature of belief flexibility and reasoning processes related to unusual delusion-like beliefs in non-clinical samples. While previous studies have examined the nature of belief flexibility for delusions in psychotic samples (Zhu et al., 2018), research on belief flexibility for delusion-like beliefs in non-clinical samples is scarce. This is one of the first programs of research to attempt to refine the measurement of belief flexibility and related constructs for delusion-like beliefs, and the first to use factor analytic statistical approach to clarify relationships between reasoning and affective processes that contribute to delusional thought, in the general population. This is important in order to gain a better understanding of how these reasoning biases interact to form and maintain delusional beliefs across the psychosis continuum.

The first phase of this endeavor was described in Chapter 2. Study 1 involved generating a pool of unusual beliefs that conceptually resembled clinically significant delusions. This resulted in an item pool comprised of 6 domains of delusion-like beliefs including: delusional psychopathology, government conspiracies, psychic-related phenomena, alien contact, supernatural entities, and astrology and urban legends. The findings from Study 2 confirmed this six-factor structure, resulting in a 34-item questionnaire covering the domains of delusion-like beliefs outlined above. The factor scores correlated with an established and validated measure of delusion-proneness, and demonstrated personal meaningfulness to participants.

In subsequent studies, participants were asked to select one of these beliefs as the most personally meaningful, and to rate the chosen belief for its flexibility. Once the item pool for target beliefs was confirmed in Study 2, a second item pool for measuring belief flexibility and related constructs was developed in Study 3. The dual processing model of cognition for delusions (Kahneman, 2011; Speechley et al., 2012) was used to generate items to reflect rapid intuitive (Stream 1) reasoning processes, and slower, analytic (Stream 2) reasoning processes, and affective processes that may influence the operation of these reasoning systems. Exploratory factor analysis was used to reduce the item pool, resulting in 17 items captured by five factors which were named: willingness to consider contradictory evidence, affective valence of belief, negative affective response to belief revision, intuitive reasoning, and reliance on confirmatory evidence. Study 4 continued to replicate and refine the model through the revision and addition of items to the measure that emerged from Study 3. This resulted in a 26-item questionnaire comprised of eight factors: willingness to consider contradictory evidence, willingness to consider contrary social feedback, intuitive reasoning, unwillingness to doubt belief, reliance on confirmatory evidence, negative affective response to belief revision, positive affective valence of belief, and negative affective valence of belief.

A second-order confirmatory factor analysis indicated that willingness to consider contrary social feedback and contradictory evidence comprised a higher-order latent factor of belief flexibility, while intuitive reasoning and unwillingness to doubt belief comprised a higher-order factor of conviction. The validity analyses included in this study showed that WBFS belief flexibility was positively associated with self-reflectiveness and negatively associated with delusion-prone conviction, and WBFS

conviction was positively associated with PDI conviction and distress and negatively associated with PDI preoccupation. Divergent validity of the WBFS with unrelated constructs was also established.

Once the WBFS was developed and validated, a structural equation modeling study (Chapter 3, Study 5) of reasoning processes that theoretically contribute to understanding the development and maintenance of delusions was conducted. Participants completed the WBFS and a number of performance measures previously demonstrated to reflect the operation of other reasoning processes (i.e. bias against disconfirmatory evidence; jumping-to-conclusions) and self-report measures of paranoia, worry, anxiety, and depression. Study 5 demonstrated that belief flexibility and belief conviction were strongly related but distinct and that JTC was more strongly correlated with flexibility than conviction. The BADE was only related to belief flexibility and contrary to expectations, the direction of this relationship was positive.

Other than the development of a scale that can be used to measure belief flexibility for delusion-like beliefs in non-clinical samples, this dissertation contributes a few additional noteworthy findings. First, findings demonstrate that belief flexibility and conviction are distinct but strongly (and inversely) related constructs even in non-clinical samples. In fact, the size of the correlation between the constructs was similar (r=-0.63 in the clinical sample (So et al., 2012) and r=-0.68 in the current study). This suggests that while they are different, psychotic impairment may impact the two processes concurrently, and that belief flexibility may be a suitable target for intervention across the spectrum of delusional beliefs. The fact that the BADE as measured by EII and conviction were not related (r=-0.04) suggests that the tendency to rate implausible

hypotheses as plausible may be distinct from acknowledging a willingness to change one's mind about a belief using contradictory evidence. That is, a general tendency to make decisions based on lower probability estimates may not be as predictive of the strength of conviction as the willingness to change one's mind about said belief is.

These studies also shed some light on the relationship between JTC and delusion proneness in the general population. While some studies have demonstrated that patient groups show the highest JTC (reaching a decision after only one or two trials), followed by delusion-prone groups, and then the non-delusion prone group (Balzan et al., 2012; Van Dael et al., 2006), others have shown that delusion-prone individuals are less likely to show JTC than their non- delusional counterparts (Freeman et al., 2010; Warman et al., 2007; So and Kwok, 2015). While the current series of studies did not include clinical groups, the findings suggest that extent of data gathering was positively and moderately associated with delusional conviction on the PDI, as well as conviction for persecutory ideation on the GTPS, indicating that even in non-clinical samples data gathering bias is predictive of strength of paranoid or delusional beliefs.

Another interesting finding of this dissertation concerns the Bias Against Disconfirmatory Evidence. Multiple recent meta-analyses (Zhu et al., 2017; McLean et al., 2016; Eisenacher & Zink, 2016) have shown that the BADE is associated with delusional severity in clinical samples. However, in Study 5 (Chapter 3), no relationship was found between WBFS conviction and BADE, and results showed that both the multivariate index of EII and the univariate index of BADE were negatively correlated with PDI conviction. However, a positive correlation was found between persecutory ideation and EII. Similar to the EII, belief flexibility on the WBFS was negatively

correlated with PDI conviction, and positively correlated to persecutory ideation. This pattern of results suggests that the BADE and belief flexibility may be indicative of a process that results in persecutory ideation, but also in reduced certainty of delusion-like beliefs.

The liberal acceptance (LA) bias may be a process that can help explain the pattern of results in current findings. In contrast to the JTC which refers to a tendency to reach conclusions using fewer data points, the LA refers to the tendency of making premature decisions based on low subjective probability estimates (Moritz et al., 2017). For example, on the beads task, a JTC would be considered reaching a conclusion after viewing only a few beads regardless of the subjective probability estimate. An LA would only be considered if the participant reaches a decision *despite* acknowledging a low probability estimate (Moritz et al., 2017). A recent study used an experimental Experience Sampling Methodology task to show that LA is was more likely to occur in psychotic groups than controls, that it was associated with psychotic and paranoid experiences, and that it moderated the association between momentary aberrant salience and psychotic experiences (Reininghaus et al., 2018).

It has been posited that excessive release of dopamine in the striatal region of the brain results in aberrant assignment of salience or meaning to neutral stimuli, and paranoid or psychotic experiences can be understood as a "top down" attempt to make sense of these experiences (Garety et al., 2007). Findings from the literature suggest that if left medically untreated, aberrant salience of internal or external stimuli can create distressing aberrant experiences and reasoning biases such as LA can result in acceptance

of psychotic explanations for these experiences, despite the awareness of low probability estimates (Reininghaus et al., 2018).

The LA bias may be able to help explain the relationship between the BADE and other affective factors in Chapter 3. The BADE (as measured using both BADE difference scores and EII) was negatively associated with worry and positively associated with anxiety. The positive association with anxiety and paranoia is consistent with past findings that show that these constructs are closely related to each other and that they can each exacerbate reasoning biases (Freeman et al., 2008), and with the idea that aberrant internal stimuli can result in a sense that 'something is not right', activating a top-down cognitive attempt to provide an explanation for an unusual experience (Freeman et al., 2008). For example, an anxious psychosomatic state (as measured by the BAI) can motivate a search to explain one's state, while the LA can lower the decisional threshold, such that even absurd explanations on the BADE task can be rated high. This sequence of events could explain the positive relationship between the BADE/EII and anxiety as well as persecutory ideation.

The negative association of the BADE/EII with worry was more surprising. The literature does show some indication that the JTC was predictive of lower worry levels in non-clinical samples (Freeman et al, 2014). However, this finding was against the authors' predictions and they cautioned against interpreting this finding without further replication. While JTC was not associated with lower worry scores, the relationship between EII and worry can be explained if we assume that perhaps a tendency to worry activates a more extensive search for information before certainty is reached. It is possible that while worrying involves excessive data gathering before certainty is

reached, the EII is reflective of a decision being made despite subjective uncertainty such that even implausible interpretations get high ratings. In this context, the negative correlation with worry is explicable.

Overall, the results of this study can also help elucidate the various fast and slow processes that underlie belief formation and maintenance. Ward and Garety (2017) suggest that distressing delusions may be a product of an over-reliance on the fast-intuitive process, with a reduced tendency to activate analytic thinking, and deficits in algorithmic thinking. Evidence to support this in the literature includes correlations between paranormal/superstitious/paranoid beliefs and experiential reasoning (Aarnio and Lindeman, 2005) and negative associations with rational reasoning (Freeman et al., 2012). Rational reasoning has also been shown to function as a protective factor against the development of need-for-care in psychotic samples.

While different methods were used to measure these constructs, support for the protective function of rational reasoning (i.e. belief flexibility) was mixed. While belief flexibility showed small correlations with ideas of reference and persecutory ideation, it did show a strong negative correlation with delusion-prone conviction. One possible explanation for this finding is that persistence in the face of disconfirmatory evidence in non-clinical samples may actually represent a rational process. For example, some philosophers of science have argued that dismissal of disconfirmatory evidence has actually resulted in advancements in science (Kuhn, 1962; Lakatos, 1978). Kuhn (1962) suggests that scientific paradigms often persist in the face of anomalies and/or contradictory evidence, as it is assumed that an explanation for the anomaly may be found in the future. Similarly, Lakatos (1978) noted that the presence of contradictory

evidence is not sufficient per se to falsify a whole program of research. Rather, it is the development of a new research program which is inconsistent with the old one and has greater explanatory power that results in abandonment of the older paradigm. To apply this argument to non-clinical unusual beliefs, it is possible that the persistence of the existing belief may represent a rational response to the lack of a better alternative explanation for unusual subjective experiences or observation.

The role of methodology cannot be ruled out in explaining the strong correlations between the WBFS and PDI subscales, given the similarities between the two measures. Using the same line of reasoning, whether the correlations between conviction (which is partially constituted of the intuitive reasoning factor) and PDI conviction reflect a true over-reliance on intuitive thinking cannot be determined without further investigation. For example, it might be interesting to administer the JTC and BADE test with time limits on some trials, in order to provide stronger support for the operation of fast vs. slow reasoning operations.

Furthermore, it is possible that belief flexibility on the WBFS may be reflective of LA. That is, instead of measuring a tendency to rely on rational thought, this scale may be capturing the ways in which the slow analytic system can be vulnerable to errors. Specifically, it would appear that items such as "I can imagine the kind of evidence that would change my mind about this belief" and "I can be persuaded to change my mind about this belief", may be more indicative of a desire to engage in algorithmic thinking (i.e. the first level of the slow analytic Stream 2). However, it is possible that the LA, which appears to be a vulnerability of the slow analytic system, creates a condition under

which even very unlikely contradictory evidence may be evaluated as sufficiently convincing for belief revision.

It is important to re-iterate that the beliefs that were selected for ratings of belief flexibility in this dissertation mainly came from the same two categories: conspiracy theories and supernatural beliefs. Therefore, it is important to exercise caution in interpreting the findings as they relate to other delusion-like beliefs. While our investigation of political, social, and religious beliefs suggests that belief flexibility does vary across belief domains, more research is warranted in order to better understand the role of belief flexibility in maintenance of other clinical (e.g. OCD) and non-clinical (e.g. the belief that the earth is round) beliefs.

Overall, the five studies in this dissertation provided an interesting first step towards the refinement of the construct of belief flexibility in the general population. Specifically, further work needs to be done to better understand the association of the belief flexibility subscale of the WBFS, the EII and the LA bias. The WBFS should be validated in a clinical sample in order to help further establish its discriminant validity and it should be re-administered to establish its test-retest reliability. Validation in non-Turk samples and of different cultural backgrounds would also be very important, given the relevance of cultural plausibility to the operationalization of delusion-like beliefs. Longitudinal studies would also be helpful in understanding how the relationship between belief flexibility and conviction evolves over the course of time, especially for delusion-prone individuals who go on to have a psychotic episode. It would also be helpful to use experimental manipulations to establish the types of conditions (i.e. states) that may be associated with reliance on fast vs. slow mechanisms as measured by the

WBFS. The WBFS can still be used in its current or modified form to study other types of beliefs and can be applied to unrelated constructs such as non-believed memories and/or suggestibility.

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APPENDICES

Appendix A

Study 1 - Target Beliefs Initial Item Pool

You will now be asked about a variety of beliefs and experiences. Some of these may appear unusual to you, but they are actually a lot more common than most people realize. Please check of all of the statements that you believe. Please answer the questions as honestly as you can. There are no right or wrong answers. Please note that we are NOT interested in experiences you may have had while under the influence of drugs. It is important that you answer ALL questions.

I believe that…

- □ certain places are in two different locations at the same time
- □ people say or do things that contain special messages for me
- □ I am not in control of some of my actions
- □ my thoughts are not fully under my own control
- □ some people communicate with the dead
- □ some people are possessed by evil spirits
- □ the government is involved in the murder of innocent citizens/well known public figures
- □ the power held by heads of state is second to that of small unknown groups who really control world politics
- □ that secret organizations communicate with extraterrestrials, but keep this fact from the public
- □ the spread of certain viruses and/or diseases is the result of the deliberate, concealed effort of some organization
- □ groups of scientists manipulate, fabricate or suppress evidence in order to deceive the public
- □ the government permits or perpetrates acts of terrorism on its own soil, disguising its involvement
- □ a small, secret group of people is responsible for making all major world decisions, such as going to war
- □ evidence of alien contact is being concealed from the public
- □ technology with mind-control capacities is used on people without their knowledge
- □ new and advanced technology which would harm current industry is being suppressed
- □ the government uses people as patsies (or scapegoats) to hide its involvement in criminal activity
- □ certain significant events have been the result of the activity of a small group who secretly manipulate world events
- □ some UFO sightings and rumors are planned or staged in order to distract the public from real alien contact

- □ experiments involving new drugs or technologies are routinely carried out on the public without their knowledge or consent
- □ a lot of important information is deliberately concealed from the public out of self-interest
- □ some individuals are able to levitate (lift) objects through mental force
- □ black magic really exists
- □ my mind or soul can leave my body and travel (astral projection)
- □ the abominable snowman of Tibet exists
- □ astrology is a way to accurately predict the future
- □ witches do exist
- □ there is a devil?
- □ psychokinesis, the movement of objects through psychic powers, does exist
- □ during altered states such as sleep or trances, the spirit can leave the body
- □ the Loch Ness monster of Scotland exists
- □ the horoscope accurately tells a person's future
- □ a person's thoughts can influence the movement of a physical object
- □ through the use of formulas and incantations, it is possible to cast spells on persons
- □ reincarnation does occur
- □ some psychics can accurately predict the future
- □ mind reading is possible
- □ some people have an unexplained ability to predict the future
- □ I am an exceptionally gifted person that others do not recognize
- □ certain people are out to harm or discredit me
- □ that the reflection in the mirror is sometimes not me
- □ that I am infested by parasites
- □ that some well-known celebrity is secretly in love with me
- □ that the world is about to end
- □ that people I know disguise themselves as others to manipulate or influence me
- □ that there is another person who looks and acts like me
- □ that part of my body doesn't belong to me
- □ that relatives or close friends are sometime replaced by identical looking imposters
- □ that I am dead or do not exist
- □ that some people transform into werewolves
- □ that the soul continues to exist even after the body dies
- □ that black cats bring bad luck
- □ that if you bring a mirror, you will have bad luck
- □ that the number '13' is unlucky
- □ that there is life on other planets

Please check off if any of the following statements apply to you.

- □ I do not believe any of the above statements
- □ I prefer not to answer

Appendix B

Study 4 – Finalized Belief Flexibility Items and Instructions

This is an example for a participant who endorsed the following three items in the target beliefs section of the questionnaire and selected the first one as most meaningful.

Of the statements you believe, please select the one that is most personally meaningful to you and the way you understand yourself, others and the world around you.

- □ some individuals are able to levitate (lift) objects through mental force
- □ the government permits or perpetrates acts of terrorism on its own soil, disguising its involvement
- □ some UFO sightings and rumors are planned or staged in order to distract the public from real alien contact

Thinking about the belief that some individuals are able to levitate (lift) objects through mental force, please rate the extent of your agreement with each statement on a scale of 1-7 where 1 = strongly disagree and 7= strongly agree.

I can imagine changing my mind about this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I can visualize the kind of evidence and/or circumstances that would change my mind about the belief this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I could be persuaded to change my mind about the belief this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I can think of alternate explanations for the experiences that lead me to hold this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

If someone I trusted disagreed with me about this belief, I might change my mind.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

If enough people disagreed with me about this belief, I might change my mind.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

If a person who cares about me disagreed with me about this belief, I might change my mind.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I can vividly remember an experience that supports this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I can think of evidence from personal experience that supports this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I can vividly imagine evidence that supports this belief.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I don’t need objective evidence to know this belief is true.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I have a gut feeling that this belief is true.

Strongly Disagree						Strongly agree
1	2	3	4	5	6	7

I did not need to think too much about this belief to know that it's true.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

The thought of changing my mind about this belief is upsetting to me.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

If I changed this belief, my life would have to change in important ways.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

It is hard for me to listen to people talk about things that contradict my belief.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

When I think about this belief, I feel good.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

I feel comforted when I think about this belief.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

I feel safe when I think about this belief.

Strongly Disagree Strongly agree
1 2 3 4 5 6 7

When I think about this belief, I feel bad.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

I feel powerless when I think about this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

I feel scared when I think about this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

I cannot imagine being wrong about this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

There is at least a small chance that I could be wrong about this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

I am certain about this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

I get uneasy when thinking about questioning this belief.

Strongly Disagree Strongly agree

1 2 3 4 5 6 7

Appendix C

Study 5 –BADE Instruction

In the top box on the screen you will be provided with *three* sentences describing an event or person. The sentences will be presented one at a time. Each new sentence will increase your knowledge about the event or person that is being described.

Below the top box you will also be provided *three* different interpretations about the event or person being described. Each interpretation has its own scale, shown beneath it, where you will be asked to rate the plausibility (or likelihood) that the interpretation is related to, or consistent with, the information you have been given about the event. You will be asked to rate the plausibility for each interpretation after you read a given sentence in the top box. It is important to rate each of the three interpretations independently from one another. That is, don't compare the interpretations to each other, instead, rate how well each relates, on its own, to the event information that is provided.

During a trial, as new information is provided, your task is to reconsider the ratings you have assigned to each interpretation. You may change your ratings for each interpretation as little or as much as you like, and one or more of the ratings can be the same if you feel that they are equally likely. You may even want to keep some ratings the same, even after being given other event information.

Please be aware that sometimes the interpretations may be unrelated to the event information, so they may not make any sense. Also, it is possible that one, or more than one of the interpretations may be related to the event information.

Appendix D

Study 5 –Example of a BADE Scenario

Trial #1: **Jane is very thin.**

Jane is a model 0% _____100%

Jane is homeless 0%_____ 100%

Jane is a librarian 0%_____100%

Trial #2: **Jane is very thin.**

Jane is hungry.

Jane is a model 0% _____100%

Jane is homeless 0%_____ 100%

Jane is a librarian 0%_____100%

Trial #3: **Jane is thin.**

Jane is hungry.

Jane lives on the streets.

Jane is a model 0% _____100%

Jane is homeless 0%_____ 100%

Jane is a librarian 0%_____100%

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