Was that just a Strange Coincidence or am I Psychic? Examining the Relationships Between Anomalistic Belief, Reasoning, and Cognitive Bias

by

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Summary

Anomalistic beliefs are commonly held throughout the general population despite being unsupported by scientific evidence (Chapman University 2017; Moore, 2005; Shannon-Missal, 2013). Therefore, it is important for psychologists to explain how and why people come to endorse anomalistic beliefs despite the lack of solid evidence to support them. Chapter 2 outlines the development of the Anomalistic Belief Scale (ABS), which was designed with a specific focus on the distinction between theoretical and experiential anomalistic beliefs. Factor analysis of the ABS supported the theoretical/experiential distinction, with a factor found that covered belief in both paranormal and extra-terrestrial experiences (experiential factor) as well as three separate for different belief types factors; one for theoretical paranormal beliefs (PSI factor), one for theoretical extra-terrestrial beliefs (ET factor), and one for experiential and theoretical life after death beliefs (LAD factor). Chapter 2 also examined the relationship between anomalistic beliefs and the conjunction fallacy and in Chapter 3 the relationships between anomalistic beliefs and both misperception of chance and the base rate fallacy were examined. The results for Chapters 2 and 3 showed that although overall anomalistic belief was related to poorer probabilistic reasoning, only the experiential factor of the ABS was related to poorer performance for both the conjunction fallacy and misperception of chance. Results for the base rate fallacy showed a relationship with overall anomalistic belief but no individual ABS factor was a unique predictor.

Chapters 4, 5, and 6 shifted the focus from probabilistic reasoning to the relationship between anomalistic belief and cognitive bias. In Chapter 4, biases against disconfirmatory evidence (BADE), biases against confirmatory evidence (BACE), liberal acceptance, and jumping to conclusions (JTC) were examined. The results showed that BADE, BACE, and liberal acceptance were positively correlated with anomalistic belief, however, only liberal acceptance uniquely predicted anomalistic belief. None of the relationships between

anomalistic belief and the biases remained once delusion proneness was controlled for, except for the relationship between BADE and experiential anomalistic beliefs. Chapter 5 explored the relationship between anomalistic belief and the accuracy of inferences drawn from news articles. After analytical (vs. intuitive) thinking and political belief were controlled for, anomalistic belief was not related to inference accuracy. Chapter 6 again focused on BADE, BACE, and liberal acceptance but analytical thinking was also included and the focus was expanded from anomalistic belief to non-evidence based beliefs more broadly. Lower analytical thinking and greater liberal acceptance were related to several non-evidence based beliefs, however, the biases and analytical thinking did not explain a significant proportion of the relationships between the non-evidence based beliefs.

The current thesis has demonstrated that anomalistic beliefs are related to a variety of probabilistic reasoning deficits and to stronger cognitive biases. The findings also clearly show the importance of considering the type of anomalistic belief held (experiential vs. theoretical) rather than relying on broad overall belief measures. Cumulatively, the work in this thesis has contributed to the development of our psychological understanding of anomalistic beliefs.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Toby Prike

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List of Manuscripts and Publications

Chapter 2: Prike, T., Arnold, M. M., & Williamson, P. (2017). Psychics, aliens, or experience? Using the Anomalistic Belief Scale to examine the relationship between type of belief and probabilistic reasoning. *Consciousness and Cognition, 53,* 151-164. doi: 10.1016/j.concog.2017.06.003

Chapter 3: Prike, T., Arnold, M. M., & Williamson, P. (2018). *The relationship between anomalistic belief, misperception of chance, and the base rate fallacy*. Manuscript submitted for publication.

Chapter 4: Prike, T., Arnold, M. M., & Williamson, P. (2018). The relationship between anomalistic belief and biases of evidence integration and jumping to conclusions. *Acta Psychologica, 190*, 217-227. doi:10.1016/j.actpsy.2018.08.006

Chapter 5: Prike, T., Arnold, M. M., & Williamson, P. (2018). *Understanding the news: The relationship between anomalistic belief, political belief, thinking style, and the interpretation of news articles*. Manuscript in preparation.

Chapter 6: Prike, T., Arnold, M. M., & Williamson, P. (2018). *What do non-evidence based beliefs have in common? Examining the potential underlying role of evidence integration biases and thinking style*. Manuscript in preparation.

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Chapter 1: General Introduction

General Introduction

Paranormal and other anomalous phenomena are not supported by mainstream scientific evidence, however, many people believe in such phenomena (Castro, Burrows, & Wooffitt, 2014; Shannon-Missal, 2013). The term used to encompass people's varying levels of conviction in this broad variety of phenomena is *anomalistic belief*. Because anomalistic beliefs are not supported by mainstream scientific or other conventional forms of evidence, there are important research questions concerning how and why people come to hold these beliefs. The aim of this thesis is to provide greater insight into the cognitive characteristics related to anomalistic belief, with a particular focus on the role of reasoning and biases in the assessment of evidence. Additionally, this thesis examined whether the relationships between anomalistic belief and cognition vary depending on the type of anomalistic belief held.

Anomalistic Beliefs

Anomalistic belief covers a wide variety of areas and encompasses any beliefs that go against the weight of current scientific evidence. Paranormal beliefs are one of the most commonly discussed types of anomalistic belief, however, the term anomalistic also encompasses a wider variety of non-evidence based beliefs (French & Stone, 2014). Because paranormal beliefs and experiences are commonly associated with anomalistic belief, this thesis will begin by briefly defining paranormal phenomena and beliefs before considering other non-paranormal anomalistic beliefs.

According to the Parapsychological Association (2015), phenomena are considered paranormal if they fall into one of the following three categories; extra-sensory perception (ESP), mind-matter interaction (also referred to as psychokinesis), or life after bodily death. ESP is the ability to gain information about the world in ways other than via physical systems of perception (e.g., sight, hearing, smell etc.) or inference (Bösch, Steinkamp, & Boller, 2006). Some common examples of ESP are telepathy and precognition (Wiseman &

Greening, 2002). Telepathy involves the ability of thoughts or ideas to be transferred directly from one brain to another, whereas precognition is the ability to gain knowledge about future events without using normal sensory input or inference. Mind-matter interaction or psychokinesis is the ability of the mental processes of the brain to directly influence the material world without being mediated by a physical system and covers phenomena such as moving or bending physical objects using only the mind (Bösch et al., 2006). For example, bending a spoon using only mental powers would be a demonstration of psychokinesis. Finally, life after death beliefs relate to the survival of some aspect (e.g., a soul, spirit, consciousness etc.) following bodily death, and includes beliefs in phenomena such as reincarnation, and apparitions (Parapsychological Association, 2015). Reincarnation is the idea that after death, some aspect of a living being is reborn and begins a new life whereas an apparition is a visual perception of a person or object that is not physically present.

Although there is debate over whether other strange and non-evidence based beliefs beyond the paranormal, should be considered anomalistic, many researchers include other non-evidence based beliefs under the “anomalistic” umbrella (Brotherton & French. 2014; French & Stone, 2014; Zusne & Jones, 1982). For example, some conspiracy theories and alternative medicine are considered anomalistic, whereas others do not clearly contradict our current understanding of reality (at least not to the same degree as paranormal beliefs; Thalbourne, 2010). Belief in the efficacy of homeopathy is one alternative medicine belief that has been argued to be anomalistic in nature due to the overwhelming amount of scientific evidence demonstrating that the treatment is ineffective (National Health and Medical Research Council, 2015). However, other alternative medicine beliefs have either mixed or unclear evidence (e.g., acupuncture; Linde et al., 2016; White, Rampes, Liu, Stead, & Campbell, 2014), and thus it is not clear whether they fit into the anomalistic category. Similarly, some conspiracy theories are not supported by evidence or have little evidentiary

support but are still consistent with or explainable in terms of current scientific knowledge (e.g., the moon landings being faked, 9/11 being an "inside job"; Brotherton, French, & Pickering, 2013). Although it is not always possible to neatly classify all phenomena as anomalistic or non-anomalistic in nature, for the purposes of clarity the term anomalistic is used throughout this thesis to broadly refer to beliefs that are inconsistent with current scientific understandings of reality. More specific terms such as paranormal, extra-terrestrial, or conspiracy theory belief are used when referring only to a specific subset of beliefs.

Prevalence of Anomalistic Beliefs and Experiences

Anomalistic beliefs appear to be pervasive in many parts of the world. For example, surveys of the general US population have shown that the majority of people (approximately 75%) endorse at least one anomalistic belief, with large proportions holding specific beliefs in ghosts (32-52%), ESP (41%), reincarnation (20-24%), and witches (21-26%; Chapman University 2017; Moore, 2005; Shannon-Missal, 2013). Pechey and Halligan (2011) found similar levels of anomalistic belief in the United Kingdom, with 78.8% of their sample endorsing at least one paranormal belief. Further, Höllinger and Smith's (2002) expansive cross-cultural study found that anomalistic beliefs were common in Latin-America, Southern Europe, and North-West Europe.

The prevalence of anomalous experiences (e.g., believing that you have seen a ghost) also has been explored. Castro et al., 2014 found that claims of such experiences were relatively common among the general UK population, with 37.8% of people reporting at least one anomalistic experience. Pechey and Halligan (2012) found that 75% of their UK participants reported having at least one anomalistic experience, with 48% reporting having at least one type of anomalistic experience occur "sometimes" or "often". Endorsement of individual anomalistic experiences was also high, with each experience endorsed by approximately 10-35% of participants (Castro et al., 2014; Pechey & Halligan, 2012). For example, 24-35%

claimed to have experienced precognition, 22% to have seen a ghost, 10% reported out-of-body experiences, and 10% reported communication with the dead. In comparison to Castro et al., Pechey and Halligan found a considerably higher proportion of participants reported anomalistic experiences. However, Pechey and Halligan included items that related to interpersonal anomalous experiences such as "sensed when a friend or family member was in trouble" and "felt that familiar people all seem colder or more distant than before" whereas Castro et al. only included paranormal anomalous experiences.

Although not directly measuring anomalistic experiences, Höllinger and Smith's (2002) cross-cultural study found that across Latin America, the US, Southern Europe, and North-West Europe, the majority of respondents (76-87%) had engaged in a new age activity (e.g., horoscopes, acupuncture, psychic healing) at least once. However, it is important to note that some of the new age activities included (e.g., meditation and massage-techniques) are not anomalistic and it is unclear how excluding these activities would influence the overall percentage of engagement with new age activities. Cumulatively, the results of these surveys clearly demonstrate that anomalistic beliefs and experiences occur frequently among the general population.

Anomalistic Psychology

A natural question that arises when considering the high levels of anomalistic belief endorsement is how and why people come to hold beliefs that are inconsistent with scientific evidence and explanations of the world. Anomalistic psychology attempts to explain these beliefs through the use of known or knowable psychological and physical factors (French, 2001; French & Stone, 2014). That is, anomalistic psychology does not assume a priori that anything paranormal or anomalistic has occurred, but rather it attempts to explain anomalistic beliefs purely in terms of psychological characteristics and physical phenomena that are consistent with current scientific explanations of the world. This a priori assumption is an

important distinction between the general approaches of anomalistic psychology and parapsychology. Traditionally, parapsychology has placed more of a focus on assessing the veracity of paranormal claims and demonstrating the existence of paranormal phenomena (Parapsychological Association, 2015). For example, when assessing claims that some people are able to telepathically communicate, parapsychology would typically test people in a lab to try to establish whether the phenomenon exists (Milton & Wiseman, 1999; Storm & Ertel, 2001). In contrast, anomalistic psychology would place greater focus on whether non-paranormal psychological explanations, such as people's understanding of chance or knowledge of base rates, can explain why people might make claims of ESP even if no paranormal phenomena have occurred (Dagnall, Parker, & Munley, 2007; Rogers, Davis, & Fisk, 2009) .

Differences in the approaches of parapsychology and anomalistic psychology may also partially explain why the focus of parapsychology is narrower. That is, because parapsychology traditionally involves testing the existence of paranormal phenomena, whether a phenomena or belief is paranormal is of great importance. In contrast, anomalistic psychology is attempting to explain these beliefs using known or knowable psychological and physical explanations and therefore greater emphasis can be placed on the psychological and physical explanations of the belief rather than whether the belief fits a strict definition of paranormal. For example, a phenomena such as sleep paralysis may lead people to have a wide variety of weird experiences. Some sleep paralysis experiences seem paranormal and therefore fall under the remit of parapsychology (e.g., demonic visitation, being attacked by a spirit; French & Santomauro, 2007; Santomauro & French, 2009). However, sleep paralysis can also lead to other experiences, such as feeling as though you have been abducted by aliens, which would be beyond the scope of parapsychology (French, Santomauro, Hamilton, Fox, & Thalbourne, 2008; McNally & Clancy, 2005). Therefore, because the same

phenomena (e.g., sleep paralysis) potentially contributes to both paranormal and non-paranormal experiences (e.g., extra-terrestrial visitation), anomalistic psychology examines the similarities and distinctions between these experiences rather than focusing purely on the paranormal phenomena.

It is important to investigate anomalistic beliefs because although many non-evidence based beliefs are benign and do no obvious harm, some beliefs can have serious consequences. For example, someone who believes in the efficacy of alternative medicine may use it to treat an illness, even though there is no evidence that it is an efficacious treatment (Maclennan, Myers, & Taylor, 2006). However, this use of alternative medicine can be costly for the person financially or, if used at the exclusion of evidence based medicine, could place the person at considerable risk of negative health outcomes (Australian Medical Association, 2012; Cancer Council Australia, 2015; National Health and Medical Research Council 2015). Another example involves belief in paranormal phenomena such as psychic ability. That is, people who believe in psychic ability may be at an increased risk of being financially and/or emotionally exploited by people falsely claiming to have psychic or other powers (Australian Competition and Consumer Commission, 2018; Cohn, 2016).

Holding non-evidence based beliefs also has some important implications for society in general. For example, Jolley and Douglas (2014) found that non-evidence based conspiracy theory beliefs about the dangers of vaccines (subsequently referred to as anti-vaccine beliefs) were negatively related to intention to vaccinate a hypothetical child, suggesting that anti-vaccine beliefs may lead to lower immunization rates. Anti-vaccine beliefs have been associated with increased outbreaks of preventable diseases, such as the outbreak of pertussis in California in 2010 (Atwell et al. 2013) and a recent outbreak of measles in the USA (Zipprich et al., 2015). Outbreaks of preventable diseases impacts all of society because many vulnerable groups are unable to be vaccinated (e.g., babies, small

children, those undergoing chemotherapy) and even for those who are vaccinated, vaccines are not 100 per cent effective (Department of Health, 2014; Feikin et al., 2000; Kim, Johnstone, & Loeb, 2011). Vulnerable groups rely on herd immunity to protect them from these diseases, so when vaccine rates drop due to anti-vaccine beliefs it impacts not only those who choose not to vaccinate themselves or their children, but also other people in the community (Feikin et al., 2000; Fine, Eames, & Heymann, 2011; Kim et al., 2011).

In addition to the importance of examining anomalistic beliefs in their own right, anomalistic psychology has the potential to provide greater insight into beliefs and judgment and decision making at a more broad level. It is already well established that human beings can be irrational and biased in their belief and judgment and decision making (Evans, 2008; Stanovich & West, 2000; Tversky & Kahneman, 1974). However, the psychological process of belief formation is generally not well understood (Connors & Halligan, 2015). Therefore, understanding anomalistic belief has the potential to provide greater insight into the psychological mechanisms that contribute to belief formation and belief updating more generally. For example, if cognitive biases contribute to the formation and/or maintenance of anomalistic belief, then it is plausible that the same cognitive biases also play a role in general belief formation. Therefore, knowledge gained in anomalistic psychology is able to feedback into psychology more broadly to provide greater insight into how people form and update their beliefs.

Cognition and Anomalistic Belief

Anomalistic belief is multifaceted and influenced by a wide variety of psychological processes. For example, social psychology has highlighted that the beliefs of peers influence paranormal belief (Auton, Pope, & Seeger, 2003) and clinical psychology has shown relationships between schizotypy and paranormal beliefs (Cella, Vellante, & Preti, 2012). However, although anomalistic belief is complex, this thesis focused on the specific role of

cognition in the formation and maintenance of anomalistic beliefs. Specifically, the focus was on the relationships between anomalistic belief and reasoning, cognitive bias, and judgment and decision making.

One proposed explanation for how and why people form anomalistic beliefs is that general cognitive deficits, such as in intelligence, make some people more predisposed to holding beliefs that are not supported (or are opposed) by evidence (Alcock & Otis, 1980). However, the evidence to support a negative relationship between anomalistic belief and intelligence or general cognitive ability is inconsistent. Several researchers have found support for a negative relationship between paranormal belief and both educational success (Messer & Griggs, 1989; Musch & Ehrenberg, 2002; Tobacyk, 1984) and performance on intelligence measures (Killen, Wildman, & Wildman, 1974; Smith, Foster, & Stovin, 1998; Watt & Wiseman, 2002). Other studies, though, have found no significant relationship between paranormal belief and either educational attainment (Rice, 2003) or intelligence (Hergovich & Arendasy, 2005; Stuart-Hamilton, Nayak, & Priest, 2006). Therefore, because of these mixed findings and weak relationships, more emphasis is now placed on the role that specific cognitive characteristics may play in the formation and maintenance of anomalistic beliefs (e.g., probabilistic reasoning, heuristics, and cognitive biases). Examining specific cognitive characteristics rather than broad, general measures of cognitive ability also allows specific deficits or biases to be found, allowing for a greater understanding of the cognitive mechanisms that potentially underpin anomalistic belief.

Poor probabilistic reasoning is one cognitive mechanism that has been proposed to lead to paranormal belief (Blackmore & Troscinako, 1985; Brugger, Landis, and Regard, 1990). Probabilistic reasoning is the ability to use knowledge of probability to reach conclusions; for example, understanding how likely it is that the result of a coin flip will be heads or that a dice roll will result in a six. Several studies have shown that people who

believe in the paranormal have poorer perception of probability, randomness, and/or chance than nonbelievers (e.g., Blackmore & Troscianko, 1985; Blagrove, French, & Jones, 2006; Brugger et al., 1990; Brugger & Taylor, 2003; Wiseman & Watt 2006). Blackmore and Troscianko (1985) and Brugger,et al. (1990) proposed that these findings suggest a poor understanding of chance and randomness may lead people to interpret coincidences/chance events as having paranormal explanations, which subsequently leads them to form (or increase their level of) anomalistic beliefs.

Related to the above, Wiseman and Watt (2006) looked at whether there was evidence to support the claim that a belief in psychic ability is due to believers misattributing paranormal causation to normal experiences. They found that greater paranormal belief was associated with both poorer syllogistic reasoning (i.e., ability to deduce whether a conclusion, asserted on the basis of two or more propositions, is logically valid) and probabilistic reasoning. Further, believers also showed lower performance on tasks that require people to identify relationships in randomly presented material; for example, believers were more likely to find non-existent relationships in random material. Some potential explanations for these relationships is that poorer performance on these tasks is caused by an over-reliance on heuristics, a failure to properly consider the logical premises, and/or a poor understanding of probability. It is relatively straightforward to illustrate how poor probabilistic reasoning may make someone more likely to form and/or maintain anomalistic beliefs. For example, if a psychic makes a prediction about a person and it ends up being correct, a poor understanding of probability may lead that person to develop an anomalistic belief; that is, the person may fail to take into account the event was highly likely to occur and/or that the prediction may be true for many people.

Although there is evidence to support the notion that paranormal believers have poorer probabilistic reasoning, it is important to note that there are also a number of studies

that have found no such relationship (Blackmore, 1997; Houtkooper & Haraldsson, 1997; Matthews & Blackmore, 1995). Dagnall et al. (2007) examined the relationship between paranormal belief and a variety of probabilistic reasoning tasks and found that paranormal belief was related to perception of randomness (also known as misperception of chance), but not to the base rate fallacy (i.e., ignoring relevant base rate information and focusing on irrelevant descriptive information), the conjunction fallacy (i.e., assuming the likelihood of multiple events co-occurring is greater than the likelihood of an individual constituent event occurring), or problems of expected value (i.e., calculating odds and payouts). Therefore, current evidence suggests that although it is likely that there are relationships between anomalistic belief and probabilistic reasoning, these relationships may vary depending on the specific reasoning task, measure of anomalistic belief, and/or the population used. The relationship between probabilistic reasoning and anomalistic belief is discussed further in Chapters 2 and 3.

Cognitive bias is another mechanism that may contribute to both the development and maintenance of anomalistic beliefs. Cognitive biases are systematic deviations within the areas of judgement and decision making that lead to suboptimal judgements and/or decisions (Keren & Teigen, 2004; Tversky & Kahneman, 1983). For example, Moritz et al. (2017) proposed that liberal acceptance increases the likelihood that people will form delusional beliefs. Specifically, they proposed that people with greater liberal acceptance are more willing to consider absurd or unlikely options and also to require less evidence before accepting a belief. It seems plausible that, due to the lack of supporting evidence for anomalistic phenomena, liberal acceptance may also increase the likelihood of accepting anomalistic beliefs. Additionally, confirmation biases may play a role in maintaining anomalistic beliefs by allowing people to maintain their anomalistic beliefs even in the face of contradictory evidence (Stanovich, West, & Toplak, 2013).

If defined sufficiently broadly, cognitive bias is present in a large amount of research into anomalistic beliefs (and a large amount of psychological research in general), however, relatively little research has had a primary focus on the relationship between cognitive bias and anomalistic belief. Russell and Jones (1980) examined how both paranormal believers and non-believers responded to articles that either supported or opposed the existence of paranormal phenomena. They found that believers were significantly less likely to accurately recall the conclusion of an article that disconfirmed their belief, and that half of the believers who made errors reported that the article was actually supportive of their belief. Similarly, Jones and Russell (1980) examined the ability of people to distinguish between a successful and unsuccessful demonstration of ESP. They showed that paranormal believers reported that the demonstrations had succeeded regardless of whether the demonstration was actually successful. In contrast, non-believers were able to distinguish between the successful and unsuccessful demonstrations. These results highlight that anomalistic believers may potentially display stronger confirmation bias when interpreting evidence and that this bias may play a role in maintaining their anomalistic beliefs in spite of the considerable counterevidence available. Chapters 4, 5, and 6 provide further elaboration and discussion of the relationship between anomalistic belief and cognitive bias.

Thesis Aims and Overview

This thesis builds on previous work by further examining the relationships between anomalistic belief and both probabilistic reasoning and cognitive biases. One goal was to disentangle and help clarify the mixed findings for the relationships between anomalistic belief, probabilistic reasoning, and cognitive bias. One important variable that had not previously received much attention was whether the type of anomalistic belief held was important for the relationship with reasoning and bias. Additionally, the role of context was investigated to see whether it moderated the relationship between anomalistic belief and

probabilistic reasoning. The broader literature on non-evidence based beliefs, such as research on delusions and delusion proneness, was also drawn from to establish whether cognitive biases and reasoning deficits that have been shown to be related to other non-evidence based beliefs are also related to anomalistic beliefs. This thesis also examined whether cognitive biases and reasoning deficits found to be related to anomalistic belief are also related more broadly to a variety of other non-evidence based beliefs. Overall, this research program was conducted to gain a clearer understanding of the relationships between probabilistic reasoning, cognitive bias, and anomalistic belief. This greater understanding was then used to investigate whether there are shared cognitive characteristics that underlie the relationships between a variety of non-evidence based beliefs.

Theoretical and Experiential Distinction. The distinction between theoretical anomalistic beliefs and claims of having experienced anomalistic phenomena is investigated throughout this thesis. However, the distinction between theoretical and experiential anomalistic beliefs is particularly highlighted in the development of a new measure of anomalistic belief, the Anomalistic Belief Scale (ABS), which is presented in Chapter 2. The ABS was developed because pre-existing scales, such as the Australian Sheep-Goat Scale (Thalbourne & Delin, 1993) and the Revised-Paranormal Belief Scale (Tobacyk, 2004; Tobacyk & Milford, 1983), either do not contain enough items related to experiential anomalistic beliefs or do not have both experiential and theoretical items for all of the subtypes of anomalistic belief. Therefore, it was not possible to examine the theoretical/experiential distinction using pre-existing scales. Although surveys have previously measured both anomalistic belief and experiences (Pechey & Halligan, 2011; 2012), often the measures of anomalistic experience have asked whether people have experienced anomalous phenomena, without also including a component of belief. For example, Pechey and Halligan (2012) asked whether people had experienced “premonitions

of events that have yet to take place" but not whether they believed that there was an anomalistic explanation for this premonition (e.g., they could have had a premonition but believed that it was just a coincidence; Irwin, Dagnall, & Drinkwater, 2013). However, probabilistic reasoning is proposed to lead to anomalistic beliefs because poorer probabilistic reasoning leads people interpret coincidences and strange experiences as having an anomalistic cause. Therefore, to fully test this hypothesis it is crucial that experiential, rather than just theoretical anomalistic beliefs are measured. Exploratory factor analysis on the ABS revealed a separate factor for items related to the experience of anomalistic beliefs (either personal experience or the experience of someone they knew), as well as three separate factors for theoretical belief in paranormal phenomena, theoretical belief in extra-terrestrial phenomena, and belief in life after death (both theoretical and experiential beliefs). Therefore, the ABS was subsequently used throughout the remainder of this thesis to examine whether there are differences in the relationships between theoretical and experiential anomalistic beliefs and the various reasoning tasks and cognitive biases examined.

It is important to note that the causal direction of the relationships between anomalistic belief, and probabilistic reasoning and cognitive biases is unclear. That is, it is plausible that probabilistic reasoning and/or cognitive biases may make people more prone to anomalistic beliefs. However, it is also plausible that holding anomalistic beliefs may make people more susceptible to cognitive biases and/or to rely more strongly on heuristics that lead to poorer probabilistic reasoning. Because we were interested in the distinction between theoretical and experiential anomalistic beliefs, throughout this thesis anomalistic beliefs have primarily been used as the predictor variables and the various measures of cognitive bias and reasoning ability as the outcome measures. This analysis strategy allowed the factors of the ABS to be entered together into the regressions so that it was possible to examine how strongly each type of anomalistic belief was related to the biases or reasoning. Additionally,

because the various types of anomalistic belief were correlated, this strategy allowed us to test whether the different types of anomalistic belief were still related to the relevant bias or reasoning measure after the effect of the other anomalistic beliefs was controlled for. However, the analysis strategy differs in Chapter 4 where the cognitive biases were used as the predictors and anomalistic belief as the outcome measure. This strategy was chosen because, unlike the other chapters, there were a large number of cognitive biases measured within Chapter 4. Therefore, we wanted to be able to test the relative strength of the relationships between these biases and anomalistic belief after controlling for the potential impact of the other biases. Additionally, choosing this strategy greatly reduced the number of analyses that were required within Chapter 4, helping to control the type 1 error rate.

Probabilistic Reasoning. In addition to covering the development of the ABS, Chapter 2 of this thesis focused on the relationship between anomalistic belief and the conjunction fallacy. The conjunction fallacy was investigated because previous work had produced mixed results (Dagnall, Drinkwater, Parker, & Rowley, 2014; Dagnall et al., 2007; Rogers et al., 2009; Rogers, Fisk, & Lowrie, 2016; Rogers, Fisk, & Wiltshire, 2011) and the distinction between experiential and theoretical anomalistic beliefs had not previously been considered. The conjunction fallacy involves judgements of the likelihood of events co-occurring and also reflects a tendency to use the representativeness and availability heuristics, all of which are highly relevant for the formation of anomalistic beliefs. Chapter 3 continued to explore the relationship between anomalistic belief and probabilistic reasoning by examining whether the context (either anomalistic or neutral) influenced relationships between anomalistic belief, and misperception of chance and the base rate fallacy problems. Additionally, because probabilistic reasoning is proposed to lead people to interpret chance or random experiences as anomalistic, Chapter 3 also examined whether there was a stronger relationship between probabilistic reasoning and experiential anomalistic beliefs.

Evidence Integration Biases. Chapter 4 examined whether anomalistic beliefs were related to greater biases in evidence integration. The specific relationships examined were between anomalistic belief and bias against disconfirmatory evidence, bias against confirmatory evidence, liberal acceptance, and the jumping to conclusions bias. These biases had previously been examined in relation to schizotypy and delusion proneness/delusion prone beliefs, however, their potential role in the formation and maintenance of anomalistic belief had not previously received much attention (with the exception of a small amount of research on anomalistic belief and the jumping to conclusions bias; Irwin, Dagnall, & Drinkwater, 2012; Irwin, Drinkwater, & Dagnall, 2014). Chapter 5 again looked at the assessment of evidence, but in the more applied context of interpreting news articles. A series of news articles on neutral (i.e., non-anomalistic) topics were presented to investigate whether anomalistic believers made less accurate inferences in a neutral, applied context. Chapter 5 also examined whether misinformation, in the form of misleading headlines, had a stronger influence on inferential reasoning for people with higher levels of anomalistic belief.

Relationships with Other Non-Evidence Based Beliefs. Chapter 6 examined whether evidence integration biases and analytical (vs. intuitive) thinking style were also related to other forms of non-evidence based beliefs. Due to the epistemological similarities between non-evidence based beliefs, there is good reason to predict that similar psychological characteristics may be associated with greater endorsement of a variety of non-evidence based beliefs. Therefore, Chapter 6 examined whether evidence integration biases and analytical thinking style explained a significant proportion of the relationships between anomalistic, conspiracist, delusion prone, and political beliefs.

Overall Summary and Discussion. Chapter 7 synthesises the major findings from this thesis and discusses the implications of the research conducted in Chapters 2-6. It reflects on the contribution of this thesis to our understanding of anomalistic beliefs, and relates the

cumulative research findings back to the broader literature. In particular, Chapter 7 focuses on cognitive theories of belief as well as the experiential/theoretical distinction and the role of causality. Chapter 7 also contains a discussion of the research limitations and makes some suggestions regarding future research directions.

Chapter 2: Psychics, Aliens, or Experience? Using the Anomalistic Belief Scale to Examine the Relationship Between Type of Belief and Probabilistic Reasoning

Prike, T., Arnold, M. M., & Williamson, P. (2017). Psychics, aliens, or experience? Using the Anomalistic Belief Scale to examine the relationship between type of belief and probabilistic reasoning. *Consciousness & Cognition, 53*, 151–164. doi:10.1016/j.concog.2017.06.003

The study materials for this chapter can be found in Appendices A and B.

Abstract

A growing body of research has shown people who hold anomalistic (e.g., paranormal) beliefs may differ from nonbelievers in their propensity to make probabilistic reasoning errors. The current study explored the relationship between these beliefs and performance through the development of a new measure of anomalistic belief, called the Anomalistic Belief Scale (ABS). One key feature of the ABS is that it includes a balance of both experiential and theoretical belief items. Another aim of the study was to use the ABS to investigate the relationship between belief and probabilistic reasoning errors on conjunction fallacy tasks. As expected, results showed there was a relationship between anomalistic belief and propensity to commit the conjunction fallacy. Importantly, regression analyses on the factors that make up the ABS showed that the relationship between anomalistic belief and probabilistic reasoning occurred only for beliefs about having experienced anomalistic phenomena, and not for theoretical anomalistic beliefs.

Keywords: anomalistic belief, paranormal belief, conjunction fallacy, reasoning, heuristics, bias

Psychics, Aliens, or Experience? Using the Anomalistic Belief Scale to Examine the Relationship Between Type of Belief and Probabilistic Reasoning

Many people hold a variety of non-evidence based beliefs that, at least in some cases, directly contradict our current understanding of reality (Moore, 2005; Ross & Joshi, 1992). One such category is anomalistic beliefs, which typically refers to paranormal and related beliefs (e.g., psychics, telekinesis, etc.) but can also include other varieties of beliefs, such as extra-terrestrial visitation, the efficacy of homeopathy and reiki, and some conspiracy theories. Researchers have argued that one explanation for the existence of anomalistic beliefs is reasoning ability. Specifically, people in general make many types of reasoning errors and reach inaccurate conclusions (e.g., Johnson-Laird, Khemlani, & Goodwin, 2015; Stanovich & West, 2000; Wason 1960), however, higher levels of anomalistic beliefs have been associated with poorer reasoning ability and stronger cognitive biases (Blackmore & Troscianko, 1985; Bressan, 2002; Tobacyk & Wilkinson, 1991; Wiseman & Watt 2006). The focus of this article is on reasoning skills and biases associated with anomalistic belief and, in particular, the propensity to commit the conjunction fallacy. We chose to focus on the conjunction fallacy because it taps into several underlying heuristics that can bias decision making (e.g., availability and representativeness; Keren & Teigen, 2004; Tversky & Kahneman, 1983), and because previous work that has looked at it in relation to anomalistic beliefs has produced mixed results.

The conjunction fallacy occurs when someone assesses the likelihood of conjunctive conditions occurring (e.g., A + B) to be greater than either of those conditions occurring on their own (A alone or B alone). Judging the conjunctive conditions as more likely is a fallacy because the probability of multiple conditions co-occurring is always lower than (or, at most, equal to) the probability of one of those conditions occurring on its own (Tversky & Kahneman, 1983). Several studies have found a positive relationship between anomalistic

belief and propensity to commit the conjunction fallacy (e.g., Dagnall, Drinkwater, Denovan, Parker, & Rowley, 2016; Brotherton & French, 2014; Rogers, Davis, & Fisk, 2009; Rogers, Fisk, & Lowrie, 2016; Rogers, Fisk, & Wiltshire, 2011), however, other studies have failed to find this relationship (Dagnall, Drinkwater, Parker, & Rowley, 2014; Dagnall, Parker, & Munley, 2007). The aim of the current study was to gain a better understanding of the relationship between anomalistic belief and the conjunction fallacy using a newly developed measure of anomalistic belief. This new measure, the *Anomalistic Belief Scale* (ABS), was designed to address some limitations of other belief scales (discussed below) and to provide a means of testing whether type of belief (e.g., experiential, psi, etc.) is an important factor.

Although there are large variations in the types of anomalistic belief people hold, one aspect that has not received much attention is whether the relationship between anomalistic belief and cognitive bias and reasoning ability is the same for different anomalistic beliefs. Rogers et al. (2016) did show that the positive relationship they found between beliefs and the propensity to commit conjunction fallacies appeared stronger for psychokinesis (PK) beliefs, compared to life after death (LAD) and extrasensory perception (ESP) beliefs. It is not clear, though, how more diverse beliefs relate to performance; for example, does it matter whether the anomalistic beliefs are just *theoretical* (e.g., you believe in the possibility of psychic ability) versus *experiential* (e.g., you believe you have experienced psychic ability) in nature? Indeed, if the relationship is not the same for different types of belief and reasoning ability then that may go some way to explaining the variation in results found across different studies.

It is not possible to use the existing beliefs scales to explore our current interest in the relationship between different types of anomalistic belief and reasoning performance. The two most widely used anomalistic belief scales are the Australian Sheep-Goat Scale (ASGS; Thalbourne & Delin, 1993), and the Revised Paranormal Belief Scale (R-PBS; Tobacyk,

2004; Tobacyk & Milford, 1983). Although both scales have shown good reliability (Dagnall et al., 2007; Goulding, 2005; Thalbourne & Delin, 1993; Tobacyk, 2004, Tobacyk & Milford, 1983), they also have several noted issues. The primary issue with the R-PBS is that it covers a wide range of areas but does not provide breadth and variety of belief within those areas. The R-PBS has 26 items broken up across seven subscales; Traditional Religious Belief, Psi, Witchcraft, Superstition, Spiritualism, Extraordinary Life Forms, and Precognition (Tobacyk, 2004). Thus, there are very few items to cover the variety of beliefs that exist in each area, and several studies that have analysed the factor structure have reported finding only two factors (New Age Philosophy and Traditional Paranormal Belief; Houran, Irwin, & Lange, 2001; Lange, Irwin, & Houran, 2000). Further, some items do not appear to map onto paranormal belief (e.g., "There is life on other planets," does not contradict our current understanding of reality), which may add noise to the measure because such items do not properly discriminate between high and low levels of anomalistic belief.

In comparison to the R-PBS, the ASGS is much more focused and consists of only 18 items that directly relate to either belief or experience of three parapsychological concepts: ESP, PK, and LAD. The narrower focus of the ASGS allows it to better capture the range, variety, and types of beliefs that people may have about these three concepts, however, this narrow focus also has some disadvantages. First, many related areas are not covered, such as psychic healing, tarot cards, extra-terrestrial visitation, et cetera. The exclusion of some anomalistic items is appropriate for a measure that focuses entirely on paranormal beliefs, however, this narrow specificity causes problems for studies looking more broadly at anomalistic beliefs. Second, there is an imbalance of items relating both to belief in and to experience of paranormal phenomena. For example, the item "I believe in the existence of ESP" relates to a theoretical belief in ESP, whereas the item "I believe I have had personal experience of ESP" relates to claimed experience of a paranormal phenomenon. Including

both theoretical and experience belief items is important because there may be different psychological mechanisms involved and/or different psychological profiles between people who hold a theoretical belief and those who claim to have experienced paranormal phenomena. However, the ASGS (and also the R-PBS) does not include enough experiential belief items to analyse whether there are any differences between theoretical and experiential anomalistic beliefs. Thus, we developed the ABS both to capture a broader range of anomalistic beliefs and to provide a better balance of theoretical and experiential scale items.

The Anomalistic Belief Scale (ABS)

The ABS has 44 belief statements and is modelled on the ASGS, with some items from the ASGS incorporated into the new measure. We chose to use items from the ASGS rather than the R-PBS because the ASGS items are more clearly anomalistic and give better comprehensive coverage of each anomalistic belief they attempt to measure. Further, the ABS was constructed with particular consideration to the limitations of the previous scales. For example, given there is argument over some of the items included in the R-PBS, including concerns raised about the inclusion of traditional religious belief items (see Lawrence, 1995), specific attention was paid to ensure that items in the ABS related only to anomalistic beliefs.

The ABS also was designed to cover a wider variety of anomalistic belief areas than the ASGS. For instance, we included items about other forms of paranormal phenomena, such as beliefs about psychic healing and making predictions using objects (e.g., tarot cards, crystals, tea leaves). A key feature of the ABS is that it includes items related both to theoretical belief and experiential belief for each of the included anomalistic phenomena. For example, an additional three life after death items were created so that, in addition to the two items from the ASGS, there were items about whether people believe that they have experienced phenomena associated with life after death.

The current version of the ABS has two broad subscales of anomalistic belief; a paranormal subscale (items related to psychic ability, psychokinesis, ghosts, etc.) and an extra-terrestrial subscale (items related to alien visitation, UFO sightings, etc.). Although there are many other types of anomalistic belief that could be included (e.g., conspiracy theories), this first version of the ABS was intentionally limited to two broad subscales to enable adequate testing of its efficacy through factor analysis. For example, given the number of questions necessary to cover both theoretical and experiential belief for each concept being measured in the two subscales, it is important to demonstrate that the larger question set enhances our understanding of how beliefs are related to conjunction fallacy performance.

Anomalistic Beliefs and the Conjunction Fallacy

The conjunction fallacy traditionally has been measured by providing participants with a scenario and several possible alternatives. The most well-known example is the 'Linda' scenario: "Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations." (Tversky & Kahneman, 1983, p 297). After reading the description, participants typically rank the provided alternatives in order of likelihood; for example, in the Linda scenario the main alternatives of interest are two single components, 'Linda is a bank teller' and 'Linda is active in the feminist movement,' and their conjunction, 'Linda is a bank teller and is active in the feminist movement.' Many participants commit the conjunction fallacy by judging the conjunctive statement – in this case that Linda is a feminist and a bank teller – as more likely than either one or both of the singular statements (Tversky & Kahneman, 1983).

The conjunction fallacy is an informative behavioural measure because it taps into several cognitive processes, such as the representativeness heuristic, the availability heuristic, illusory correlations, and/or poor understanding of probability (Keren & Teigen, 2004;

Tversky & Kahneman, 1983). The representativeness heuristic involves using the characteristics of something to make judgements about its likelihood in conditions of uncertainty, whereas the availability heuristic involves using immediate examples that come to mind to make a decision (Kahneman & Tversky, 1973; Keren & Teigen, 2004). Using the Linda example given above, the representativeness heuristic may lead to the decision that it is more likely she is a feminist bank teller than just a bank teller because she appears to share the characteristics of a stereotypical feminist. Alternatively, it could be the extent to which the unrepresentative component (e.g., that Linda is a bank teller) is "surprising" or unrepresentative in comparison to the conjunction that primarily contributes to the occurrence of the conjunction fallacy (see Fisk, 2002; Fisk & Pidgeon, 1998, for detailed discussion of this *potential surprise* explanation of the conjunction fallacy). Further, the description of Linda is more readily available than specific knowledge of probability (i.e., likelihood of conjunctions vs. single components), and thus the availability heuristic also may play into the incorrect conclusion she is both a feminist and bank teller (Tversky & Kahneman, 1983).

A stronger reliance on and/or willingness to use mental shortcuts such as heuristics may be at least one factor that plays into paranormal belief. For example, if a person is thinking of a friend she has not talked to in a long time, and that friend then calls, she may judge the likelihood of those two events occurring by chance as unlikely (e.g., because the co-occurrence of the two events feels more "representative" of a paranormal explanation; Keren & Teigen, 2004; Tversky & Kahneman, 1974; Tversky & Kahneman, 1983). However, if the person had used a more systematic approach, such as taking into consideration all of the times she had thought of the friend and had not received a call, or all the times the friend had called when she had not been thinking about this friend, then the conclusion that the co-occurrence of the two events was due to chance starts to feel much more plausible. Indeed, several studies have found that there is a positive relationship between paranormal beliefs and

a heuristic/intuitive (vs. analytical or systematic) thinking style (e.g., French & Stone, 2014; Irwin, 2009).

As mentioned previously, research on the relationship between anomalistic beliefs and the conjunction fallacy has produced varying results. Dagnall et al. (2007; 2014) found there was a relationship between perception of randomness and paranormal belief (i.e., believers were more likely to see a pattern in random events), but that there was no relationship between belief and the conjunction fallacy. However, both Rogers et al. (2009; 2011; 2016) and a follow-up study by Dagnall, Drinkwater, et al. (2016) did find paranormal believers (vs. nonbelievers) were more likely to commit the fallacy. Further, Rogers et al. (2009) argued that the small number of conjunction fallacy trials – four in Dagnall et al. (2007) and eight in Dagnall et al. (2014) – may have limited their ability to find any differences. Additionally, Dagnall et al.'s correlations between paranormal belief and propensity to commit the conjunction fallacy were primarily positive and in the same direction as those reported by both Rogers et al. (2009, 2011) and Brotherton and French (2014).

Given the discrepancy in results between the above studies, we attempted to address the methodological concerns by using a large set of conjunction fallacy scenarios that were closely modelled on scenarios traditionally used to study the fallacy (i.e., several singular statements and one conjunction statement; Tversky & Kahneman, 1983). The current study also included different analyses to previous studies. Conjunction fallacy errors were separated into two categories depending on whether participants placed the conjunction ahead of at least one of the components that make up the conjunction, or if the conjunction was placed ahead of both of the items that make up the conjunction (i.e., a more conservative measure of the fallacy). Analyses in the current study also differed through the use of Bayesian analyses. A Bayesian approach provides several advantages over just standard null hypothesis significance testing. For example, a Bayesian approach allows for comparison between the

null and alternative hypothesis (rather than just rejecting the null), and because the Bayes factor (*BF*) is presented as a likelihood ratio the weight of evidence can be easily interpreted (e.g., a BF_{10} of 7 indicates the data are 7 times more likely to have occurred under the alternative hypothesis than the null). For a more detailed discussion of Bayesian analyses refer to Jarosz and Wiley (2014), Masson (2011), and/or Wagenmakers (2007).

In addition to these changes, the newly developed ABS made it possible to investigate the relationship between the conjunction fallacy and different types of anomalistic belief (vs. just an overall average belief score). Two recent studies have highlighted that using factors may provide a more detailed and fine-grained understanding of the relationship between beliefs and the fallacy. Dagnall, Drinkwater et al. (2016) found that only the traditional paranormal belief factor (vs. the new age philosophy factor) of the R-PBS measure was significantly related to performance on the conjunction fallacy task. Additionally, Rogers et al. (2016) found that all three factors of the ASGS measure were significantly correlated with propensity to commit the conjunction fallacy, however, the PK factor was the most strongly related (r = .24), followed by the LAD factor (r = .17) and the ESP factor (r =.15). Given the issues noted above for both the ASGS and R-PBS, though, further work is warranted; for example, neither scale is able to pull out experiential versus theoretical belief. This particular distinction may be key because there also is some evidence that paranormal experience is related to the conjunction fallacy. That is, Rogers et al. (2009) had participants report personal experiences of events that could be seen as paranormal and found that those who reported having more of these types of events also were more prone to the conjunction fallacy. Therefore, measuring anomalistic belief with the ABS should help us better understand the type(s) of belief, including experiential versus theoretical, that are important in this relationship.

The two experiments outlined below measured paranormal belief (using the ASGS), anomalistic belief (using the ABS), and propensity to commit the conjunction fallacy. Including the ASGS measure allowed for a more direct comparison to previous studies (i.e., as an established scale), and the data from both experiments were used to assess the reliability, validity, and factor structure of the ABS. The conjunction fallacy was measured using a series of scenarios and statements, with none of the scenarios involving paranormal/anomalistic contexts. In Experiment 1A participants ranked the responses in order of likelihood, whereas in Experiment 1B participants made a numerical likelihood judgement for each response. Religiosity also was measured because previous research has suggested there is a link between religious belief and thinking style. That is, similar to anomalistic belief, religious belief has been shown to be positively related to an intuitive (vs. analytical) thinking style, which typically leads to more reasoning errors (Gervais & Norenzayan, 2012; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012; Shenhav, Rand, & Greene, 2012). Further, there is some evidence of a positive correlation between religious and anomalistic beliefs (e.g., Lindeman & Aarnio, 2007; Pennycook et al., 2012), thus we wanted to ensure that any effects found for anomalistic belief were over and above any potential effects related to religious belief. Finally, participants also provided information about their level of education in four categories (general, psychology, statistics, maths) so that we could control for any effect of education on performance (Rogers et al., 2009).

Method

Participants.

Two hundred and seventy-five participants were recruited from the Microworkers and Crowdflower websites for Experiment 1A, and 196 participants for Experiment 1B. All participants were reimbursed $1.75 for their participation. Sample size was chosen based on the effect sizes reported in previous studies that looked at the relationship between

paranormal belief and the conjunction fallacy (Rogers et al. 2009; Rogers et al. 2011). Nineteen participants were removed prior to data analyses for Experiment 1A, and eighteen participants were removed prior to data analyses for Experiment 1B because they did not follow instructions and complete the tasks properly (i.e., they took too long, completed too quickly, or did not complete all of the items).[1]

Design and materials.

A correlational design was used. The variables of interest were overall anomalistic belief (average scores on the ASGS, ABS, and two separate questions asking about overall paranormal belief and extra-terrestrial belief), level of belief for the factors of the ABS, conjunction fallacy errors, religiosity, level of education (general, psychology, mathematics, and statistics), and order. The ASGS and ABS questionnaires were separated by having participants complete one scale before the conjunction fallacy task and the other after: Participants were randomly assigned to complete either the ASGS first or the ABS first (*order*: ASGS first, ABS first).

Belief Measures. There were three measures of paranormal and anomalistic belief. First, paranormal belief was measured using the ASGS, which is a widely used and psychometrically sound measure of paranormal belief that has good empirical support for its validity, reliability, and factor structure. The ASGS consists of 18 items that assess belief in things such as psychic ability, life after death phenomena, and psychokinetic abilities. Participants responded to the items using a 7-point scale from 1 = 'strongly disagree' to 7 = 'strongly agree' (Brotherton & French, 2014; Rogers et al., 2009, 2011).

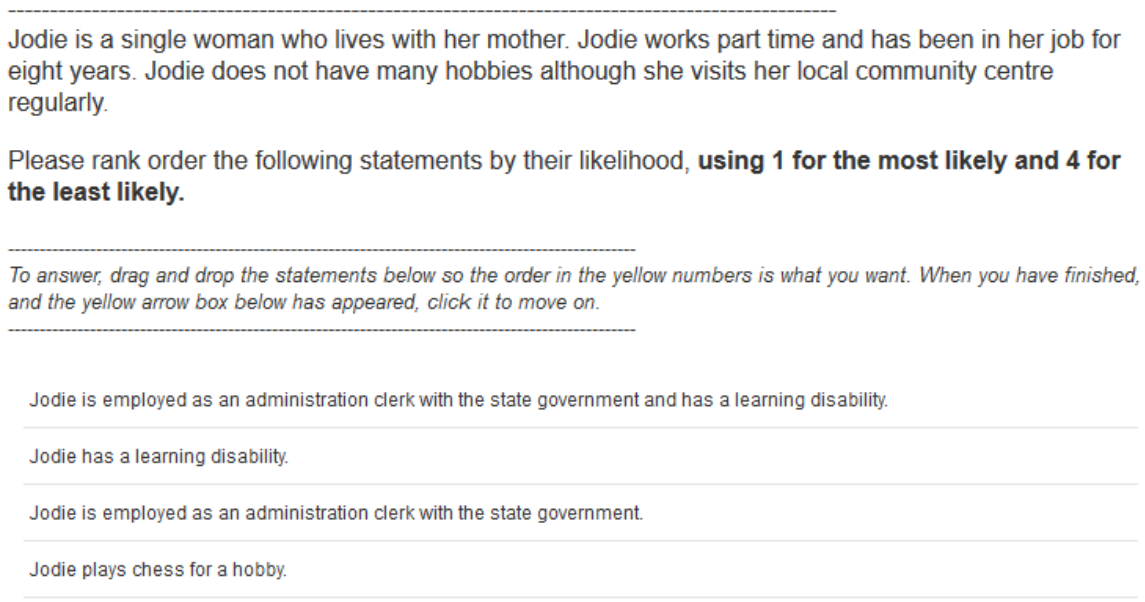
Anomalistic belief was measured using the newly developed ABS. The ABS has 44 belief statements that participants respond to on a 7-point scale (from 1 = 'strongly disagree' to 7 = 'strongly agree'). The belief statements are a mixture of existing, adapted, and new items; that is, some items were taken directly or adapted from the ASGS, and other items

were created specifically for the ABS (see Table 2.1). There are two general subscales that make up the ABS, with the first consisting of 28 items that have traditionally been referred to as paranormal (PSI subscale) and the second consisting of 16 items related to beliefs about extra-terrestrials (ET subscale). The extra-terrestrial items cover a similar range of beliefs to other measures of extra-terrestrial belief (Chequers, Joseph & Diduca, 1997; Patry & Pelletier, 2001; Swami, Furnham, Haubner, Stieger & Voracek, 2009), however, new items were created so that they were similar in both structure and style to the paranormal items. Finally, participants also were asked to provide two separate self-report ratings of their overall belief in the paranormal and extra-terrestrials on a scale from 1-100. This blunt measure of belief was collected to test whether using a more complex scale (i.e., ASGS, ABS) provided useful information above and beyond a simple overall self-rating by participants.[2]

Religious belief also was measured using the Religiosity Inventory (Pennycook et al., 2012), and with one additional question ("What is your religion?"). We chose the Religiosity Inventory because it is a brief measure that has 9 items focused on non-denominational religious beliefs and practices. It has two factors, with one measuring religious engagement (e.g., "Outside of attending religious services, how often do you pray?") and the other measuring religious beliefs (e.g., "Religious miracles occur."). An exploratory factor analysis has supported this two factor structure, and both factors have good internal consistency (Pennycook et al., 2012).

Scenario Judgements Questionnaire (SJQ). The SJQ was used to measure participants' propensity for committing conjunction fallacies. Participants in both Experiment 1A and 1B were presented with 20 neutral (i.e., non-anomalistic) scenarios, each with four response options. In Experiment 1A, participants were required to rank the likelihood of the options from 1 to 4 (see Figure 2.1A). In Experiment 1B, participants rated the likelihood of each

2.1A



2.1B

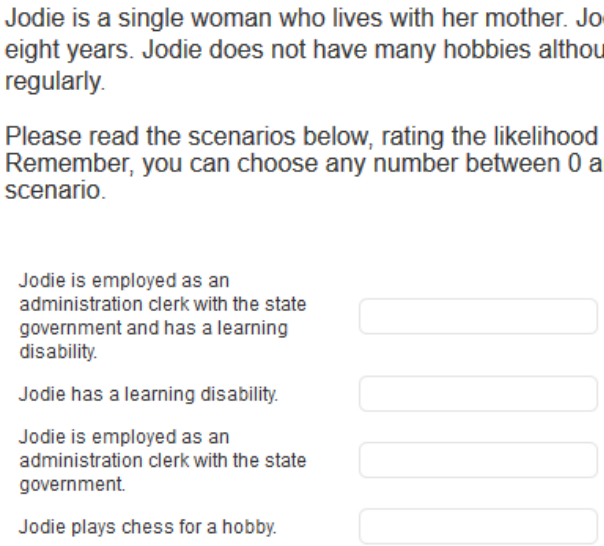


Figure 2.1. Example item from the Scenario Judgements Questionnaire for Experiment 1A (1A) and Experiment 1B (1B)

item occurring out of 100, which allowed them to rate items as being of equal likelihood (see Figure 2.1B). Of the four options that participants ranked, three options were relevant for the conjunction fallacy; that is, two components made up the conjunction (e.g., *Jodie is employed as an administration clerk with the state government* and *Jodie has a learning disability*) and

one was the conjunction (*Jodie is employed as an administration clerk with the state government and has a learning disability*). The fourth option was a filler item (e.g., *Jodie plays chess for a hobby*). Responses to the SJQ were scored in two separate ways. First, if a participant ranked the likelihood of the conjunction ahead of at least one of the components that make up the conjunction it was counted as making a "single" conjunction fallacy (s*ingle-CF*). Second, if participants ranked the conjunction ahead of both of the components that make up the conjunction it was counted as a "both" conjunction fallacy (*both-CF*).

Additional measures. Several additional measures were collected, including demographic information (e.g., gender, age). Participants also were asked what their highest level of education was at a general level (less than high school, high school, some education above high school, undergraduate degree, postgraduate/professional degree, other), as well as separate questions about their level of education in psychology, statistics, and mathematics. Participants who responded 'other' for the education question were able to type in a response, and all typed 'other' responses were able to be re-categorised under one of the other five education options presented. Education was measured to ensure that the effects of anomalistic belief on the conjunction fallacy task were not being influenced by a relationship between level of education and level of anomalistic belief.

Procedure.

After reading introduction, information, and consent forms, participants were randomly assigned to complete either the ASGS or the ABS as the first part of their experiment. Participants then completed the 20 conjunction fallacy scenarios before they were given the scale that they had not previously completed. After the second anomalistic scale, participants answered the two questions about their overall belief in the paranormal and extra-terrestrials before completing the Religiosity Inventory and the demographic and education measures. Participants were then debriefed about the purpose of the experiment.

This procedure was identical for both Experiment 1A and 1B, and thus the only difference between the two experiments was whether participants were asked to rank order (1A) or rate the likelihood (1B) of the responses for the conjunction fallacy scenarios.

Results

Because the ABS is a newly developed measure, we first report the analysis we conducted to establish the underlying factor structure of the scale. These factors were then used in the subsequent analyses of the conjunction fallacy for Experiments 1A and 1B.

Anomalistic Belief Scale Principal Component Analysis.

Data were pooled across Experiment 1A (n = 256) and 1B (n = 178), as well as from a pilot study (n = 85) to provide an adequate sample size for Principal Components analysis (total n = 519, ratio of 11.8 cases per variable).[3] Principal Components analysis (with a varimax rotation) was used because the aim was to identify and compute scores for the underlying components of the ABS (see Table 2.1). The five factors identified explained 22.57, 19.36, 16.81, 9.84, and 5.14 percentage of the variance, respectively. Although there was a fifth factor identified, a four factor solution was chosen because the fifth factor was after the point of "levelling off" on the scree plot, had very few primary loadings, and did not provide a theoretical contribution. Any item that did not meet the minimum criteria of loading on a primary factor at .50 or higher was removed, which led to the removal of four PSI items.

The first of the identified factors was primarily made up of items on the scale that relate to personal experience of anomalistic phenomena and included items from both the PSI and the ET subscales (*experiential factor*). The second factor consisted of the remaining items from the PSI subscale (*PSI factor*), and the third factor was made up of all of the remaining items from the ET subscale (*ET factor*). Finally, the fourth factor identified was made up of the items from the PSI subscale that relate to life after death (*LAD factor*). The

Table 2.1.

Principal Components Analysis of the ABS

Item#	Item	Factors			
		1	2	3	4
3.	I believe I have personally exerted psychokinesis on at least one occasion.*	**0.67**	0.39	0.03	0.14
9.	I have personally known someone who has had an illness that was treated or cured through the use of psychic healing.	**0.69**	0.32	0.10	0.13
14.	I believe I am psychic.*	**0.62**	0.53	0.09	0.11
19.	I believe that, on at least one occasion, inexplicable disturbances of an apparently psychokinetic origin have occurred in my presence.+	**0.58**	0.47	0.18	0.30
21.	I believe I have marked psychokinetic ability.*	**0.81**	0.33	0.07	0.12
26.	I have had at least one experience with psychic healing that helped treat or cure an illness that I was suffering from.	**0.74**	0.31	0.11	0.20
31.	I believe that I have had direct contact with an extra-terrestrial here on earth.	**0.83**	0.20	0.19	0.05
32.	I personally know of someone who has been taken aboard the space ship of extra-terrestrials and then returned back to earth.	**0.89**	0.14	0.11	0.06
33.	I personally know someone who has had an experience that I believe is evidence of the existence of extra-terrestrials.	**0.79**	0.17	0.31	0.09
36.	I believe that, on at least one occasion, I have been taken aboard the space ship of extra-terrestrials and then returned back to earth.	**0.88**	0.12	0.07	0.04
38.	I personally know of someone who has had direct contact with an extra-terrestrial here on earth.	**0.85**	0.15	0.20	0.07
39.	I believe that, on at least one occasion, I have had an experience that is evidence of the existence of extra-terrestrials.	**0.79**	0.16	0.32	0.09
43.	I personally know of someone who I believe has seen a UFO in the sky that was an extra-terrestrial space ship.	**0.59**	0.15	0.47	0.20
44.	I have seen at least one UFO in the sky that I believe was an extra-terrestrial space ship.	**0.60**	0.18	0.44	0.15
1.	I believe in the existence of ESP.*	0.16	**0.65**	0.30	0.43
2.	I have had at least one vision that was not a hallucination and from which I received information that I could not have otherwise gained at that time and place.*	0.32	**0.70**	0.08	0.12

(continued)

Table 2.1.

Principal Components Analysis of the ABS (continued)

Item#	Item	Factors			
		1	2	3	4
4.	I believe that it is possible to gain information about the future that does not depend on rational prediction or normal sensory channels through the use of certain objects (e.g., tarot cards, tea leaves, crystals, etc.).	0.27	**0.59**	0.28	0.38
7.	I believe that I have a "sixth sense".	0.30	**0.74**	0.16	0.14
8.	I have had at least one dream that came true and which (I believe) was not just a coincidence.*	0.15	**0.71**	0.19	0.22
11.	I believe I have had at least one experience of telepathy between myself and another person.*	0.39	**0.64**	0.21	0.10
12.	I believe that some people have a "sixth sense" that allows them to know things that do not depend on normal sensory channels.	0.09	**0.74**	0.30	0.39
13.	I believe that it is possible to gain information about the thoughts, feelings or circumstances of another person, in a way that does not depend on rational prediction or normal sensory channels.*	0.18	**0.74**	0.28	0.30
18.	I believe I have had personal experience of ESP.*	0.35	**0.76**	0.21	0.11
20.	I believe everyone has at least some ESP ability, but that only people open to the possibility of ESP can have a personal experience of ESP.	0.31	**0.68**	0.29	0.24
24.	I believe it is possible to gain information about the future before it happens, in ways that do not depend on rational prediction or normal sensory channels.*	0.20	**0.72**	0.23	0.33
25.	I have had at least one premonition about the future that came true and which (I believe) was not just a coincidence.*	0.23	**0.77**	0.18	0.17
28.	I believe that it is possible to send a 'mental message' to another person (i.e., telepathy), or in some way influence them at a distance, by means other than the normal channels of communication.*	0.24	**0.64**	0.33	0.24
29.	I believe that at least some sightings of unidentified flying objects (UFOs) in the sky are the space ships of extra-terrestrials.	0.17	0.24	**0.83**	0.25
30.	I believe extra-terrestrials have visited earth.	0.14	0.25	**0.87**	0.18
34.	I believe that extra-terrestrials have left objects or relics here on earth (e.g., the pyramids).	0.27	0.21	**0.81**	0.15
35.	I believe extra-terrestrials have made contact with human beings.	0.24	0.28	**0.82**	0.15
37.	I believe that extra-terrestrials have taken humans aboard their space ships and then returned them back to earth.	0.45	0.22	**0.68**	0.18

(continued)

Table 2.1.

Principal Components Analysis of the ABS

Item#	Item	Factors			
		1	2	3	4
40.	I believe in the existence of extra-terrestrials somewhere in the universe.	-0.01	0.13	**0.77**	0.03
41.	I believe that concrete evidence of extra-terrestrials (e.g., crashed space ship) has been hidden from the general public.	0.22	0.23	**0.83**	0.19
42.	I believe that, given the large number of personal accounts that have been reported over the years of extra-terrestrial contact, at least some of those accounts must be true.	0.20	0.26	**0.84**	0.20
10.	I believe that sometimes the spirits of the dead (or souls, ghosts, etc.) remain here attached to a particular place or person.	0.12	0.41	0.35	**0.70**
15.	I believe that some people can contact spirits of the dead.*	0.23	0.43	0.27	**0.67**
16.	I believe in life after death (e.g., souls, spirits of the dead, ghosts, etc.).+	0.00	0.31	0.14	**0.68**
17.	I have personally known someone who, on at least one occasion, has had an experience with spirits of the dead (or souls, ghosts, etc.).	0.21	0.34	0.25	**0.70**
23.	I believe that, on at least one occasion, I have had personal experience with spirits of the dead (or souls, ghosts, etc.).	0.35	0.37	0.19	**0.65**
5.	I believe that, on at least one occasion, I have witnessed someone use an object or objects (e.g. tarot cards, tea leaves, crystals, etc.) to gain information about the future that did not depend on rational prediction or normal sensory channels.	0.41	0.38	0.16	0.40
6.	I believe that, on at least one occasion, I have gained information about the future that does not depend on rational prediction or normal sensory channels through the use of certain objects (e.g. tarot cards, tea leaves, crystals, etc.).	0.45	0.48	0.13	0.28
22.	I believe that psychic healing can be used to treat or cure disease.	0.45	0.37	0.27	0.25
27.	I believe in the existence of psychokinesis, that is, the direct influence of mind on a physical system, without the mediation of any known physical energy.*	0.44	0.37	0.33	0.31

Items are ordered by the factor they load onto. All scale loadings over .5 are in bold. Items marked with "" are from the ASGS, items marked with "+" are modified ASGS items, and items with no markings are newly developed.*

four identified factors suggest that paranormal and extra-terrestrial anomalistic belief is made up of an overall belief about experiencing anomalistic events, as well as separate factors for theoretical belief in several distinct types of anomalistic belief (i.e., PSI belief, ET belief, and LAD belief).

The overall ABS showed good internal consistency (α = .97), as did each of its subscales (Experiential factor, α = .96; PSI factor, α = .96; ET factor, α = .96; LAD factor, α = .89). There also was support for the convergent and discriminatory validity of the ABS, shown by the correlations between the ABS, ABS factors, and the ASGS (see Table 2.2). The strong and significant correlation between the overall ABS and the ASGS shows convergent validity because these scales are intended to measure similar underlying constructs. Convergent validity also was supported by the significant correlation between the ASGS and the PSI factor, which are both designed to measure paranormal beliefs. The comparatively weaker (although still strong and significant) correlations between the ASGS and the other three ABS factors support the discriminatory validity of the ABS because these three factors are primarily made up of items that were included to expand the scope of the ABS beyond that of the ASGS.

Correlations Between the Scales.

Scores on the ASGS, the ABS, the ABS factors, and the Religiosity Inventory were coded so that higher scores reflected greater belief in the measured phenomena. The education measure was coded so that higher scores reflected greater level of educational attainment in that area. Descriptive statistics for all scales are reported in Table 2.3.[4]

As can be seen in Table 2.4, the ASGS, ABS, and the four factors were all highly correlated, and the patterns for both Experiment 1A and 1B did not differ from the overall patterns discussed in the previous section. However, the results also showed that there were significant relationships between religious belief and anomalistic belief. Specifically, for both Experiment 1A and 1B there were positive relationships between level of religious belief and both the ASGS and ABS. Both experiments also showed positive relationships between level of religious belief and the PSI and LAD factors of the ABS. In Experiment 1B there also was a positive relationship between religious belief and the experiential factor of the ABS. These

Table 2.2.

Correlations between ASGS, ABS, and ABS Factors

Scales						
	1	2	3	4	5	6
1. ASGS						
2. ABS	.91***					
3. Experiential Factor	.75***	.84***				
4. PSI Factor	.93***	.91***	.66***			
5. ET factor	.60***	.79***	.54***	.60***		
6. LAD factor	.77***	.81***	.54***	.77***	.58***	
7. ABS*			.68***	.78***	.65***	.74***

Note: n = 519
ABS* = ABS without the factor being compared included (e.g., no experiential factor included when ABS compared to the experiential factor).
***$p < .001$ (two-tailed).

findings suggest that people who hold stronger religious beliefs and/or are more engaged in religious practice are more likely to hold anomalistic beliefs, but only for certain types of anomalistic belief (i.e., there was no relationship between religiosity and the ET factor in either experiment).

As would be expected, there were significant and strong correlations between the various measures of educational attainment (general, psychology, mathematics, and statistics) in both experiments. However, there also were some relationships between education and level of anomalistic belief. In Experiment 1A, higher levels of psychology education were associated with higher levels of overall anomalistic belief on the ASGS and ABS, as well as increased level of belief for the experiential and PSI factors. Further, higher levels of statistics education were associated with higher scores on the experiential factor. In

Table 2.3.

Descriptive statistics for all scales for Experiments 1A and 1B

Scales	Mean	SD	Median	Min.	Max.	α	*K-s*
Experiment 1A							
1. ASGS	3.15	1.52	3.17	1.00	7.00	.96	0.09**
2. ABS	3.02	1.39	2.80	1.00	6.68	.98	0.09**
3. Experiential Factor	2.04	1.39	1.43	1.00	6.50	.96	0.23**
4. PSI Factor	3.45	1.70	3.62	1.00	7.00	.96	0.09**
5. ET Factor	3.51	1.87	3.50	1.00	7.00	.96	0.10**
6. LAD Factor	3.81	1.84	3.80	1.00	7.00	.89	0.09**
7. Religiosity Inventory	29.95	10.95	30.00	9.00	49.00	.93	0.04
8. General Education	3.32	0.94	3.00	1.00	5.00	N/a	0.22**
9. Psychology Education	2.26	1.00	2.00	1.00	5.00	N/a	0.19**
10. Mathematics Education	2.75	0.91	3.00	1.00	5.00	N/a	0.22**
11. Statistics Education	2.44	1.03	2.00	1.00	5.00	N/a	0.19**
Experiment 1B							
1. ASGS	2.95	1.40	2.75	1.00	7.00	.95	0.08*
2. ABS	2.83	1.35	2.64	1.00	7.00	.98	0.12**
3. Experiential Factor	1.87	1.25	1.29	1.00	7.00	.96	0.24**
4. PSI factor	3.16	1.61	3.00	1.00	7.00	.96	0.10**
5. ET factor	3.53	1.94	3.44	1.00	7.00	.96	0.12**
6. LAD factor	3.57	1.83	3.20	1.00	7.00	.89	0.10**
7. Religiosity Inventory	28.89	10.81	29.50	9.00	49.00	.93	0.05
8. General Education	3.57	0.98	4.00	1.00	5.00	N/a	0.24**
9. Psychology Education	2.39	1.06	2.00	1.00	5.00	N/a	0.18**
10. Mathematics Education	2.81	1.01	3.00	1.00	5.00	N/a	0.23**
11. Statistics Education	2.49	1.08	2.00	1.00	5.00	N/a	0.19**

Note: Experiment 1A $n = 247$, *K-S df* = 247, Experiment 1B $n = 178$, *K-S df* = 178

*Kolmogorov-Smirnov is significant at the level $p < .01$.

**Kolmogorov-Smirnov is significant at the level $p < .001$

Experiment 1B, general education level was negatively correlated with all of the measures of anomalistic belief except for the experiential factor.

Conjunction Fallacy.

In addition to standard analyses, the data for the relationships between the number of conjunction fallacy errors made and the ASGS, ABS, and ABS factors were analysed in JASP (JASP Team, 2016, Version 0.8.0.0) by estimating a Bayes factor (Wagenmakers, 2007). Bayes factors are reported in the form of BF_{10} which provides the odds ratio of the alternative/null hypotheses given the data (i.e., 1 means they are equally likely, larger values indicate evidence in support of the alternative, and values smaller than 1 indicate evidence in support of the null).

Experiment 1A. Independent samples t-tests and regressions were run to check whether order (ABS first, ASGS first) affected scores on any of the scales or conjunction fallacy performance, or interacted with any of the predictors. There was no effect of presentation order on participants' results for the ASGS, ABS, the four factors, Religiosity Inventory, or the number of single-CF or both-CF conjunction fallacies, all ts ≤ 1.46, ps $\geq .14$, ds ≤ 0.19 and order did not interact with scores on the ASGS, ABS, or any of the four ABS factors, all $\beta \leq .12$, $t(246) \leq 1.39$, $p \geq .17$. Therefore, order was not included as a variable in any of the analyses reported below. Additionally, there were no significant relationships between performance on the conjunction fallacy task and religiosity or any of the education measures (all rs $\leq .12$, ps $\geq .05$) so those variables were not included in any of the analyses.

The proportion of participants who made a conjunction error for each scenario was examined to test that all of the items included in the SJQ were appropriate. For each scenario, some proportion of the sample made a single-CF error, range = 36.0 – 59.5%, and a both-CF error, range = 15.0 – 38.9%. Therefore, all of the items were appropriate to include in the analysis. Also, a large proportion of the sample made at least one conjunction fallacy error for

both the single-CF errors (93.9%; possible range = 0-20; actual range = 0-20; *M* = 10.43; *SD* = 6.24) and both-CF errors (77.7%; possible range 0-20; actual range 0-20; *M* = 4.78; *SD* = 4.30).

Four separate regression analyses were conducted to compare the overall scores on the ASGS and ABS with the number of conjunction fallacy errors (single-CF and both-CF) and they are reported in Table 2.5. There was a significant relationship between the ASGS and number of conjunction fallacy errors for single-CF errors and for the both-CF errors. Table 2.5 also shows that this relationship was found between the ABS and single-CF errors and both-CF errors.

We also were interested in the relationships between the factors that make up the ABS and the conjunction fallacy. As can be seen in Table 2.4, all of the factors were positively correlated with the number of conjunction fallacy errors made. When all of the factors were entered into a regression, the model significantly predicted performance on the conjunction fallacy task for single-CF errors and both-CF errors (see Table 2.5). However, with all of the factors entered together into the regression, only the experiential factor was a significant predictor of propensity to commit the conjunction fallacy for single-CF and both-CF. These results suggest that, even though overall anomalistic belief is a predictor of performance on the conjunction fallacy task, it also matters which specific types of belief a person holds. Specifically, claimed (or belief in claimed) anomalistic experiences are a more important predictor of performance on the conjunction fallacy task than beliefs that are more theoretical in nature.

Experiment 1B. Similar to Experiment 1A, some proportion of participants made a conjunction fallacy for all of the scenarios and therefore all were included in the analyses (single-CF range 13.5 – 49.4%; both-CF range 3.9 – 19.7%). A large proportion of the sample

Table 2.4.

Correlations for Conjunction Fallacy Errors and all scales for Experiments 1A and 1B

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Experiment 1A														
1. Single-CF														
2. Both-CF	.82***													
3. ASGS	.21***	.25***												
4. ABS	.25***	.30***	.91***											
5. Overall Paranomal Question	.17**	.19**	.80***	.79***										
6. Overall ET Question	.07	.09	.40***	.58***	.46***									
7. Experiential Factor	.30***	.37***	.73***	.84***	.54***	.37***								
8. PSI Factor	.18**	.20**	.94***	.91***	.79***	.41***	.65***							
9. ET Factor	.19**	.21***	.59***	.80***	.56***	.82***	.57***	.60***						
10. LAD Factor	.15*	.19**	.76***	.79***	.80***	.39***	.51***	.77***	.55***					
11. Religiosity Inventory	.12	.11	.30***	.23***	.32***	-.01	.08	.29***	.08	.39***				
12. General Education	-.11	-.09	-.03	-.04	-.07	-.04	.01	-.03	-.08	-.05	.02			
13. Psychology Education	.04	.07	.15*	.17**	.08	.10	.21***	.14*	.09	.08	-.07	.36***		
14. Mathematics Education	-.08	-.08	-.04	-.03	-.07	.00	.01	-.02	-.04	-.10	-.02	.47***	.47***	
15. Statistics Education	-.00	.01	.01	.01	-.05	-.02	.13*	-.02	-.05	-.08	-.06	.42***	.53***	.68***

(continued)

Table 2.4.

Correlations for Conjunction Fallacy Errors and all scales for Experiments 1A and 1B (continued)

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Experiment 1B														
1. Single-CF														
2. Both-CF	.75***													
3. ASGS	.31***	.33***												
4. ABS	.35***	.35***	.91***											
5. Overall Paranomal Question	.29***	.22**	.81***	.83***										
6. Overall ET Question	.11	.08	.47***	.63***	.62***									
7. Experiential Factor	.35***	.43***	.75***	.82***	.54***	.38***								
8. PSI Factor	.31***	.30***	.91***	.92***	.80***	.48***	.66***							
9. ET Factor	.25***	.18*	.64***	.81***	.70***	.81***	.50***	.65***						
10. LAD Factor	.30***	.23**	.78***	.84***	.82***	.50***	.54***	.78***	.67***					
11. Religiosity Inventory	.17*	.14	.31***	.24**	.27***	-.04	.15*	.27***	.08	.38***				
12. General Education	-.05	.04	-.20**	-.23**	-.19*	-.15*	-.14	-.20**	-.23**	-.24**	-.11			
13. Psychology Education	.07	.15	.14	.09	.09	-.03	.13	.10	-.02	.07	.09	.28***		
14. Mathematics Education	.02	.08	-.08	-.02	-.05	.10	.05	-.04	-.05	-.05	-.05	.46***	.30***	
15. Statistics Education	.03	.15*	-.05	.03	-.04	.09	.12	.02	-.04	-.03	-.10	.44***	.44***	.77***

*$p < .05$, **$p < .01$, ***$p < .001$ (two-tailed).

Table 2.5.

The Six Regressions of Anomalistic Belief on Conjunction Fallacy Errors for Experiment 1A

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	$Adj.Rr^2$
Single-CF								
ASGS Model				< .001	34.02	11.81	.05	.04
ASGS	.21	.09 - .34	3.44	<.001				
ABS Model				< .001	262.85	16.30	.06	.06
ABS	.25	.13 - .37	4.04	< .001				
ABS Factors Model				< .001	124.46	6.27	.09	.08
Experiential	.32	.15 - .48	3.75	< .001	145.78			
PSI	-.06	-.27 - .16	-0.53	.60	0.28			
ET	.04	-.12 - .20	0.45	.65	0.27			
LAD	.01	-.18 - .20	0.10	.92	0.25			
Both-CF								
ASGS Model				< .001	350.30	16.95	.06	.06
ASGS	.25	.13 - .38	4.12	< .001				
ABS Model				< .001	6932.80	23.66	.09	.08
ABS	.30	.18 - .42	4.86	< .001				
ABS Factors Model				< .001	38908.05	9.76	.14	.12
Experiential	.40	.24 - .56	4.84	< .001	8430.78			
PSI	-.12	-.33 - .09	-1.17	.24	0.42			
ET	.02	-.14 - .17	0.22	.83	0.23			
LAD	.08	-.11 - .26	0.83	.41	0.31			

also made at least one conjunction fallacy for single-CF (94.4%; possible range = 0-20; actual range = 0-17; $M = 7.33$; $SD = 4.32$) and both-CF errors (70.8%; possible range 0-20; actual range 0-10; $M = 2.10$; $SD = 2.33$). Independent-samples t-tests also showed that the change in methodology in Experiment 1B (i.e., where participants could rate items as equally likely) led to participants making fewer conjunction fallacies than in Experiment 1A for single-CF, $t(422.37) = 6.04$, $p < .001$, $d = .56$, and both-CF errors, $t(396.23) = 8.25$, $p < .001$, $d = .74$.

Unlike Experiment 1A, there was a significant effect of order on scores for the ABS, with participants in the ABS-first condition scoring higher ($M = 3.14$, $SD = 1.31$) than those in the ABS-second condition ($M = 2.50$, $SD = 1.32$), $t(176) = 3.31$, $p = .001$, $d = .50$. Further, the PSI, ET, and LAD factors of the ABS showed this same pattern, all $ts(176) \geq 2.84$, $p \leq .01$, $ds \geq .43$. However, there were no significant interactions between order and the ASGS, the ABS or the ABS factors, all $\beta s \leq -.18$, $ts(174) \leq -1.80$, $ps \geq .07$. In addition to order effects, there also were significant positive relationships between religiosity and single-CF errors, $r(178) = .17$, $p = .02$, and between statistics education and both-CF errors, $r(178) = .15$, $p = .05$. Therefore, order, religiosity, and statistics education were entered at the first step in all regressions to control for these effects.

As in Experiment 1A, four separate regression analyses were conducted to compare the overall scores on the ASGS and ABS with the number of conjunction fallacy errors (single-CF and both-CF; see Table 2.6). The results showed that for both the ASGS and the ABS higher levels of belief were associated with both a larger number of single-CF errors and a larger number of both-CF errors. Also, as in Experiment 1A, the four factors were used to gain a better understanding of the relationship between anomalistic belief and performance on the conjunction fallacy task. When the four factors were entered at the second step they made a significant contribution to explaining the variance in single-CF errors (see Table 2.6). However, just as in Experiment 1A, only the experiential factor was a significant predictor.

Table 2.6.

The Six Regressions of Anomalistic Belief on Conjunction Fallacy Errors for Experiment 1B

Variables		*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Single-CF												
Step 1 (All Models)					.06	0.31	2.47	.04	.02			
	Religiosity	.18	.03 - .32	2.37	.02	3.48						
	Statistics	.04	-.11 - .19	0.52	.60	0.31						
	Order	.11	-.04 - .25	1.43	.15	0.71						
Step 2 ASGS Model					< .001	36.05	5.43	.11	.09	13.76	.07	< .001
	Religiosity	.09	-.06 - .24	1.19	.24	0.52						
	Statistics	.05	-.10 - .19	0.65	.51	0.33						
	Order	.08	-.07 - .22	1.05	.30	0.46						
	ASGS	.28	.13 - .43	3.71	< .001	117.87						
Step 2 ABS Model					< .001	243.53	6.62	.13	.11	18.31	.09	< .001
	Religiosity	.09	-.05 - .24	1.25	.21	0.54						
	Statistics	.02	-.12 - .16	0.34	.73	0.28						
	Order	.02	-.12 - .17	0.32	.75	0.28						
	ABS	.32	.17 - .47	4.28	< .001	796.19						
Step 2 ABS Factors Model					< .001	22.78	4.11	.14	.11	5.17	.10	<.001
	Religiosity	.10	-.06 - .26	1.19	.23	0.64						
	Statistics	.01	-.14 - .15	0.09	.93	0.34						
	Order	.04	-.11 - .19	0.49	.62	0.38						
	Experiential	.25	.06 - .44	2.58	.01	6.17						
	PSI	.03	-.22 - .29	0.25	.80	0.35						
	ET	.04	-.16 - .25	0.43	.67	0.37						
	LAD	.06	-.20 -.32	0.46	.65	0.37						

(continued)

Table 2.6.

The Six Regressions of Anomalistic Belief on Conjunction Fallacy Errors for Experiment 1B (continued)

Variables		*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Both-CF												
Step 1 (All Models)					.03	0.59	2.99	.05	.03			
	Religiosity	.16	.01 - .30	2.12	.04	2.07						
	Statistics	.16	.01 - .31	2.16	.03	2.28						
	Order	.06	-.09 - .21	0.80	.42	0.36						
Step 2 ASGS Model					< .001	555.06	7.14	.14	.12	18.71	.09	< .001
	Religiosity	.06	-.09 - .20	0.77	.44	0.34						
	Statistics	.17	.03 -.31	2.40	.02	3.63						
	Order	.02	-.12 - .16	0.34	.74	0.27						
	ASGS	.32	.18 - .47	4.33	< .001	934.74						
Step 2 ABS Model					< .001	787.22	7.36	.15	.13	19.51	.10	< .001
	Religiosity	.07	-.07 - .22	0.96	.34	0.39						
	Statistics	.15	.01 - .29	2.06	.04	1.82						
	Order	-.03	-.17 - .12	-0.35	.72	0.27						
	ABS	.33	.18 - .48	4.42	< .001	1325.70			.			
Step 2 ABS Factors Model					<.001	5096.47	6.22	.20	.17	8.27	.15	< .001
	Religiosity	.09	-.06 - .25	1.18	.24	0.57						
	Statistics	.10	-.03 - .24	1.49	.14	0.83						
	Order	.01	-.13 - .15	0.15	.88	0.31						
	Experiential	.41	.22 - .59	4.36	< .001	1023.08						
	PSI	.05	-.19 - .30	0.44	.66	0.33						
	ET	-.03	-.23 - .17	-0.31	.76	0.32						
	LAD	-.05	-.30 - .21	-0.36	.72	0.32						

*change statistics represent change from Step 1.

The same pattern also was found for both-CF errors. Thus, taken together, the results from Experiment 1B support the findings from Experiment 1A: Even though overall anomalistic belief is associated with the number of conjunction fallacy errors that people make, certain types of anomalistic belief (i.e., experiential) are more predictive of the relationship.

Discussion

The data from the current study demonstrated several key findings. First, the factor analysis of the ABS showed a distinction between experiential and theoretical belief, with the highest loading factor consisting almost entirely of items from both subscales that refer specifically to beliefs of having experience with anomalistic phenomena. This finding is not necessarily surprising given that there are phenomenological differences between holding a theoretical belief and claiming to have experienced phenomena. Specifically, for people to endorse the claim that they have experienced an anomalistic phenomenon (e.g., personally exerted psychokinesis) they must also theoretically believe that this phenomenon is possible. Thus, the experiential items require two types of beliefs (i.e., theoretical possibility and personal experience), whereas the items that ask solely about theoretical belief only require the belief that the phenomena are possible.

Although the experiential factor included items from both subscales of the ABS, the three theoretical factors each related to separate areas of anomalistic belief; that is, psi belief, extra-terrestrial belief, and life after death belief. Finding separate psi and extra-terrestrial belief factors also is not surprising because even though both are anomalistic, they are quite different and distinct types of belief. That is, although they were strongly correlated, people may believe in psi phenomena but have very little or no belief in extra-terrestrial phenomena, and vice versa. Indeed, there is evidence that people may believe strongly in some anomalistic phenomena and not others; for example, females generally are more prone to holding paranormal beliefs, whereas males are more likely to hold extra-terrestrial beliefs

(Aarnio & Lindeman, 2005). As for life after death factor, this finding is consistent with previous research with the ASGS that also found that life after death was a separate factor (Lange & Thalbourne, 2002; Thalbourne & Delin, 1993). Many religions have teachings about the continuation of life after death and many people also have a strong desire for life to continue after death, which has been shown to be associated with increased belief in a variety of forms of afterlife (e.g., reincarnation, continuation of the soul; Thalbourne, 1996). Therefore, belief in life after death related paranormal phenomena may occur for different reasons than for most other types of paranormal belief that are less related to traditional religious beliefs and/or desire for an afterlife.

A second key finding from the current experiments was the support for the relationship between anomalistic belief and performance on the conjunction fallacy task. The results were similar to those found by Rogers et al. (2009; 2011; 2016), Brotherton and French (2014), and Dagnall, Drinkwater et al. (2016), who found that people with higher levels of anomalistic belief were especially prone to making conjunction fallacy errors. However, the ABS allowed for a more nuanced examination of the relationship. This more fine-grained analysis found that all factors of the ABS were positively correlated with the number of conjunction fallacy errors made, but only experiential beliefs were a significant predictor when all four factors were entered together into a regression. One potential explanation for this relationship is that underlying tendencies to rely on heuristic/intuitive thinking (French & Stone, 2014; Irwin, 2009) and a poor understanding of probability (Dagnall, Denovan, Drinkwater, Parker, & Clough, 2016; Dagnall, Drinkwater et al., 2016) leads people to have both an increased likelihood of committing the conjunction fallacy and to attributing anomalistic causes to phenomena they or an acquaintance have experienced.

Previous work has highlighted that there are important distinctions between having an experience that seems anomalistic and interpreting events as having an anomalistic cause

(Irwin, Dagnall, & Drinkwater, 2013). For example, you may occasionally see something strange out of the corner of your eye, but there is an important difference between having this experience without attributing it to an anomalistic cause, and having the same experience and concluding that what you saw was a ghost. If the relationship between propensity to commit the conjunction fallacy and anomalistic belief does exist because of the way in which people interpret experiences then this may explain why the same relationship was not found for theoretical beliefs in anomalistic phenomena. Unlike experiential belief, theoretical belief in anomalistic phenomena does not necessarily involve a person interpreting a specific experience as anomalistic. Instead, theoretical believe can involve a more distant appraisal of how plausible one thinks the phenomena is and/or reaching a conclusion based on an analysis of the evidence for and against the existence of the phenomena. Although coming to a theoretical position on anomalistic phenomena may also be influenced by heuristics and reasoning errors, the heuristics and reasoning errors that lead to the conjunction fallacy may play less of a role in the development of theoretical beliefs than they do for beliefs about specific anomalous experiences.

The finding that only the experiential factor significantly predicted conjunction fallacy errors may also be important for explaining the variation in results that has been found between studies. Participants who score highly on anomalistic belief due to high levels of theoretical belief may not show the same patterns as participants who also scored highly due to experiential belief. Further evidence for this argument comes from Rogers et al.'s (2009) study that used both an overall ASGS score and several separate questions about paranormal experiences. Their findings support the idea that experiential anomalistic beliefs are positively related to the number of conjunction fallacy errors made, however they did not specifically examine whether claims of paranormal experience were more strongly associated with the conjunction fallacy than theoretical beliefs. Because most studies rely on an overall

averaged score of anomalistic belief (such as on the ASGS or R-PBS) it is not possible to tease apart whether participants are high on just theoretical belief versus experiential belief. Therefore, variation in the type of belief that is leading to a high score on the anomalistic belief measure, both between participants and also between studies, may lead to different results.

Overall, the results of this study suggest that there is a relationship between anomalistic belief and propensity to commit the conjunction fallacy. The data also support the creation of the ABS and suggest that the use of factors, rather than just an overall averaged score, can provide a more nuanced understanding of the relationship between anomalistic belief and reasoning. Further, the findings expand upon recent work that has shown that understanding the relationship between anomalistic belief and reasoning can be improved if anomalistic belief is measured and analysed at a more detailed level rather than using an overall averaged score (Dagnall, Drinkwater et al., 2016; Irwin, Drinkwater, & Dagnall, 2014; Rogers et al. 2016). Future research should build on the findings of the current study, and other recent studies in the area, by analysing anomalistic belief at a more fine-grain level. Taking this new, more nuanced approach will allow us to gain a better understanding by helping to triangulate the mechanisms and key influences that lead to the relationships found between anomalistic belief and various behavioural measures.

Footnotes

[1] Because the study was conducted online and we could not observe participants, we applied a lower-bound cut off of 15 minutes and an upper-bound cut off of one hour. The lower-bound was decided based on how long it would take to click through the survey without doing any reading, whereas the upper-bound was chosen because it gave participants enough time to complete the study at even a very leisurely pace and enter their completion code into the MicroWorkers/CrowdFlower web site. Average time to complete was slightly less than 30 minutes (before participants removed, M = 29:34, SD = 22:24; after participants removed for timing, M = 26:45, SD = 08:04).

[2] Using the ASGS and ABS scales, and particularly the factors of the ABS, provided a more detailed and nuanced understanding of the relationship between anomalistic belief and performance on the conjunction fallacy task, thus the blunt overall paranormal and extra-terrestrial questions are not discussed further in the Results or Discussion. However, as can be seen in Table 2.4, in Experiment 1A the overall measure of paranormal belief was positively correlated with both the number of single-CF errors made, r (247) = .17, p = .01, and the number of both-CF errors made, r (247) = .19, p = .003. The same pattern was found in Experiment 1B; single-CF errors, r (178) = .29, p < .001, and both-CF errors, r (178) = .22, p = .003. The overall measure of extra-terrestrial belief was not significantly correlated with the number of either single-CF or both-CF errors made in either experiment, all rs ≤ .11, ps ≥ .15.

[3] The pilot study was similar to Experiment 1A except that it included fewer SJQ items and did not include the overall measure of paranormal belief and extraterrestrial belief, or education and religiosity measures. Additionally, nine participants who were excluded from the Experiment 1A analyses were included in the ABS scale analyses because, although

they missed some items on the religiosity and/or education measures, they completed all sections related to the ABS.

[4] We thank the reviewer for pointing out the importance of including K-S statistics to show normality. Normality assumptions were violated for several of the scales. Inspection of the histograms revealed one outlier for the both-CF measure in Experiment 1A and issues with skew for the experiential factor. All other measures were appropriate for parametric analyses. Analyses were run with the outlier removed and the experiential factor transformed, but these changes did not substantially change the results of any analyses or any of the interpretations made. Specifically, when the experiential factor was transformed the slight change in strength of correlations meant that statistics education was no longer positively correlated with the experiential factor in Experiment 1A, and in Experiment 1B the negative correlation between general education and the experiential factor was now significant. However, for simplicity of interpretation, and because these differences did not impact the analyses of interest or main conclusions of the article, the analyses are reported for all participants and the untransformed experiential factor.

Chapter 3: The Relationship Between Anomalistic Belief, Misperception of Chance, and the Base Rate Fallacy

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The study materials for this chapter can be found in Appendices A and C.

Abstract

A poor understanding of probability may lead people to misinterpret every day coincidences and form anomalistic (e.g., paranormal) beliefs. We investigated the relationship between anomalistic belief (including type of belief) and misperception of chance and the base rate fallacy across both anomalistic and control (i.e., neutral) contexts. Greater anomalistic belief was associated with poorer performance for both types of items; however there were no significant interactions between belief and context. For misperception of chance items only experiential (vs. theoretical) anomalistic beliefs predicted more errors. In contrast, overall anomalistic belief was positively related to the base rate fallacy but no specific subtype of anomalistic belief was a significant predictor. The results indicate misperception of chance may lead people to interpret coincidental events as having an anomalistic cause, and a poor understanding of base rates may make people more prone to forming anomalistic beliefs.

Keywords: Anomalistic belief; paranormal belief; probabilistic reasoning; misperception of chance; base rate fallacy

The Relationship Between Anomalistic Belief, Misperception of Chance, and the Base Rate Fallacy

Anomalistic beliefs relate to non-evidence based phenomena that contradict our current scientific understanding of reality, such as telekinesis, extra-terrestrial visitation, some conspiracy theory beliefs, and some alternative medicine beliefs (Brotherton & French, 2014; Drinkwater, Dagnall, & Parker, 2012; French, 2001; French & Stone, 2014). These beliefs tend to be widely held, with the majority of the population believing in at least one type of anomalistic phenomena (Chapman University, 2017; Moore, 2005; Shannon-Missal, 2013). One growing field of research centres around understanding the link between anomalistic belief and probability reasoning errors, with much of the work showing that stronger belief in anomalistic phenomena is related to more reasoning errors (e.g., Dagnall, Drinkwater, Denovan, Parker, & Rowley, 2016; Rogers, Fisk, & Lowrie, 2016; van Prooijen, Douglas, & De Inocencio, 2018; Wiseman & Watt, 2006). The current study focused on the relationship between anomalistic belief and two different types of probabilistic reasoning tasks; misperception of chance and the base rate fallacy. Misperception of chance (also sometimes referred to as the perception of randomness) refers to how well people understand and perceive chance (Bar-Hillel & Wagenaar, 1991). The base rate fallacy is an error that occurs when people ignore information about the base rate of something (e.g., percentage of the population who contract a disease) even when that information is highly relevant and should be considered (Fischoff & Bar-Hillel, 1984; Kahneman & Tversky, 1973). We investigated whether these two reasoning errors were related to anomalistic belief, and whether any relationship was due to general anomalistic belief or was specific to a particular type of belief.

It is important to focus on probabilistic reasoning because it may help to explain how anomalistic beliefs are formed (Blackmore & Troscianko, 1985; Brugger, Landis, & Regard,

1990). Specifically, several studies have established that higher anomalistic belief is associated with poorer probabilistic reasoning in areas such as judging and producing randomness, and responding to changes in sample size (Blackmore & Troscianko, 1985; Brugger et al., 1990; Dagnall, Parker, & Munley, 2007). Based on these findings, one proposed explanation for the formation of anomalistic beliefs is that people attribute anomalistic explanations to chance occurrences and this leads them to develop anomalistic beliefs. For example, if people have a poor understanding of how likely two events are to occur by coincidence, they may assume that a purely coincidental occurrence has an anomalistic cause. However, a solid understanding of probabilistic reasoning would allow them to realise that coincidences, even if unlikely, can occur purely by chance and do not require an anomalistic explanation.

Misperception of chance may be an important contributor to the formation of anomalistic beliefs because we are prone to finding patterns and are quick to notice coincidences that seem unlikely (Alloy & Tabachnik, 1984; Griffiths & Tenenbaum, 2007; Griffiths & Tenenbaum, 2009). This process of finding patterns is crucial because it allows us to gain insights into the world around us (Griffiths & Tenenbaum, 2009), however, there also is potential for this process to lead to the attribution of meaningful (or paranormal) interpretations to random patterns or coincidences (Blackmore & Troscianko, 1985; Brugger et al., 1990; Kareev, 1995). A common way that people misperceive chance is by expecting something that is random overall (e.g., flipping an unbiased coin) to also show random patterns when a small sequence is selected (Kahneman & Tversky, 1972; Tversky & Kahneman, 1974). For example, even though an unbiased coin has a 50/50 chance of coming up heads or tails when flipped, a small sequence of flips will not necessarily have an equal number of heads and tails. People also prefer sequences of coin flips that alternate more frequently than would be statistically expected (Lopes & Oden, 1987; Wagenaar, 1970).

One way to demonstrate how these biases can influence perception of chance in the coin flip example is to ask people which of the following two sequences is more likely; that an unbiased coin flipped five times in a row will produce the pattern of five heads in a row or the pattern heads, tails, tails, heads, tails? Many people think that the second pattern is more likely because it seems more representative of the 50/50 probability of the coin, and it also is more representative of the random patterns that we are used to seeing when flipping a coin. However, in this case these cognitive biases will lead to a misperception of chance because both patterns make five predictions in a row, and given that heads and tails are equally likely to occur when flipping an unbiased coin, both patterns are equally likely (i.e., probability of each pattern is 3.125%).

The base rate fallacy is another well-established judgement and decision-making error (Fischoff & Bar-Hillel, 1984; Kahneman & Tversky, 1973) that may contribute to anomalistic beliefs. People demonstrate the base rate fallacy when they do not consider background information that is important and relevant to a task, and instead focus on the available descriptive information. A common example of the base rate fallacy is the cabs problem, where people are told that 85% of the cabs in a city are blue and 15% are green. They also are told that there was a hit and run accident at night and that a witness, who has been shown to be able to correctly identify the colour of the cab at night 80% of the time, identified the cab as being green. People are then asked how likely it is that the cab is green, and many report an 80% likelihood. However, this conclusion is incorrect because it does not consider the base rate of the two colours of cabs within the city (Bar-Hillel, 1980; Kahneman & Tversky, 1973). Specifically, to work out the correct probability of the cab being green it is important to consider both the individual descriptive information about the witness's accuracy and the base rate of green cabs. Based on both, the correct probability of the cab being green is 41% because, even though the witness is 80% accurate and identified the cab as green, the witness

is still wrong 20% of the time; thus, due to the low base rate of green cabs (15%), it is more likely that the cab was blue than green.

Blackmore and Troscianko (1985) and Brugger et al. (1990) also have proposed that a poor understanding of probability may contribute to anomalistic belief. Blackmore and Troscianko found that people who were higher in anomalistic belief performed worse when responding to changes in sample size, were less accurate when answering questions about sampling, were less accurate in their estimate of chance performance, and were more likely to believe they exerted control when performing a random task. On the basis of these findings, they argued that a poor understanding of probability and chance (as well as illusions of control) may lead to the formation or strengthening of anomalistic beliefs. Further, Brugger et al. (1990) found that higher levels of anomalistic belief were consistently associated with greater repetition avoidance when both generating sequences and when assessing the randomness of a sequence. Thus, they proposed that this poorer understanding of randomness and probability may lead people to assume that everyday coincidences must have a causal explanation rather than being the result of chance.

Dagnall and colleagues also have investigated the relationship between anomalistic belief and a variety of probabilistic reasoning measures, including the misperception of chance and base rate fallacy (Dagnall, Drinkwater, Parker, & Rowley, 2014; Dagnall et al., 2016; Dagnall et al., 2007). Across these studies there has been a robust relationship between higher anomalistic belief and higher misperception of chance; however, the findings for other forms of probabilistic reasoning, such as the base rate fallacy, have been mixed. For example, Dagnall et al. (2007) found no significant relationship between anomalistic belief and the base rate fallacy, however in a subsequent study Dagnall et al. (2014) showed that anomalistic belief was significantly negatively correlated with performance on a base rate task. In both studies, though, the strength of the correlations were similar (r = -.16 in the

earlier study; r = -.12 in the later study). However, there was a much smaller sample size in the earlier study (n = 96 in Dagnall et al. 2007 vs. n = 305 in Dagnall et al., 2014), and thus the later study had greater power to detect small effects. Thus, overall there is at least some evidence that both misperception of chance and the base rate fallacy are associated with higher anomalistic belief.

Although there is support for an overall relationship between anomalistic belief and probabilistic reasoning, a growing area of research focuses on whether this relationship varies depending on the *type* of anomalistic belief held (Dagnall et al., 2016; Prike, Arnold, & Williamson, 2017; Prike, Arnold, & Williamson, 2018; Rogers et al., 2016). For example, Dagnall et al. (2016) used the Revised-Paranormal Belief Scale (Tobacyk, 2004) to show that, although both traditional paranormal beliefs and new age philosophy beliefs were related to poorer perception of chance, the relationship was stronger for traditional paranormal beliefs. One limitation of this finding, though, is that the scale contains items that only relate to theoretical anomalistic belief; that is, no items ask people about their experiences of anomalistic phenomena. Thus, one goal of the current study was to examine whether the relationships between anomalistic belief, misperception of chance, and base rates were stronger for experiential (vs. theoretical) anomalistic beliefs. We used the Anomalistic Belief Scale (ABS; Prike et al. 2017) because it contains items that cover both experiential (e.g., "I believe that I have had direct contact with an extra-terrestrial here on earth") and theoretical (e.g., "I believe extra-terrestrials have visited earth") beliefs, and factor analysis has revealed a separate factor for experiential anomalistic beliefs. Because one argument is that poorer probabilistic reasoning may lead people to assign an anomalistic cause to coincidences or chance events that they (or others) experience, the relationship between anomalistic belief and probabilistic reasoning should be strongest for anomalistic beliefs that relate to experiences.

We also investigated the role of context in the relationship between anomalistic belief and performance. That is, context was included as a within-subjects variable to explore whether people higher in anomalistic belief are even more prone to misperception of chance and the base rate fallacy when making judgments about anomalistic phenomena compared to the "non-anomalistic" phenomena that are usually used in probabilistic reasoning tasks. Context is important to consider because previous research has shown that reasoning is influenced by beliefs and motivations (Dawson, Gilovich, & Regan, 2002; Kahan, Peters, Dawson, & Slovic, 2017; Kunda, 1990; Stanovich, West, & Toplak, 2013). For example, Dawson et al. (2002) used a Wason selection task to show that people who were presented with a threatening proposition were much more likely to attempt to disconfirm the proposition than those who were presented with non-threatening propositions. This finding suggests that when motivated (i.e., by a threatening scenario) people applied higher levels of scrutiny and attempted to discredit the proposition, whereas when the proposition was not threatening they instead only looked for confirming evidence that supported the proposition. Evidence for a positive relationship between anomalistic belief and motivated reasoning comes from recent research showing that higher anomalistic belief is related to several evidence integration biases (Prike et al., 2018). Specifically, people higher in anomalistic belief were more willing to accept unlikely conclusions based on little evidence, demonstrating a liberal acceptance bias. Prike et al. also found that higher levels of anomalistic belief were associated with a decreased willingness either to adjust a position when presented with counter evidence or to accept an alternative conclusion that was supported by new evidence. Therefore, higher anomalistic belief may be related to reduced reasoning performance in general, but this reduction may be especially pronounced for reasoning tasks that are related to the anomalistic beliefs.

There is mixed evidence regarding whether people higher in anomalistic beliefs are more prone to probabilistic reasoning errors for an anomalistic context (Dagnall et al., 2014; Dagnall et al. 2016; Rogers, Davis, & Fisk, 2009; Rogers et al., 2016; Rogers, Fisk, & Wiltshire, 2011). Rogers et al. (2009) found that higher anomalistic belief was associated with making more conjunction fallacy errors but that both anomalistic believers and non-believers made fewer conjunction fallacy errors when scenarios were presented in an anomalistic context. However, in follow up studies, Rogers et al. (2011; 2016) did not find this main effect of context. Similar to Rogers et al. (2009), Dagnall et al. (2014; 2016) found fewer conjunction fallacy errors on problems framed in an anomalistic context. Dagnall et al. (2014; 2016) also found that the size of the correlation between anomalistic belief and the conjunction fallacy was significantly larger for problems presented in an anomalistic (vs. general) context.[1] Of particular relevance for the current study, Dagnall et al. (2016) investigated the role of context in the relationship between anomalistic belief and misperception of chance by framing half of the trials in an anomalistic context and half in a control context. For both the overall scale of the Revised-Paranormal Belief measure and its Traditional Paranormal Belief and New Age Philosophy factors, participants higher in anomalistic belief were more prone to misperception of chance. However, correlations between belief and misperception of chance were significantly stronger in the anomalistic context for the overall scale and the New Age Philosophy factor.[2] Thus, with all of the results taken together, it is important to investigate whether this impact of context on the relationship between misperception of chance and anomalistic belief replicates and extends to the base rate fallacy.

Beyond context, we also investigated the potential relationship between gambling attitudes, anomalistic belief, and probabilistic reasoning. Because gambling involves games of chance it is possible that people who hold positive views of gambling are more prone to

misconceptions about probabilistic reasoning. A number of studies have shown that gamblers are more prone to several probabilistic reasoning errors, such as the aptly named gamblers fallacy, hot hand, and finding illusory patterns (Croson & Sundali, 2005; Fortune & Goodie, 2012; Gaissmaier, Wilke, Scheibehenne, McCanney, & Barrett, 2016; Goodie & Fortune, 2013; Wilke, Scheibehenne, Gaissmaier, McCanney, & Barrett, 2014; Xu & Harvey, 2014; Yakovenko et al. 2016). Therefore, a more positive attitude towards gambling also may be associated with the misperception of chance and base rate fallacy tasks used in the current study.

Gambling also was of interest because several beliefs held by gamblers are superstitious (or otherwise non-evidence based) and thus gambling attitudes may have some overlap with anomalistic beliefs (Joukhador, Blaszczynski, & Maccallum, 2004; McInnes, Hodges, & Holub, 2014; Passanisi, Craparo, & Pace, 2017). For example, many gamblers hold beliefs about luck, the superstitious nature of certain items, or the ability of their gut/intuition to make correct predictions. These gambling beliefs could be considered anomalistic in nature, particularly gambling beliefs that are related to predicting or influencing outcomes. To the best of our knowledge, only Morris and Griffiths (2013) have looked at the relationship between anomalistic belief and gambling. They used a convenience sample of gamblers and found that attitude towards gambling was positively correlated with anomalistic belief. We aimed to build on this previous research by examining the relationship between anomalistic belief, gambling, and probabilistic reasoning in the general population.

Overview of the Study

Anomalistic belief was measured with both the Australian Sheep-Goat Scale (ASGS: Thalbourne & Delin, 1993) and the recently developed ABS (Prike et al., 2017). The ASGS is widely used within the literature, which allows the findings of the current study to be easily compared with previous research. The ABS also was used because it covers a wider range of

anomalistic beliefs than the ASGS, and because the factors of the ABS enable us to investigate whether the relationships between belief and the other variables depends on whether the anomalistic belief is experiential or theoretical. Attitudes toward gambling were collected using the Gambling Attitudes Scale (GAS; Kassinove, 1998), which provides both an overall measure of gambling attitudes and specific attitudes toward casino, horse race, and lottery gambling. Participants also completed two types of probabilistic reasoning problems: misperception of chance and base rate fallacy. The reasoning problems were manipulated within-subject so that all participants received trials in both anomalistic and control contexts to test whether the relationship between higher anomalistic beliefs and poorer reasoning performance was stronger for the anomalistic context.

Method

Participants

One hundred and ninety-nine participants (60.1% female; 76.4% Caucasian) completed the study via the crowdsourcing website CrowdFlower and were reimbursed $1.75 for their participation. Twenty-one participants were removed prior to analyses because they had not completed the study properly and/or failed to follow all instructions (e.g., did not complete the study in a reasonable time frame by taking less than 10 minutes or longer than 60 minutes).[3]

Design

The study had a within-subjects factor of context of the problem (control, anomalistic). The key predictors of interest were: (1) overall anomalistic belief, measured using the ASGS and ABS, (2) level of belief in the factors of the ABS, and (3) gambling attitudes, measured using the GAS. The key dependent variables in the study were proportion correct for misperception of chance problems and proportion correct for base rate fallacy

problems. Level of education (general, psychology, mathematics, and statistics) was included to control for the potential effect of education.

Materials

Anomalistic belief was measured using three measures; the ABS, ASGS, and two overall questions. The ABS is a 40-item scale that measures a variety of anomalistic beliefs (Prike et al., 2017). Factor analysis of the ABS has revealed four factors; an experiential factor (14 items), a theoretical paranormal belief factor (PSI factor; 13 items), a theoretical extra-terrestrial belief factor (ET factor; 8 items), and a factor that covers both theoretical and experiential life after death beliefs (LAD factor; 5 items). The experiential factor is related to the experience of anomalistic phenomena and contains items related to belief in both PSI and extra-terrestrial experiences. The other three factors are composed of items related to theoretical belief in three distinct areas, paranormal belief, extra-terrestrial belief, and belief in life after death. The ASGS is a psychometrically valid 18-item scale that measures paranormal belief in the areas of extra-sensory perception, psychokinesis, and life after death (Thalbourne & Delin, 1993). Both the ASGS and the ABS are measured on a 7-point scale (from 1 = “strongly disagree” to 7 = “strongly agree”). Scores on the ASGS and ABS were computed by averaging the items that make up that scale (or factor). Anomalistic belief also was measured using the two overall questions of “Overall, how would you rate your level of belief in what is commonly referred to as the "paranormal" or "psi" (e.g., psychics, spirits, telekinesis, crystals, etc.)?” and “Overall, how would you rate your level of belief in extra-terrestrials (e.g., that extra-terrestrials have visited earth, UFOs have been seen in the sky, etc.)”. Participants responded to the overall questions on a scale from 1 to 100.[3]

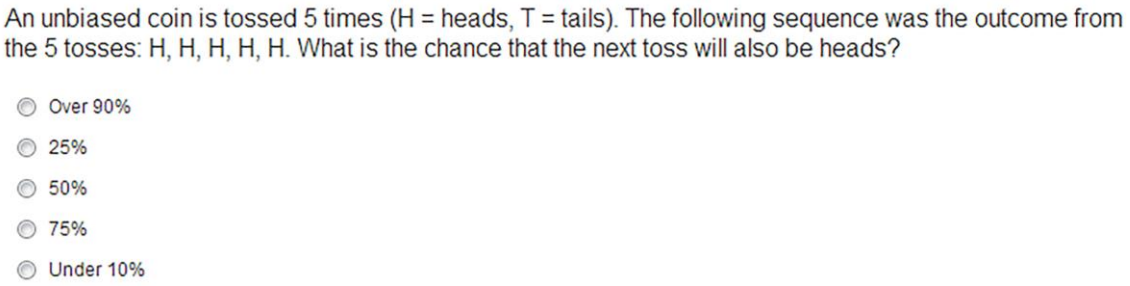
Gambling attitudes were measured using a modified version of the GAS (Kassinove, 1998). The original GAS includes 59 items, with some items also measuring risk-taking and liberal-conservative leaning. However, for the purposes of our study we only included the 36

items that related to gambling. The GAS has four gambling related subscales; general gambling, casino gambling, horse race gambling, and lottery gambling, and these subscales can be combined to compute an overall gambling attitudes score. Participants respond to the GAS using a 6-point scale (from 1 = “strongly agree” to 6 = “strongly disagree”).

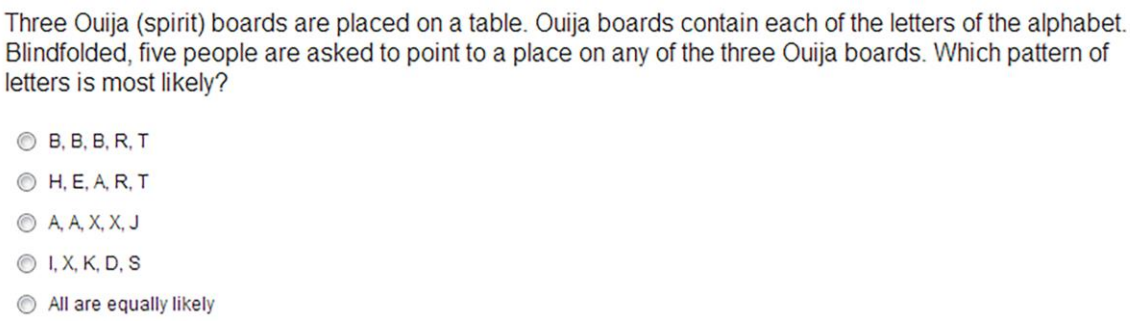
Misperception of chance and propensity to commit the base rate fallacy were each measured with 10 control (i.e., neutral) and 10 anomalistic items, for a total of 40 trials (see Figure 3.1 for examples). For ease of interpretation, scores for the probabilistic reasoning items were converted to proportion correct. The misperception of chance problems required participants either to estimate the likelihood of the next item in a pattern occurring (e.g., the chance that the toss of an unbiased coin will result in heads if it has come up heads 5 times in a row) or to assess how likely several patterns were (e.g., 5 cards are drawn from a deck of playing cards, which combination of cards is most likely). The base rate fallacy problems required participants to read representative descriptions of an outcome that had a low base rate (either explicitly stated or implied) and they were required to choose between a representative statement that ignored the base rate information and a statement that accurately represented the base rate but was less representative. The misperception of chance and base rate fallacy problems were presented in two randomised orders, with the restriction that no more than two of the same problem type (misperception of chance or base rate fallacy) and no more than two of the same context (anomalistic or control) were presented in a row. Participants were randomly assigned to one of these two orders.

Several additional measures were also collected, including basic demographic information about age, ethnicity, and gender. Previous research has suggested that education may be related to both anomalistic belief (Aarnio & Lindeman, 2005; Schulter & Papousek, 2008) and probabilistic reasoning (Hertwig, Zangerl, Biedert, & Margraf, 2008; Siegrist & Keller, 2011). Therefore, to control for potential effects of education participants were asked

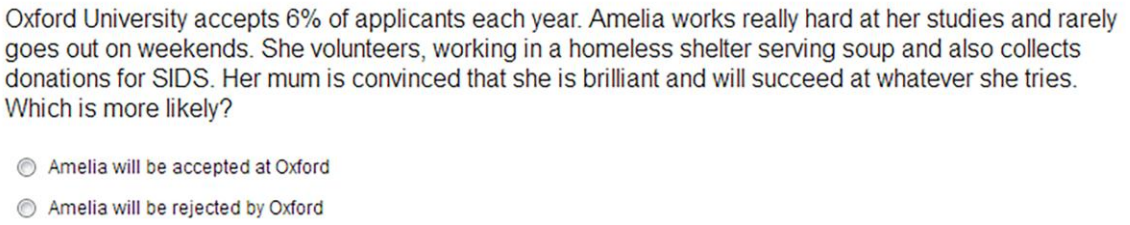
3.1A



3.1B



3.1C



3.1D

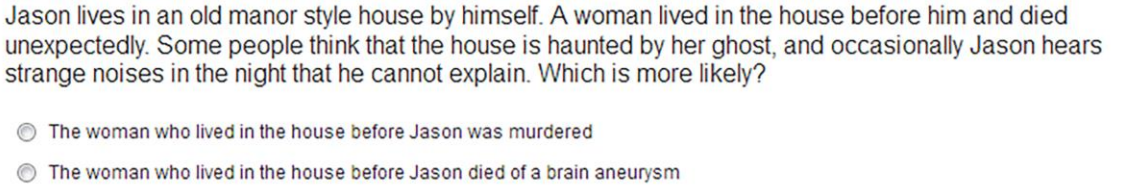


Figure 3.1. Examples of trials for misperception of chance control context (3.1A), misperception of chance anomalistic context (3.1B), base rate fallacy control context (3.1C), and base rate fallacy anomalistic context (3.1D)

about their overall level of education, as well as their level of education in the specific domains of psychology, mathematics, and statistics. For each education question they chose from 6 options; less than high school, high school, some education above high school, undergraduate degree, professional/postgraduate degree, or other (Brotherton & French, 2014; Rogers et al., 2011). When participants selected 'other' they were able to type in a response and these responses were then re-categorised under one of the other five options.

Procedure

The experiment was conducted online using Qualtrics software (Qualtrics, Provo, UT). Participants first read through an introduction, information sheet, and consent form. They then completed the misperception of chance and base rate fallacy problems in one of two randomised orders. Participants were instructed to read each scenario and its answer options, and then choose the answer they thought was correct. After completing the reasoning problems participants then completed the anomalistic belief measures and the GAS. For these measures participants were told that there were no right or wrong answers and to select the option that best represented what they think. Participants completed one of the two anomalistic belief measures first (either the ASGS or the ABS), then the GAS, and then they answered whichever anomalistic measure they had not yet completed (e.g., if they completed the ABS first they then completed the ASGS). Finally, participants answered the two overall anomalistic belief questions before completing the demographic and education questions.

Results

Traditional multiple regression analyses for the misperception of chance and the base rate fallacy problems were not possible because context of the problems (i.e., control vs. anomalistic) is a within-subjects variable. However, Ruscher (n.d.) outlined a suitable repeated-measures multiple regression that can be run using a general linear model repeated-measures ANCOVA and accommodates the continuous variables by entering them as covariates to retrieve the

multiple regression parameter estimates. Therefore, the probabilistic reasoning tasks were analysed using a repeated-measures ANCOVA, with context as the within-subjects variable and anomalistic belief and gambling attitudes entered as covariates. In situations where there were no significant interactions between context and any of the key predictors, multiple regression analysis was used to obtain parameter estimates for probabilistic reasoning averaged across context (see Tables 3.3 and 3.4). Neither overall gambling nor attitude towards specific types of gambling were significantly correlated with performance on either of the probabilistic reasoning tasks. However, because we made specific predictions about the relationship between gambling attitudes, anomalistic belief, and probabilistic reasoning, overall gambling was entered as a predictor in all regressions. Additionally, to control for potential effects of education and/or order (survey or counterbalance) these variables were entered into the regression whenever they were significantly related to performance on the probabilistic reasoning task (see Table 3.2).

Traditional null hypotheses significance tests are reported here, however, Bayes factors were also calculated (as recommended by Wagenmakers, 2007) using JASP with default priors (JASP Team, 2017, Version 0.8.1.1) and are reported for all main analyses. All Bayes factors are reported using the form BF_{10}, which provides the odds ratio of the alternative/null hypotheses given the data (i.e., a value of 1 indicates the data support the alternative and null equally, values larger than 1 indicate support for the alternative, and values smaller than 1 indicate support for the null). All anomalistic belief scales, the GAS, and the education measures were coded so that larger values indicate a higher level of belief, attitude, or education, respectively. Further, misperception of chance and base rate fallacy items were analysed using the proportion correct and therefore higher values indicate better performance. Descriptive statistics for all scales are reported in Table 3.1.

Correlations Between the Scales

Strong positive correlations were found between the overall anomalistic belief measures (see Table 3.2). Additionally, the factors of the ABS were highly positively correlated with each other and with the overall anomalistic belief scales. The strength of these correlations were in line with what would be expected based on the composition of the scale, and with what has been found in previous studies (Prike et al., 2017; 2018a). For example, the PSI factor of the ABS had the strongest positive correlation with the ASGS, which would be expected because the ASGS is only a measure of paranormal beliefs and the PSI factor is also comprised of items about paranormal belief. There also were positive correlations between gambling attitudes and anomalistic belief: Participants who were higher in anomalistic belief were also more likely overall to have more positive attitudes toward gambling. Further, positive correlations were found between nearly all of the subtypes of gambling attitude and anomalistic belief except there were no significant correlations between the experiential factor and attitudes towards casino and lottery gambling, or between the ET factor and lottery gambling.

There also were several positive correlations between anomalistic belief and education: (1) general education was positively correlated with the experiential factor, (2) psychology education correlated positively with the overall ABS and the experiential factor, (3) mathematics education was positively correlated with the overall ASGS, overall ABS, the experiential factor, and the PSI factor, and (4) statistics education was correlated positively with the overall ASGS, overall ABS, and the experiential factor. Neither the ET factor nor the life after death factor were correlated with any of the education measures. There also were significant negative correlations between attitudes towards lottery gambling and both general education and mathematics education. There were no other significant relationships between gambling and education.

Table 3.1.

Mean scores for all scales.

Scales	Mean	SD	Min.	Max.	α
1. ASGS	2.70	1.33	1.00	6.56	.95
2. ABS	2.59	1.30	1.00	6.00	.98
3. Experiential Factor	1.78	1.17	1.00	5.93	.96
4. PSI Factor	2.82	1.59	1.00	6.92	.96
5. ET Factor	3.22	1.86	1.00	7.00	.96
6. Life After Death Factor	3.28	1.85	1.00	7.00	.91
7. Gambling	3.59	1.00	1.39	6.00	.97
8. General Education	3.60	0.98	1.00	5.00	n/a
9. Psychology Education	2.20	1.12	1.00	5.00	n/a
10. Mathematics Education	2.74	0.94	1.00	5.00	n/a
11. Statistics Education	2.36	1.03	1.00	5.00	n/a

Note: n = 178

Table 3.2.

Correlations for Base Rate, Misperception of Chance, and all scales

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Reasoning Tasks																				
1. Base Rate – Control																				
2. Base Rate –Anomalistic	.59***																			
3. Chance – Control	.26***	.30***																		
4. Chance – Anomalistic	.26***	.41***	.84***																	
Anomalistic Belief																				
5. ASGS	-.15	-.20***	-.24**	-.27***																
6. ABS	-.19*	-.22***	-.30***	-.32***	.91***															
ABS Factors																				
7. Experiential	-.13	-.23***	-.41***	-.44***	.74***	.83***														
8. PSI	-.14	-.18*	-.20**	-.22**	.92***	.93***	.66***													
9. ET	-.21**	-.17*	-.20**	-.20**	.60***	.79***	.53***	.63***												
10. LAD	-.17*	-.16*	-.21**	-.20**	.78***	.81***	.55***	.78***	.52***											

(continued)

Table 3.2.

Correlations for Base Rate, Misperception of Chance, and all scales

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Gambling Attitudes																				
11. Overall Gambling	.04	-.05	-.05	-.07	.26***	.28***	.15*	.27***	.22***	.33***										
12. General	.05	-.02	-.11	-.12	.26***	.29***	.16*	.27***	.24***	.33***	.95***									
13. Casino	.02	-.01	.00	-.02	.22**	.22**	.04	.25***	.19*	.30***	.94***	.92***								
14. Horses	.03	-.09	-.13	-.12	.23**	.28***	.31***	.22**	.20***	.21**	.78***	.67***	.59***							
15. Lottery	.02	-.06	.05	.02	.19**	.20**	.03	.23**	.14	.33***	.87***	.78***	.81***	.50***						
Education																				
16. General	.17*	.06	-.00	-.01	.09	.12	.23**	.07	.09	-.05	-.08	-.06	-.12	.06	-.16*					
17. Psychology	.12	-.07	-.27***	-.17*	.14	.16*	.24**	.13	.06	.09	.01	-.01	-.04	.09	-.01	.31***				
18. Mathematics	.07	-.05	-.21**	-.21**	.16*	.20**	.28***	.16*	.13	.05	-.09	-.08	-.13	.04	-.16*	.51***	.42***			
19. Statistics	.13	.06	-.22**	-.17*	.16*	.16*	.24**	.13	.07	.08	-.07	-.05	-.10	.05	-.15	.51***	.46***	.67***		
Order																				
20. Survey	.02	.05	.03	-.00	-.15*	.02	-.00	-.01	.09	-.03	-.03	-.02	-.03	-.04	-.03	.17*	.02	.05	.10	
21. Counterbalance	-.10	-.07	-.00	-.03	-.04	-.03	.03	-.08	-.01	-.02	-.01	-.05	-.03	.06	-.02	-.03	.04	.10	.10	.06

*Correlation is significant at the level $p < .05$, **Correlation is significant at the level $p < .01$, ***Correlation is significant at the level $p < .001$.

Misperception of Chance

The relationship between anomalistic belief, overall gambling attitude, and misperception of chance was analysed first using separate analyses for the overall ASGS and ABS scales, and then using the ABS factors (see Table 3.3). In all analyses there was a main effect of context, range Fs (1, 169 – 172) [5] = 48.51 – 48.92, all MSEs = .01, all ps ≤ .001, all η_p^2 = .22, range BF_{10} = 78910000 – 80690000, with the proportion of correct responses higher in the control context (M = 0.68, SD = 0.25) than in the anomalistic context (M = 0.61, SD = 0.22). For the overall ASGS there also was a significant main effect of anomalistic belief, β = -.22, 95% CI [-.37, -.07], with higher anomalistic belief leading to a lower proportion of correct responses. The same pattern was found for the overall ABS scale, with higher anomalistic belief associated with a lower proportion of correct responses, β = -.28, 95% CI [-.43, -.13]. However, in both the overall ASGS and ABS regressions there was no main effect of overall gambling attitude, range β = -.02 - .01. Further, in both regressions neither overall gambling attitude nor anomalistic belief significantly interacted with context, Fs (1, 172) ≤ 0.10, all MSEs = .01, all ps ≥ .75, all η_p^2 ≤ .001, range BF_{10} = 0.07 – 0.14.

The relationship between anomalistic belief and misperception of chance was also analysed at a more fine-grained level by using the four ABS factors. This analysis found that only the experiential factor was a significant negative predictor of the proportion of items correct, β = -.47, 95% CI [-.66, -.28]. Again, there was no significant effect of overall gambling attitude, β = -.02, 95% CI [-.16, .12], and no significant interactions between context and overall gambling attitude or any of the factors, Fs (1, 169) ≤ 0.83, all MSEs = .01, all ps ≥ .36, all η_p^2 ≤ .005, range BF_{10} = 0.06 – 0.15.

Table 3.3.

Regressions Predicting Proportion Correct for Misperception of Chance using Anomalistic Belief (i.e., ASGS, ABS Total, or ABS Factors)

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1 (All Models)				.004	4.49	4.56	.07	.06			
Psychology	-.16	[-.32, .01]	-1.89	.06	1.33						
Mathematics	-.11	[-.31, .09]	-1.11	.27	0.45						
Statistics	-.06	[-.26, .14]	-0.59	.56	0.30						
Step 2 ASGS Model				< .001	27.61	4.78	.12	.10	4.80	.05	.009
Psychology	-.14	[-.30, .02]	-1.73	.09	1.16						
Mathematics	-.09	[-.29, .10]	-0.96	.34	0.46						
Statistics	-.04	[-.24, .15]	-0.44	.66	0.33						
Overall Gambling	-.02	[-.16, .13]	-0.21	.83	0.31						
ASGS	-.22	[-.37, -.07]	-2.91	.004	12.89						
Step 2 ABS Model				< .001	300.96	6.00	.15	.12	7.64	.08	<.001
Psychology	-.13	[-.29, .03]	-1.65	.10	0.99						
Mathematics	-.07	[-.26 .12]	-0.73	.47	0.36						

(continued)

Table 3.3.

Regressions Predicting Proportion Correct for Misperception of Chance using Anomalistic Belief (i.e., ASGS, ABS Total, or ABS Factors)

Variables	*β*	*β CI 95%*	*t*	*P*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Statistics	-.05	[-.25, .14]	-0.52	.60	0.32						
Overall Gambling	.01	[-.14, .16]	0.11	.91	0.29						
ABS	-.28	[-.43, -.13]	-3.76	<.001	140.51						
Step 2 ABS Factors Model				< .001	18464.60	6.27	.23	.19	6.84	.16	< .001
Psychology	-.10	[-.25, .06]	-1.25	.21	0.63						
Mathematics	-.05	[-.24 .14]	-0.52	.60	0.36						
Statistics	-.03	[-.22, .15]	-0.35	.73	0.33						
Overall Gambling	-.02	[-.16, .12]	-0.25	.80	0.32						
Experiential	-.47	[-.66, -.28]	-4.93	<.001	7871.01						
PSI	.20	[-.05, .45]	1.55	.12	0.93						
ET	-.02	[-.20, .15]	-0.25	.80	0.32						
LAD	-.08	[-.30, .14]	-0.72	.47	0.40						

*change statistics represent change from Step 1.

B represents standardised regression coefficients

Base Rate Fallacy

The base rate fallacy also was analysed using a repeated-measures ANCOVA, with context as the within-subjects variable, and anomalistic belief and overall gambling attitude entered as the covariates (see Table 3.4). Separate analyses were first run for the overall ASGS and ABS scales, and then using the ABS factors. There was a main effect of context in all analyses, range *F*s (1, 171 – 174) = 43.54 – 44.17, all *MSE*s = .02, all *p*s ≤ .001, range η_p^2 = .20 – .21, range BF_{10} = 17210000 – 18530000. Unlike for misperception of chance, though, the main effect for the base rate fallacy items occurred because participants had a higher proportion of correct responses in the anomalistic context (*M* = 0.49, *SD* = 0.21) than in the control context (*M* = 0.40, *SD* = 0.19). For the ASGS there was a significant main effect of anomalistic belief, β = -.22, 95% CI [-.37, -.07], with higher belief leading to a lower proportion of correct responses. The same pattern was found for the overall ABS, with a negative relationship between level of anomalistic belief and proportion correct for the base rate fallacy items, β = -.27, 95% CI [-.42, -.12]. However, in both the ASGS and ABS regressions there was no main effect of overall gambling attitude, range β = .06 - .08, and neither anomalistic belief nor gambling attitude significantly interacted with context, *F*s (1, 174) ≤ 1.59, all *MSE*s = .02, all *p*s ≥ .21, all η_p^2 ≤ .009, range BF_{10} = 0.19 – 0.35.

The relationship between anomalistic belief and the base rate fallacy was also analysed using the ABS factors. This analysis found that, although the overall regression was significant, no individual ABS factor was a significant predictor of the proportion of correct responses. Further, there also was no main effect of gambling attitude, and no significant interactions between context and overall gambling attitude or any of the ABS factors, all *F*s (1, 171) ≤ 3.19, all *MSE*s = .02, all *p*s ≥ .08, all η_p^2 ≤ .02, range BF_{10} = 0.15 – 0.67.

Table 3.4.

Regressions Predicting Proportion Correct for Base Rate Fallacy using Anomalistic Belief (i.e., ASGS, ABS Total, or ABS Factors)

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1 (All Models)				.09	0.60	2.84	.02	.01			
General Education	.13	[-.02, .27]	1.68	.09	0.60						
Step 2 ASGS Model				.01	1.69	3.80	.06	.05	4.23	.05	.02
General Education	.15	[.00, .30]	2.02	.04	1.72						
Overall Gambling	.06	[-.09, -.21]	0.78	.44	0.35						
ASGS	-.22	[-.37, -.07]	-2.91	.004	11.91						
Step 2 ABS Model				.002	10.13	5.21	.08	.07	6.31	.07	.002
General Education	.16	[.02, .31]	2.23	.03	2.47						
Overall Gambling	.08	[-.07, .23]	1.04	.30	0.42						
ABS	-.27	[-.42, -.12]	-3.55	<.001	71.40						

(continued)

Table 3.4.

Regressions Predicting Proportion Correct for Base Rate Fallacy using Anomalistic Belief (i.e., ASGS, ABS Total, or ABS Factors)

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Step 2 ABS Factors Model				.01	0.80	2.92	.09	.06	2.91	.08	.02
General Education	.18	[.03, .33]	2.35	.02	3.81						
Overall Gambling	.07	[-.08, .22]	0.93	.36	0.51						
Experiential	-.18	[-.38, .02]	-1.76	.08	1.35						
PSI	.05	[-.23, .32]	0.34	.74	0.36						
ET	-.15	[-.33, .04]	-1.52	.13	0.96						
LAD	-.06	[-.30, .18]	-0.50	.62	0.39						

*change statistics represent change from Step 1.

β represents standardised regression coefficient

Discussion

Overall, the results of the study support the prediction that greater anomalistic belief is related to poorer probabilistic reasoning ability: Higher levels of belief were related to lower performance for both misperception of chance and the base rate fallacy. However, there were no interactions with context, suggesting that the relationship between anomalistic belief and probabilistic reasoning is general and is not amplified in an anomalistic context. Further, although higher overall anomalistic belief was related to more errors on the misperception of chance problems, the more fine-grained analysis showed that only higher levels of experiential anomalistic belief was related to this poorer performance. In contrast, though, no individual factor was a significant predictor for the base rate fallacy. Therefore, it appears that it is higher anomalistic belief in general (i.e., experiential and theoretical) that is related to a poorer understanding of base rates.

The finding that, regardless of context, higher anomalistic belief was associated with a poorer understanding of probabilistic reasoning supports the idea that differences in reasoning ability may contribute to the formation of anomalistic beliefs (Blackmore & Troscianko, 1985; Brugger et al., 1990). For example, misperception of chance or a poor understanding of base rates may lead people to assign an anomalistic explanation to experiences that occurred due to coincidence or chance. Additionally, this finding casts some doubt on the idea that people higher in anomalistic belief have poorer reasoning abilities because they are motivated to reason in a way that supports their belief. If people higher in anomalistic belief were simply engaging in motivated reasoning or wishful thinking, then differences in probabilistic reasoning ability should have been more pronounced for items in an anomalistic context. Our findings differ, though, from Dagnall et al. (2016) who found that anomalistic belief was more strongly related to performance on misperception of chance items presented in an anomalistic context. However, previous work on the role of context for the conjunction

fallacy also has produced mixed results (Dagnall et al., 2014; 2016; Rogers et al., 2009; 2011; 2016). Therefore, future work may need to explicitly manipulate the characteristics of probabilistic reasoning items, such as varying item difficulty, the specific anomalistic context used, or the level of detail provided in the descriptions, to establish whether these characteristics influence the strength of context effects. For example, context may only play a role if participants detect a conflict between the incorrect heuristic response and the correct systematic answer (i.e., people are aware of the two options and so choose the belief congruent option; Pennycook, Fugelsang, & Koehler, 2012). Stimuli difficulty may influence the likelihood of conflict detection because for stimuli that are too difficult or too easy then people may choose either the heuristic answer (too difficult) or the systematic answer (too easy) without detecting any conflict between the response options. It would also be useful to design a study to test the relationships between specific types of anomalistic belief and stimuli that are set in that specific context (e.g., belief in psychics and stimuli presented in the context of a psychic demonstration).

The positive relationship found between misperception of chance errors and experiential belief is consistent with previous work on the conjunction fallacy and biases in evidence integration, and thus provides further evidence that there may be an important difference between experiential and theoretical anomalistic beliefs. (Prike et al., 2017; 2018a). One way to understand this relationship is through consideration of what differentiates experiential from theoretical anomalistic beliefs. That is, experiential beliefs involve actively interpreting experiences as having an anomalistic cause; for example, judging something you see out of the corner of your eye as a ghost (vs. as a perceptual illusion). Thus, as mentioned in the Introduction, misperception of chance may play a particularly pronounced role in relation to experiential beliefs because many experiences that are assigned an anomalistic explanation are likely to be coincidences or strange experiences

(Hadlaczky & Westerlund, 2011; Ross, Hartig, & McKay, 2017). In contrast, theoretical anomalistic beliefs are less likely to involve evaluating whether a particular experience could have occurred by chance, and thus are less likely to be related to misperception of chance; that is, theoretical beliefs only need to involve the possibility that something potentially exists (or is true) in a general and/or abstract sense.

In contrast to misperception of chance, the propensity to commit the base rate fallacy was not related to any individual subset of anomalistic belief, which demonstrates that one particular type of belief (e.g., experiential) may not be uniquely related to performance for all probabilistic reasoning tasks. However, it is important to note that the average proportions correct on the base rate fallacy task were either below chance (control context) or at chance level (anomalistic context). Thus, consistent with previous research, participants were just as likely (or more likely for the control context) to choose the answer supported by the superficial representative statement than to use the statistical base rate information to guide their decision (Pennycook et al., 2012). This combination of overall poor performance and negative relationships between anomalistic belief and base rate fallacy accuracy suggests that participants with higher levels of anomalistic belief were more likely to rely on the superficial representative statement than the base rate information, whereas participants with lower levels of anomalistic belief were approximately equally likely to rely on either the representative information or the base rate. This pattern may help explain why no individual factor significantly increased the likelihood that participants would choose the representative rather than base rate response. That is, because participants had a high likelihood overall of choosing the representative option, there was a limited range to find an association between a specific subtype of anomalistic belief and more reliance on the representative rather than base rate information.

Although we found a context effect for both types of probabilistic reasoning items, the pattern differed between them. Errors for the base rate items were lower in the anomalistic (vs. control) context, and one potential explanation is that, regardless of level of anomalistic belief, participants recognised that anomalistic events are rare. Therefore, when the stimuli context was anomalistic, the superficial descriptive information was less likely to lead them to overlook the base rate information. In contrast, errors for the misperception of chance items were lower for the control (vs. anomalistic) stimuli, which may be due in part to familiarity. That is, previous research has shown that familiarity can influence performance on probabilistic reasoning tasks; for example, people perform better on tasks that contain familiar and concrete, rather than abstract content (Markovits, 1986; Markovits & Vachon, 1990; McKenzie, 2006). Participants in our study likely were more familiar with the control misperception of chance materials (e.g., with standard coins, decks of cards) than for the anomalistic items (e.g., tarot cards, Ouija board), which may have contributed to the increased probabilistic reasoning performance for the control context items. Although it could be argued that increased familiarity should also influence performance for the base rate fallacy task, the nature of the task makes it less conducive to familiarity effects. Specifically, base rate items do not require participants to engage in any calculation or consideration of probabilities that may have benefitted from increased familiarity.

It will be important for future research to more clearly establish whether probabilistic reasoning and cognitive biases cause some experiences to be interpreted as having an anomalistic cause. Although it is difficult to experimentally manipulate either anomalistic belief or reasoning ability, there are several avenues that may more closely link probabilistic reasoning and experiential anomalistic beliefs. For example, the anomalistic scenarios used in the current study (and in previous work) were generally quite abstract. That is, even items presented in anomalistic context were still basic probabilistic reasoning questions preceded

by a brief description and presented in a similar format to a math or exam question. Thus, future work should focus on developing more realistic and engrossing scenarios that present ambiguous events that either can be (incorrectly) interpreted as an anomalistic experience or (correctly) explained using probabilistic reasoning. This type of stimuli would more clearly show that not engaging in probabilistic reasoning can cause someone to interpret a realistic experience as anomalistic. Additionally, monetary rewards could be offered for correct responses to increase motivation to engage in effortful probabilistic reasoning. A monetary reward would help to discern whether people higher in anomalistic belief simply differ in their preference or willingness to engage in systematic and analytical thinking (i.e., are cognitive misers) or whether they are unable to accurately complete the reasoning scenarios.

Consistent with the claim that there is overlap between anomalistic beliefs and gambling attitudes (Joukhador et al., 2004; McInnes et al., 2014; Passanisi et al., 2017), for most of our measures we found that more positive gambling attitudes were related to higher levels of anomalistic belief. However, unlike previous work on gambling and reasoning, we did not find any relationship between gambling attitudes and probabilistic reasoning (Fortune & Goodie, 2012; Gaissmaier et al., 2016; Goodie & Fortune, 2013; Wilke et al., 2014; Xu & Harvey, 2014). It is possible, though, that the results would have been different if we had targeted problem or pathological gamblers. Additionally, we used a measure of gambling attitudes rather than gambling behaviour. Although previous research has shown that gambling attitudes are predictive of gambling behaviour and intentions to gamble (Dahl, Tagler, & Hohman, 2018; Moore & Ohtsuka, 1999), the relationship between probabilistic reasoning and gambling may exist for gambling behaviour rather than gambling attitudes. That is, poorer probabilistic reasoning may not be related to the attitudes that people hold towards gambling, but may be predictive of the gambling behaviour that people engage in.

Overall, the current study showed that higher levels of anomalistic belief were related to poorer probabilistic reasoning for both misperception of chance and the base rate fallacy. Further, finding that misperception of chance was primarily related to experiential anomalistic beliefs adds to the recent work that has highlighted the importance of investigating the relationships between specific subsets of anomalistic belief and different reasoning/cognitive biases (i.e., rather than just using broad overall measures; Dagnall et al. 2016; Prike et al. 2017; 2018a; Rogers et al. 2016). Using this more fine-grained approach of focusing on specific types of belief allows for the relationships to be disentangled, leading to the development of a more nuanced understanding for these non-evidence based beliefs. The findings also support the notion that poorer probabilistic reasoning may contribute to the formation of anomalistic beliefs and suggest that misperception of chance may have an important role in whether people assign anomalistic explanations to experiences.

Footnotes

[1] Dagnall et al. (2016) did not report whether the correlations were significantly different, however, we tested if they significantly differed using methods outlined in Steiger (1980).

[2] The difference between correlations again was not reported in Dagnall et al. (2016), thus we tested if they significantly differed using methods outlined in Steiger (1980).

[3] Minimum timing was decided based on the time taken to complete the survey without reading and maximum time was decided so that participants could complete the study at a leisurely pace. Average time taken to complete the study was approximately half an hour (before participants removed, M = 27:51, SD = 15:19; after participants removed for timing, M = 27:55, SD = 11:13).

[4] The overall paranormal and extra-terrestrial belief questions showed the same patterns as the ABS and ASGS belief scales and/or the relevant factors of the ABS, however, the belief scales and factors provided a better understanding of the relationship between probabilistic reasoning and anomalistic belief. Therefore, the overall questions are not discussed further.

[5] The reported degrees of freedom vary because some of the analyses include the ABS factors, and some include only an overall anomalistic belief measure (i.e., analyses with the ABS factors include an extra 3 variables and therefore the degrees of freedom are reduced).

Chapter 4: The Relationship Between Anomalistic Belief and Biases of Evidence Integration and Jumping to Conclusions

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The study materials for this chapter can be found in Appendices A and D.

Abstract

Biases in the assessment and integration of evidence are likely contributors to anomalistic (e.g., paranormal, extra-terrestrial) beliefs because of the non-evidence based nature of these beliefs. However, little research has examined the relationship between anomalistic beliefs and evidence integration biases. The current study addressed this gap by examining the relationship between anomalistic belief and four such biases; bias against disconfirmatory evidence (BADE), bias against confirmatory evidence (BACE), liberal acceptance bias, and the jumping to conclusions bias (JTC). Standard BADE scenarios were used to measure BADE, BACE, and the liberal acceptance bias: Participants were given three pieces of evidence, one at a time, and required to rate several alternative explanations. The JTC was measured using two draws-to-decisions tasks (beads and emotionally salient), and participants also completed measures of anomalistic belief and delusion-proneness. Results showed that, liberal acceptance was the only evidence integration bias that significantly predicted greater overall anomalistic belief. However, this relationship was no longer significant once delusion proneness was controlled for. Additionally, BADE significantly predicted experiential (but not other types of) anomalistic beliefs even after controlling for delusion proneness. We propose that liberal acceptance may lead people to form anomalistic beliefs on the basis of little evidence, and that stronger BADE may make these beliefs highly resistant to change.

Keywords: anomalistic belief; paranormal belief; cognitive bias; evidence integration; jumping to conclusions

The Relationship Between Anomalistic Belief and Biases of Evidence Integration and Jumping to Conclusions

The majority of the general public in the United States and the United Kingdom believes in at least one type of anomalistic phenomena, and anomalistic beliefs also are common throughout Latin-America, Southern Europe, and North-West Europe (Höllinger and Smith, 2002; Moore, 2005; Pechey & Halligan, 2011; Shannon-Missal, 2013). Anomalistic belief is a broad term that refers to any belief that contradicts the current scientific understanding of reality (French & Stone, 2014). Research typically focuses on paranormal beliefs (e.g., extra-sensory perception), but other non-evidence based beliefs, such as belief in alien visitation or certain conspiracy theories, also fall under the anomalistic umbrella. Given that anomalistic beliefs are not supported by rigorous evidence or science, it is important to use known or knowable physical and psychological factors to explain their high levels among the general population (French, 2001). One area that has provided some potential explanations for why people hold anomalistic beliefs is cognitive bias and reasoning ability. Specifically, previous research has found that people with higher levels of anomalistic belief may be especially prone to some cognitive biases and are more likely to make reasoning errors (e.g., Dagnall, Drinkwater, Denovan, Parker, & Rowley, 2016; Lawrence & Peters 2004; Rogers, Fisk, & Wiltshire, 2011; Wiseman & Watt, 2006). The current study expanded on this research by investigating whether anomalistic belief is related to several cognitive biases that typically are studied in relation to delusion-proneness and schizotypy; that is, the bias against disconfirmatory evidence (BADE), the bias against confirmatory evidence (BACE), liberal acceptance, and the jumping to conclusions (JTC) bias.

People exhibit a BADE when they do not adequately *reduce* their initial likelihood judgements about an event or outcome after they have been provided with new information that contradicts their initial judgement (Moritz & Woodward, 2006; Woodward, Moritz,

Menon, & Klinge, 2008). The BACE is also a bias against updating judgements, however, it is a bias against adequately *increasing* likelihood judgements for an event or outcome when provided with evidence that supports it (Moritz & Woodward, 2006; Sanford, Veckenstedt, Moritz, Balzan, & Woodward, 2014). The liberal acceptance bias occurs when someone has a lowered decision threshold and is more receptive to improbable outcomes (Moritz et al., 2017). Finally, people demonstrate the JTC bias when they reach a conclusion after having received very little information (Fine, Gardner, Craigie, & Gold, 2007; Huq, Garety, & Hemsley, 1988). These biases primarily have been found to be related to greater delusion proneness, schizotypy, and schizophrenia (Buchy, Woodward, & Liotti, 2007; Colbert & Peters, 2002; Fine et al., 2007; McLean, Mattiske, & Balzan, 2016; Woodward, Buchy, Moritz & Liotti, 2007; Zawadski et al. 2012), although a small amount of work has shown that anomalistic belief is related to greater JTC bias (Irwin, Dagnall, & Drinkwater, 2012; Irwin, Drinkwater, & Dagnall, 2014). One key aim was to look at the relationship between anomalistic beliefs and these biases because the JTC and liberal acceptance biases may contribute to the development of anomalistic belief and the BADE and BACE may then help to maintain those beliefs in the face of contradicting evidence.

A second aim of the current study was to use the recently developed Anomalistic Belief Scale (ABS; Prike, Arnold, & Williamson, 2017) to provide a more fine-grained understanding of any relationship found between anomalistic belief and the above-mentioned biases. The ABS has four factors; experiential belief, psi (i.e., paranormal) belief, extra-terrestrial belief, and life after death belief. Thus, the ABS allows us to examine whether it is overall anomalistic belief that is associated with the four biases, or only a specific subset(s) of anomalistic belief. Using a more nuanced analysis is important because recent research has shown that the relationship between anomalistic belief, bias, and reasoning performance may depend on specific type(s) of belief (Dagnall et al., 2016; Rogers, Fisk, & Lowrie, 2016). For

example, Dagnall et al. found that, although there was a negative relationship between performance on a conjunction fallacy task and anomalistic belief, this relationship occurred only for the Traditional Paranormal Beliefs factor of the Revised-Paranormal Belief Scale and not for the New Age Philosophy factor. Relatedly, recent work with the ABS found that only beliefs about experiencing anomalistic phenomena (e.g., “I have seen at least one UFO in the sky that I believe was an extra-terrestrial space ship”) were related to performance on a conjunction fallacy task, whereas theoretical anomalistic beliefs (e.g., “I believe extra-terrestrials have visited earth”) were not (Prike et al., 2017).

Liberal acceptance and the JTC bias potentially contribute to the formation of anomalistic beliefs because they lead people to consider implausible options and to accept conclusions without requiring much supporting evidence. For example, a person may have a dream about an event and then when a similar event occurs they may conclude that they have some form of precognition. However, if the person had engaged in a more thorough consideration of the evidence and been less willing to consider such an implausible option, then s/he probably would have concluded either that precognition is not the likely explanation or at least that there is insufficient evidence to support a precognition interpretation. Once an anomalistic belief is considered and accepted, BADE and BACE biases may contribute to the maintenance of those beliefs. BADE and BACE biases may make people less willing to adjust their beliefs when presented with new evidence and, given the non-evidence based nature of anomalistic beliefs, it is plausible that anomalistic believers are more prone to these biases. Similar arguments have been proposed in the delusions literature: Both liberal acceptance and JTC contribute to the initial formation of delusions (Fine et al., 2007; Moritz et al., 2017), and BADE and BACE biases subsequently help to maintain delusions and make them resistant to change (Moritz et al., 2017; Woodward et al., 2007). Because all of these biases have been proposed to contribute to the formation and maintenance of beliefs, it was

important to consider them all within the one study to examine whether they each make a unique contributions or if the relationship primarily is driven by only a subset of the biases.

There is some existing evidence for a positive relationship between anomalistic beliefs and the JTC bias. Specifically, Irwin, Dagnall, and Drinkwater (2012) and Irwin, Drinkwater, and Dagnall (2014) found that participants who were higher in anomalistic belief were more prone to the JTC bias. However, one potential issue with these studies is that they mainly focused on self-report (vs. behavioural) measures of the JTC bias (Irwin et al. 2012), although Irwin et al. (2014) did include two trials of the beads task in their second experiment. Nonetheless, this potential relationship warrants further investigation because if believers are prone to reaching conclusions quickly (i.e., without fully considering other available evidence), then this tendency may provide a partial explanation for how some people come to hold anomalistic beliefs.

Previous research also suggests that people who hold anomalistic beliefs may be biased in the way that they interpret evidence. For example, Jones and Russell (1980) found that anomalistic believers described demonstrations of extrasensory perception as having been successful regardless of whether the demonstration was a success or failure. In contrast, non-believers accurately reported the extrasensory perception demonstration as having succeeded when it was successful and as having failed when the demonstration was unsuccessful. Wiseman, Greening, and Smith (2003) also found that anomalistic believers were more likely to report a séance as having been successful even when it was not. Similarly, Russell and Jones (1980) found that anomalistic believers were more likely to report that scientific abstracts supported their beliefs even if they did not, whereas non-believers accurately remembered whether the article was supportive or unsupportive of paranormal phenomena.

Although there already is some evidence that anomalistic believers are biased in the way that they interpret evidence, one potential issue with this previous research is that it relied on participants' pre-existing beliefs that can often be strongly held and highly resistant to change. In contrast, the BADE paradigm, which also provides measures of BACE and liberal acceptance, does not rely on pre-existing beliefs. Instead, participants are given a short description of a person or event, followed by several options/explanations that they rate the likelihood of. Thus, participants develop a belief about the most likely option based on the initial short description, but then they are subsequently provided with additional evidence that suggests an option that initially seemed implausible is actually the correct answer. For example, in one BADE scenario participants are initially provided with the information "Andrea has made some new friends," which may make the option that "Andrea has just started going to university" seem likely. However, as additional information is provided, such as "Andrea's new friends control every single aspect of her life" and "Andrea has very suddenly cut off all contact with her family," this initial option becomes less likely and the option "Andrea has joined a cult" becomes more likely to be true (Woodward et al., 2007). Participants demonstrate BADE when they inadequately reduce their likelihood ratings for the options they initially thought were likely. That is, most participants will rate the correct answer as likely after having seen all of the evidence, but participants who exhibit a BADE are less willing to reduce their likelihood rating for the option(s) they initially chose. Conversely, participants demonstrate a BACE when they are less willing to increase their likelihood rating for the correct option, despite being presented with evidence that strongly supports it.

The BADE paradigm also allows for analysis of liberal acceptance; that is, the early acceptance of hypotheses based on insufficient evidence (Moritz & Woodward., 2004). BADE scenarios all have one absurd option that is highly improbable at all stages of the task

(and would usually be ruled out by most people), and liberal acceptance is calculated by averaging the likelihood ratings for these absurd options. The JTC bias is somewhat similar to the liberal acceptance bias because they both involve the acceptance or consideration of conclusions based on very little evidence. The most common JTC paradigm is the beads task in which participants are shown two jars of beads with different ratios of coloured beads (e.g., one jar with 80% yellow and 20% blue beads and the other with 20% yellow and 80% blue beads; Huq et al., 1988). Participants are then shown a series of beads one at a time and when they believe they have seen enough beads to make a decision, they choose which jar the beads were drawn from. A related JTC paradigm is the emotionally salient task, but instead of using neutral coloured beads participants are told that descriptive words are being drawn from a survey that describes a person that is either "mostly positive" (e.g., 80% positive, 20% negative) or "mostly negative" (e.g., 20% positive, 80% negative; Dudley, John, Young, & Over, 1997; Zawadzki et al., 2012).

The primary focus in the current study was the relationship between anomalistic belief and the BADE, BACE, liberal acceptance, and JTC biases. Anomalistic belief was measured using the newly developed ABS (Prike et al., 2017) because this measure allowed us to examine any relationship found between belief and the biases at a more fine-grained level; for example, whether experiential versus theoretical anomalistic beliefs are more predictive of the relationships. However, we also measured anomalistic belief with the Australian Sheep-Goat Scale (ASGS; Thalbourne & Delin, 1993) because it has been used extensively in previous anomalistic beliefs research. The JTC bias was measured using two separate draws-to-decision tasks; the commonly used beads task and the emotionally salient task. The BADE scenarios described earlier were used to measure BADE, BACE, and liberal acceptance. Additionally, several studies have established a relationship between schizotypy and/or delusion-proneness and level of anomalistic belief (Dagnall, Munley, Parker, & Drinkwater,

2010; Hergovich, Schott, & Arendasy, 2008; Houran, Irwin, & Lange, 2001). Therefore, delusion-proneness also was collected using the Peters et al. Delusions Inventory (PDI; Peters, Joseph, Day, & Garety, 2004), which allowed us to check whether any relationships between anomalistic belief and the BADE, BACE, liberal acceptance bias, and/or JTC were due to beliefs per se, or whether the relationships only existed because of the association between anomalistic belief and delusion-proneness.

Method

Participants

Two hundred and fifty-nine participants (58.9% female; 78.6% Caucasian) between the ages of 18 and 81 (M = 35.44 years, SD = 11.94 years) from the crowdsourcing website CrowdFlower completed the study and were reimbursed $1.75 for their time. Thirty-five participants were removed prior to analyses for not following all instructions and/or not completing the study properly (e.g., did not complete the study in a reasonable time frame by finishing in less than 15 mins or taking longer than 80 mins).[1]

Design and Materials

This study used a correlational design. The key predictor variables were: (1) BADE, (2) BACE, (3) liberal acceptance, and (4) JTC. The main outcome measures were (1) overall anomalistic belief for the ASGS and the ABS, (2) ABS factors, and (3) delusion-proneness. Participants were randomly assigned to one of two counterbalanced orders for the main test block of BADE and JTC trials. Within each order the 24 BADE trials and 8 JTC trials were randomly intermixed with the restriction that no more than two BADE test trials be presented in a row, and no more than one JTC trial was presented in a row. The ABS and ASGS order also was counterbalanced.

Anomalistic Belief Measures. Belief was measured using three separate measures; the ASGS, the ABS, and two general questions. The ASGS is psychometrically sound with 18

items that cover belief in paranormal phenomena related to psychokinesis, life after death, and extra-sensory perception (Thalbourne & Delin, 1993). The ABS is a 40-item scale that covers a wide range of paranormal and extra-terrestrial beliefs (Prike et al., 2017). Factor analysis of the ABS has revealed that the scale has four factors; experiential belief (experiential factor, 14 items), paranormal belief (PSI factor, 13 items), extra-terrestrial belief (ET factor, 8 items), and life after death belief (LAD factor, 5 items). The experiential factor is composed of items related to the experience of both paranormal and extra-terrestrial phenomena, whereas the other three factors are composed of items that primarily relate to theoretical belief in three distinct areas of anomalistic belief. Participants respond to items on both the ASGS and the ABS using a 7-point scale (from 1 = "strongly disagree" to 7 = "strongly agree). Anomalistic belief also was measured using two general questions that participants responded to on a scale from 1 to 100; one question was on overall paranormal belief and one was on overall extra-terrestrial belief.[2]

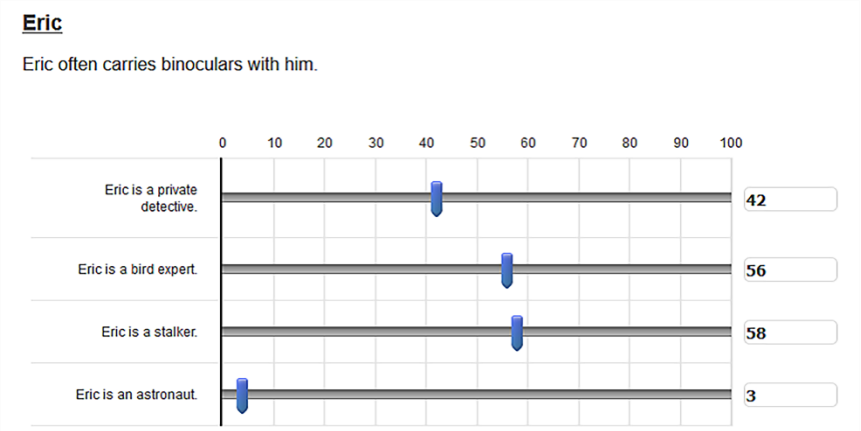
Delusion-proneness Measure. Delusion-proneness was measured using the Peters et al. Delusions Inventory (PDI; Peters et al., 2004). The PDI is a widely-used measure of delusion-proneness that can gage subclinical delusional ideation in the general population (Peters et al., 2004; Zawadski et al., 2012). The PDI consists of 21 questions about delusions that require either a "yes" or "no" answer. For the questions that participants respond yes to, they complete three follow-up questions on a 5-point scale that measure how distressing the belief is (from 1 = "not at all distressing" to 5 = "very distressing"), how often they think about it (from 1 = "hardly ever think about it" to 5 = "think about it all the time"), and how true they believe it to be (from 1 = "don't believe it's true" to 5 = "believe it is absolutely true"). Because we were interested in overall delusion proneness, scores on the PDI were calculated by summing the total number of yes responses and the total scores for the follow up questions (Peters et al., 2004). This overall measure of delusion proneness (Total PDI) has

a potential range of 0 to 336. It was important to measure delusion-proneness in the current study because of the aforementioned studies that have shown a relationship between schizotypy/delusion-proneness and performance on the BADE and JTC tasks.

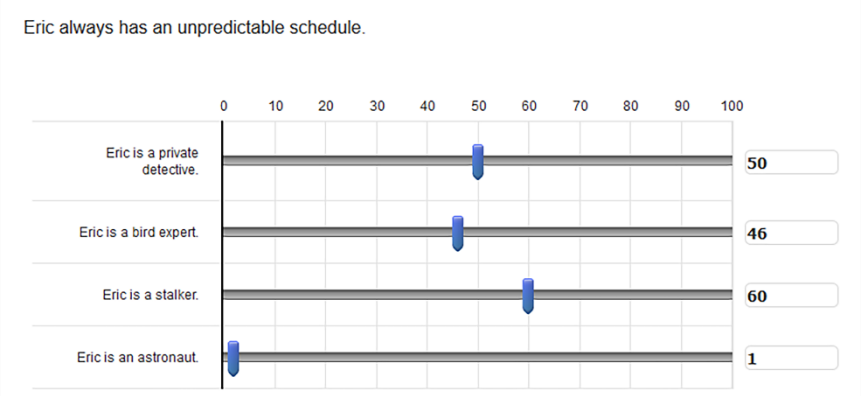
BADE Scenarios. The BADE, BACE, and liberal acceptance were measured using a series of 24 scenarios (18 test trials, 6 filler trials; Woodward et al., 2007). Each scenario consisted of three statements presented one at a time; after each statement was presented participants responded to four options by providing a likelihood rating from 0-100 (see Figure 4.1). Thus, participants provided likelihood ratings for the same four options after each statement, which allowed them to change their likelihood ratings as additional evidence was provided. On test trials the four options consisted of: (1) a true interpretation, which was less or equally as plausible as the lure options after the first statement but became the clear answer by the end of the three statements, (2) an absurd interpretation, which was implausible at all stages of the scenario, (3) a neutral lure option, and (4) an emotional lure option. Both lure options appeared plausible at first but they became far less plausible as additional evidence was provided. The filler trials consisted of one or two true options that were equally or more plausible than the other options, and they stayed the most plausible as new information was provided.

BADE, BACE, and liberal acceptance were calculated using the methods suggested in McLean et al.'s (2016) recent meta-analysis of the area. BADE was calculated separately for the emotional lures and neutral lures by subtracting the likelihood rating after the third statement from the likelihood rating after the first statement, which shows how much participants reduced their initial likelihood rating across the later statements in reaction to being presented with disconfirming evidence (therefore, lower scores indicate stronger BADE). BACE was calculated by subtracting the likelihood rating of the true interpretation after the first statement from the likelihood rating after the third statement. This calculation

4.1A



4.1B



4.1C

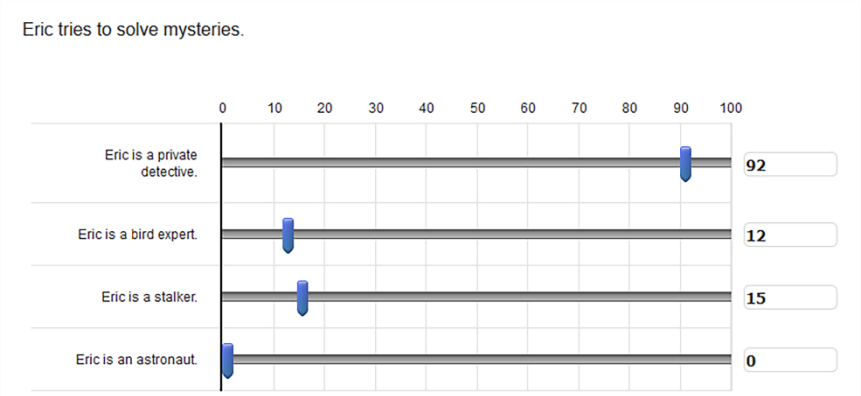
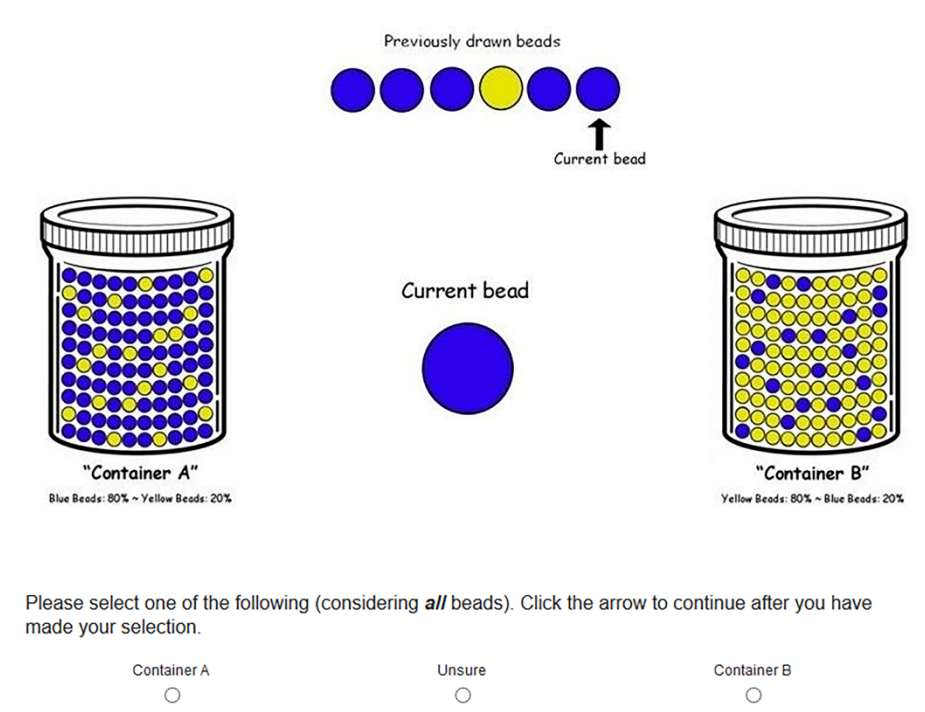


Figure 4.1. Example of a BADE test trial after one statement (4.1A), two statements (4.1B), and the final statement (4.1C).

shows how much participants increased their subsequent likelihood ratings when presented with evidence that supports the true interpretation (therefore, lower scores indicate stronger BACE). Liberal acceptance was calculated by computing the average rating for the absurd interpretation across all three statements, which shows how prone participants were to accepting an absurd interpretation (therefore, higher scores indicate greater liberal acceptance).

JTC Trials. The JTC bias was measured using 8 trials of a draws-to-decision task. Four of the trials were emotionally neutral and used the draws-to-decision beads task (see Figure 4.2a). The other four trials were based on Dudley et al.'s (1997) emotionally salient trials (see Figure 4.2b). For the emotionally salient trials the participants were told that they would see descriptive words that had been used to describe a person and that these words were being drawn from a description of a person that was either mostly positive or mostly negative. Two different ratios were used for both the beads and emotionally salient JTC trial types: Half of the trials used a ratio of 60:40 and half used a ratio of 80:20. To control for potential differences between mostly positive and mostly negative emotionally salient trials, participants received one 60:40 ratio trial that was mostly negative and one that was mostly positive, and the same was done for the 80:20 ratio trials. The same format was used for the beads trials (e.g., one 60:40 trial of mostly blue and one 60:40 trial of mostly yellow) to provide consistency across the two JTC types. The JTC task was scored based on the number of draws participants took to reach their decision; that is, lower numbers represent fewer draws taken and thus a stronger JTC bias.

4.2A



4.2B

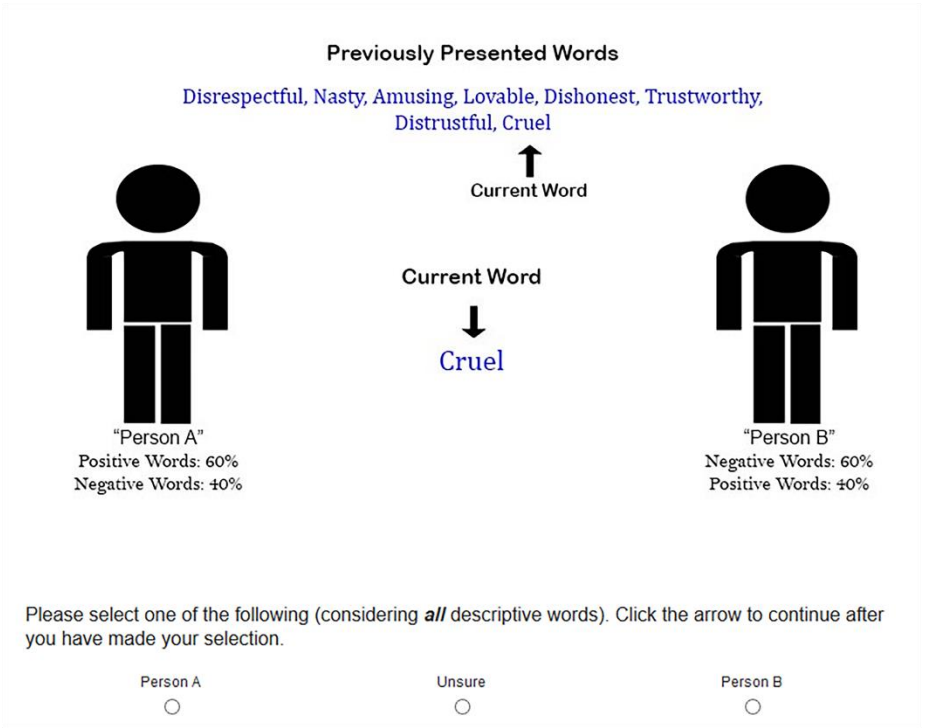


Figure 4.2. Example of JTC trials for the beads version (4.2A) and the emotionally salient version (4.2B).

Additional Measures. Participants also completed several additional measures that included demographic information such as age, gender, and ethnicity. Level of education also was collected for overall education and with three separate questions for the specific domains of psychology, mathematics, and statistics (options for each question: less than high school, high school, some education above high school, undergraduate degree, postgraduate/professional degree, other; Brotherton & French, 2014; Rogers et al., 2011).[3] Participants who selected 'other' were able to type in a response and these responses were then re-categorised under one of the other five options. Education was collected to ensure that any relationships between anomalistic beliefs, BADE, and JTC were not occurring due to a relationship between education level and anomalistic belief.

Procedure

The experiment was run online via Qualtrics software (Qualtrics, 2017). After participants read through information about the study and provided consent the program randomly assigned them to complete the BADE and JTC measures in one of the two counterbalanced orders. The BADE instructions explained that three statements would be presented, one at a time, and that after each statement they should provide an independent rating for each of the four separate interpretations. JTC instructions clearly explained that the beads would be presented one at a time and that the sequence of beads were drawn from the same container. They also were told that after each trial the bead was returned to the container and a new bead was drawn. Participants were instructed not to select a container until they were 100% positive that the beads were being drawn from that container. The emotionally salient JTC task used the same instructions with minor adjustments (e.g., words rather than beads). After the BADE and JTC tasks participants completed their first anomalistic belief scale (i.e., either the ASGS or the ABS). All participants then completed the delusion-proneness measure before they were given the anomalistic belief measure they had not yet

completed. For all the belief measures participants were instructed that there were no right or wrong answers and to answer honestly. Participants then answered the two overall questions about paranormal and extra-terrestrial belief, followed by the demographic and education questions before being debriefed about the purpose of the experiment.

Results

In addition to conducting traditional null hypothesis significance testing, relationships between anomalistic belief and the four biases were analysed by estimating a Bayes factor (Wagenmakers, 2007) using JASP with default priors (JASP Team, 2018, Version 0.8.6). The form BF_{10} is used when reporting the Bayes factors, which provides the odds ratio of the alternative/null hypotheses given the data (i.e., values larger than 1 indicate support for the alternative, values smaller than 1 indicate support for the null, and values of 1 indicate equal support for the null and alternative). All measures of anomalistic belief, delusion-proneness, and education were coded so that higher scores represented higher levels of the attribute (i.e., higher level of belief, more delusion-prone, and higher level of education, respectively). Descriptive statistics for all scales are reported in Table 4.1.[4]

Correlations Between the Scales

As can be seen in Table 4.2, there were strong positive correlations between the ASGS and ABS, which suggests both are measuring a similar underlying construct (i.e., anomalistic belief). There also were strong positive correlations between the overall anomalistic belief scales and the factors of the ABS, as well as between the ABS factors themselves. The variations in the strength of the correlations are in line both with what would be expected based on the composition of the scales and with what has been found in a previous study (Prike et al., 2017). For example, the PSI factor had the strongest correlation with the ASGS and the ET factor had the weakest correlation, which would be expected given the ASGS is a measure of only paranormal belief (i.e., not extra-terrestrial belief).

Table 4.1.

Descriptive statistics for all scales

Scales	Mean	Sd	Min.	Max.	α
1. ASGS	2.70	1.38	1.00	6.17	.96
2. ABS	2.51	1.24	1.00	6.00	.97
3. Experiential Factor	1.72	1.12	1.00	6.00	.95
4. PSI Factor	2.82	1.55	1.00	6.85	.96
5. ET Factor	2.98	1.81	1.00	7.00	.96
6. LAD Factor	3.18	1.76	1.00	7.00	.90
7. Total PDI	43.71	40.42	0.00	275.00	.92
8. General Education	3.50	1.00	1.00	5.00	n/a
9. Psychology Education	2.31	1.14	1.00	5.00	n/a
10. Mathematics Education	2.78	1.01	1.00	5.00	n/a
11. Statistics Education	2.53	1.10	1.00	5.00	n/a

Note: $n = 224$

There also were positive correlations between all the measures of anomalistic belief and the PDI delusion-proneness measure. For the ABS factors, the experiential factor was the most strongly related to delusion-proneness. All of the education measures were positively correlated with each other, which suggests that participants with higher education in one area were also more likely to be more highly educated in the other areas. General education level did not correlate significantly with any of the anomalistic belief or delusion-proneness measures. However, psychology, statistics, and mathematics education all were positively correlated with the ASGS, the overall ABS, the experiential and PSI factors, and the PDI. Psychology and statistics education also were significantly positively correlated with the LAD factor. None of the education measures correlated significantly with the ET factor.

Table 4.2.

Correlations for BACE, BADE, Liberal Acceptance, JTC, and all scales

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Biases																	
1. BACE																	
2. BADE – Neutral	.01																
3. BADE – Emotional	-.09	.95***															
4. Liberal Acceptance	-.77***	-.40***	-.31***														
5. JTC – Overall	.12	.02	.03	-.14*													
Anomalistic Belief																	
6. ASGS – Overall	-.22***	-.22***	-.19**	.35***	-.07												
7. ABS – Overall	-.26***	-.25***	-.23***	.40***	-.12	.87***											
ABS Factors																	
8. Experiential	-.45***	-.44***	-.40***	.62***	-.12	.69***	.82***										
9. PSI	-.18**	-.18**	-.16*	.29***	-.07	.90***	.90***	.64***									
10. ET	-.11	-.10	-.10	.18**	-.10	.51***	.77***	.51***	.54***								
11. LAD	-.09	-.05	-.04	.17**	-.12	.75***	.82***	.52***	.77***	.55***							

(continued)

Table 4.2.

Correlations for BACE, BADE, Liberal Acceptance, JTC, and all scales

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Delusion Proneness																	
12. Total PDI	-.38***	-.27**	-.19**	.50***	-.12	.50***	.47***	.52***	.43***	.24***	.35***						
Education																	
13. General	-.06	-.04	-.01	.06	.05	.01	-.00	.03	.04	-.04	-.07	.06					
14. Psychology	-.18**	-.12	-.08	.27***	-.17*	.29***	.25***	.27***	.28***	.07	.18**	.25***	.27***				
15. Mathematics	-.17*	-.15*	-.13	.22***	-.03	.16*	.19**	.27***	.19**	.03	.08	.25***	.51***	.40***			
16. Statistics	-.14*	-.20**	-.19**	.22***	-.08	.23***	.23***	.29***	.23***	.08	.14*	.24***	.49***	.47***	.80***		
Order																	
17. Survey	-.01	.01	-.00	.06	-.04	-.12	.05	.01	.08	.07	-.02	.02	.05	.03	.11	.09	
18. Counterbalance	.03	-.10	-.10	.07	-.13*	.07	.09	.11	.07	.05	.06	.12	-.03	.00	.05	.10	.11

* = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Evidence Integration Biases and Anomalistic Belief

Correlations revealed that stronger BADE, BACE, and liberal acceptance biases were related to greater belief for the overall ASGS and ABS, the experiential and PSI factors of the ABS, and delusion proneness. Greater liberal acceptance was also related to higher belief for the ET and LAD factors. However, JTC was not related to any measures of anomalistic belief or delusion proneness. Because we used more JTC trials than are traditionally used, we examined the correlations for the first JTC trial and the first 2 JTC trials. These JTC measures were also not correlated with anomalistic belief or delusion proneness, $r \leq -.11$, $ps \geq .09$.

The relationships between evidence integration biases and overall anomalistic belief were analysed using multiple linear regression analyses. The evidence integration biases were entered in the first step to establish whether they were related to anomalistic belief. Because delusion proneness was related to the evidence integration biases (except JTC) and anomalistic belief, we were interested in whether any relationships between anomalistic belief and evidence integration biases remained once delusion proneness was controlled for. Finally, because counterbalance order and psychology, mathematics, and statistics education were significantly related to either anomalistic belief or evidence integration biases (see Table 4.2), they also were entered into the regressions at the second step to control for their potential effects.

The overall regression for the ASGS (see Table 4.3) showed that, at the first step, liberal acceptance was the only evidence integration bias significantly related to anomalistic belief. However, after delusion proneness and the control variables were entered, none of the evidence integration biases were significant predictors of anomalistic belief. Delusion proneness was significantly positively related to anomalistic belief, as was psychology education; however, the size of the Bayes factors suggests that the evidence for an effect of psychology education is only anecdotal (Wetzels & Wagenmakers, 2012). Similarly, the

results for the regression predicting overall ABS score (see Table 4.4) showed that, at the first step, liberal acceptance was the only evidence integration bias significantly related to anomalistic belief. Once again, after delusion proneness and the control variables were entered, none of the evidence integration biases were significant predictors of anomalistic belief. Delusion proneness was again a significant positive predictor of anomalistic belief, but there was no effect of psychology education. Taken together, the results for the overall scales indicate that liberal acceptance is related to a greater endorsement of anomalistic beliefs. However, once the variance in anomalistic belief explained by delusion proneness and the control variables was controlled for, liberal acceptance did not uniquely explain variance in anomalistic belief. This finding suggests that evidence integration biases are not significant predictors of overall anomalistic belief.

Because ABS factor was a within-subjects variable, standard multiple regression analyses were not possible. However, Ruscher (n.d.) outlined a suitable method for within-subjects regression that uses a general linear model repeated measures ANCOVA. This method allows the ABS factors to be entered as a within-subjects variable and the evidence integration bias variables to be entered as covariates. The ANCOVA provided results for the ABS factor main effect and for the interactions between ABS factor and the continuous variables. Additionally, regression parameter estimates showed the effects of the continuous variables (e.g., the evidence integration biases) on each of the ABS factors (see Tables 4.5, 4.6, 4.7, and 4.8). All variables were standardised prior to analysis because we were interested in the relative rather than absolute effects of the continuous variables (the evidence integration biases) and their associated interactions with ABS factor. Standardization does prevent analysis of the main effect of ABS factor (standardization means that all factors have $M = 0$, $SD = 1$), however, it allows for simpler comparison of the effect of the predictor variables. As with the overall

Table 4.3.

Regression Predicting Average ASGS Score using Evidence Integration Biases

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1				< .001	3653.73	8.31	.13	.12			
BADE	-.07	[-.23, .09]	-0.88	.38	0.34						
BACE	.07	[-.16, .30]	0.57	.57	0.28						
Liberal Acceptance	.37	[.13, .62]	2.98	.003	14.19						
JTC	-.03	[-.15, .10]	-0.42	.67	0.26						
Step 2 (with control variables)				< .001	1.13×10^{10}	10.19	.30	.27	10.28	.17	<.001
BADE	-0.04	[-.18, .10]	-0.55	.58	0.30						
BACE	0.06	[-.15, .27]	0.53	.60	0.30						
Liberal Acceptance	0.13	[-.10, .37]	1.10	.27	0.46						
JTC	0.02	[-.10, .14]	0.32	.75	0.28						
Delusion-Proneness	0.41	[.28, .55]	6.07	<.001	1.73×10^{6}						
Psychology	0.15	[.02, .28]	2.21	.03	2.52						
Mathematics	-0.13	[-.32, .06]	-1.32	.19	0.59						
Statistics	0.13	[-.07, .34]	1.32	.19	0.60						
Counterbalance	0.00	[-.12, .11]	-0.08	.94	0.26						

*change statistics represent change from Step 1.

β represents standardised regression coefficients

Table 4.4.

Regression Predicting Average ABS Score using Evidence Integration Biases

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1				< .001	618640.63	11.55	.17	.16			
BADE	-0.11	[-.26, .05]	-1.39	.17	0.54						
BACE	0.02	[-.20, .24]	0.17	.86	0.22						
Liberal Acceptance	0.37	[.13, .61]	3.01	.003	14.83						
JTC	-0.06	[-.19, .06]	-1.01	.313	0.35						
Step 2 (with control variables)				< .001	8.97×10^8	9.32	.28	.25	6.41	.11	<.001
BADE	-0.08	[-.22, .07]	-1.05	.30	0.45						
BACE	0.01	[-.20, .23]	0.12	.90	0.27						
Liberal Acceptance	0.17	[-.06, .41]	1.45	.15	0.72						
JTC	-0.03	[-.15, .09]	-0.46	.65	0.30						
Delusion-Proneness	0.33	[.20, .47]	4.84	<.001	7959.78						
Psychology	0.09	[-.05, .22]	1.26	.21	0.57						
Mathematics	-0.07	[-.26, .13]	-0.68	.50	0.34						
Statistics	0.11	[-.09, .31]	1.07	.29	0.46						
Counterbalance	0.02	[-.10, .14]	0.31	.76	0.28						

*change statistics represent change from Step 1.

β represents standardised regression coefficients

anomalistic belief regressions, delusion proneness, counterbalance, and psychology, mathematics, and statistics education were entered at the second step.

The first step of the analysis predicting belief for the four ABS factors revealed a main effect of liberal acceptance, $F(1, 219) = 9.03$, $p = .003$, $\eta_p^2 = .04$, $BF_{10} = 12.91$. There were no significant main effects for any of the other evidence integration biases. Fs $(1, 219) \leq 1.26$, all ps $\geq .26$, all $\eta_p^2 \leq .01$, range $BF_{10} = 0.21 – 0.48$. However, there were significant interactions between factor and BADE, $F(2.62, 573.04) = 9.41$, $p < .001$, $\eta_p^2 = .04$, $BF_{10} = 4560.09$, as well as between factor and BACE, $F(2.62, 573.04) = 3.40$, $p = .02$, $\eta_p^2 = .02$, $BF_{10} = 0.78$. Inspection of the multiple regression parameter estimates revealed that the significant interaction between factor and BADE occurred because BADE was only a significant negative predictor of experiential anomalistic belief; that is, a stronger BADE was related to higher experiential belief. The interaction between BACE and factor occurred because the strength and direction of the relationship varied for the different ABS factors, however, BACE was not a significant predictor of any of the ABS factors. Finally, there were no significant interactions for liberal acceptance or JTC, Fs $(2.62, 573.04) \leq 0.97$, all ps $\geq .40$, all $\eta_p^2 \leq .004$, range $BF_{10} = 0.01 – 0.03$.

The analysis predicting belief for ABS factors with delusion proneness and the other control variables included in step 2 showed no main effects for any of the evidence integration biases, Fs $(1, 214) \leq 2.16$, all ps $\geq .14$, all $\eta_p^2 \leq .01$.[5] Only delusion proneness had a significant main effect, $F(1, 214) = 23.31$, $p < .001$, $\eta_p^2 = .10$, all control variables, Fs $(1, 214) \leq 1.31$, all ps $\geq .26$, all $\eta_p^2 \leq .01$. However, there again were significant interactions between factor and BADE, $F(2.64, 564.91) = 9.34$, $p < .001$, $\eta_p^2 = .04$, and between factor and BACE, $F(2.64, 564.91) = 3.24$, $p = .03$, $\eta_p^2 = .01$. The multiple regression parameter estimates for the factor by BADE interaction showed the same pattern as at step 1: BADE was only a significant negative predictor of experiential belief. Similarly, the BACE by factor

Table 4.5.

Regression Predicting Experiential Factor using Evidence Integration Biases

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1				< .001	2.62×10^{23}	42.78	.44	.43			
BADE	-.29	[-.41, -.16]	-4.51	.000	1854.93						
BACE	-.15	[-.34, .03]	-1.62	.106	0.48						
Liberal Acceptance	.39	[.20, .59]	3.93	.000	200.53						
JTC	-.04	[-.14, .06]	-0.74	.462	0.18						
Step 2 (with control variables)				< .001	1.10×10^{25}	24.00	.50	.48	5.47	.06	<.001
BADE	-.26	[-.38, -.14]	-4.26	.000	842.44						
BACE	-.15	[-.33, .03]	-1.69	.092	0.74						
Liberal Acceptance	.25	[.05, .45]	2.50	.013	3.65						
JTC	-.01	[.11, .08]	-.27	.790	0.19						
Delusion-Proneness	.24	[.13, .35]	4.21	.000	700.54						
Psychology	.05	[-.06, .16]	.87	.383	0.27						
Mathematics	.05	[-.11, .21]	.57	.568	0.22						
Statistics	.03	[-.14, .20]	.39	.696	0.20						
Counterbalance	.03	[-.06, .13]	.70	.484	0.24						

*change statistics represent change from Step 1.

β represents standardised regression coefficients

Table 4.6.

Regression Predicting PSI Factor using Evidence Integration Biases

Variables	β	β CI 95%	t	p	BF_{10}	F	R^2	Adj. R^2	ΔF*	ΔR^2*	Δp*
Step 1				< .001	31.16	5.41	.09	.07			
BADE	-.06	[-.22, .10]	-.70	.485	0.32						
BACE	.05	[-.18, .29]	.44	.662	0.28						
Liberal Acceptance	.30	[.05, .55]	2.37	.018	3.45						
JTC	-.03	[-.16, .10]	-.51	.612	0.29						
Step 2 (with control variables)				< .001	405420.57	6.82	.22	.19	7.33	.13	<.001
BADE	-.03	[-.18, .12]	-.38	.706	0.32						
BACE	.04	[-.18, .26]	.37	.709	0.32						
Liberal Acceptance	.09	[-.16, .33]	.69	.492	0.37						
JTC	.01	[-.11, .13]	.16	.870	0.30						
Delusion-Proneness	.34	[.20, .48]	4.77	.000	5447.16						
Psychology	.15	[.01, .29]	2.16	.032	2.47						
Mathematics	-.05	[-.25, .15]	-.50	.614	0.34						
Statistics	.10	[-.12, .31]	.90	.370	0.44						
Counterbalance	.01	[-.11, .14]	.22	.827	0.31						

*change statistics represent change from Step 1.
β represents standardised regression coefficients

Table 4.7.

Regression Predicting ET Factor using Evidence Integration Biases

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Step 1				.06	0.17	2.34	.04	.02			
BADE	-.02	[-.19, .14]	-.27	.785	0.30						
BACE	.05	[-.19, .29]	.41	.680	0.31						
Liberal Acceptance	.20	[-.05, .46]	1.56	.121	0.87						
JTC	-.07	[-.20, .06]	-1.07	.284	0.49						
Step 2 (with control variables)				.05	0.03	1.90	.07	.04	1.52	.03	.18
BADE	.00	[-.17, .16]	-.06	.955	0.39						
BACE	.05	[-.19, .29]	.39	.694	0.42						
Liberal Acceptance	.12	[-.15, .39]	.85	.394	0.53						
JTC	-.06	[-.19, .08]	-.85	.395	0.53						
Delusion-Proneness	.20	[.04, .35]	2.52	.012	5.76						
Psychology	-.02	[-.17, .14]	-.21	.830	0.40						
Mathematics	-.12	[-.34, .10]	-1.10	.274	0.65						
Statistics	.12	[-.11, .35]	.99	.323	0.59						
Counterbalance	.01	[-.13, .14]	.08	.938	0.39						

*change statistics represent change from Step 1.
β represents standardised regression coefficients

Table 4.8.

Regression Predicting LAD Factor using Evidence Integration Biases

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2	*ΔF**	ΔR^2*	*Δp**
Step 1				.03	0.33	2.73	.05	.03			
BADE	.08	[-.08, .24]	.96	.340	0.43						
BACE	.18	[-.06, .42]	1.47	.144	0.76						
Liberal Acceptance	.32	[.07, .58]	2.49	.014	4.68						
JTC	-.09	[-.22, .04]	-1.37	.174	0.67						
Step 2 (with control variables)				< .001	90.74	4.25	.15	.12	5.26	.10	<.001
BADE	.11	[-.05, .27]	1.34	.182	0.76						
BACE	.17	[-.06, .40]	1.46	.146	0.88						
Liberal Acceptance	.14	[-.12, .40]	1.08	.281	0.57						
JTC	-.06	[-.19, .07]	-.88	.380	0.48						
Delusion-Proneness	.34	[.19, .48]	4.51	.000	1812.93						
Psychology	.07	[-.07, .22]	.98	.330	0.52						
Mathematics	-.14	[-.35, .07]	-1.32	.188	0.74						
Statistics	.15	[-.07, .37]	1.34	.181	0.76						
Counterbalance	.00	[-.13, .13]	.04	.965	0.34						

*change statistics represent change from Step 1.

β represents standardised regression coefficients

interaction was due to the varied strength and direction of the relationship for the different ABS factors, but BACE was not a significant predictor of any of the factors. There were no other significant interactions, Fs (2.64, 564.91) ≤ 2.31, all ps ≥ .08, all η_p^2 ≤ .01.

Discussion

The results of this study showed correlations between anomalistic belief and three of the four evidence integration biases; BADE, BACE, and liberal acceptance. However, when all four biases were used to predict anomalistic belief, only liberal acceptance was a significant predictor. This positive relationship between belief and liberal bias, though, was no longer significant once delusion proneness was controlled for. Therefore, the findings suggest that the relationship between anomalistic belief and liberal acceptance is at least partially attributable to the relationship between delusion proneness and anomalistic beliefs. Specifically, the relationship between liberal acceptance and anomalistic belief either is spurious and due to delusion proneness, or delusion proneness mediates the relationship between liberal acceptance and anomalistic belief. Moritz et al. (2017) proposed that liberal acceptance plays a causal role in the formation of delusions, and therefore it seems more likely that the relationship between liberal acceptance and anomalistic belief is mediated by delusion proneness. However, the correlational design of our study does not allow us to establish the causal direction.

The more fine-grained analyses using the ABS factors revealed that, even after controlling for delusion proneness, greater BADE was associated with higher levels of experiential anomalistic beliefs, which suggests that BADE may contribute to the maintenance of experiential anomalistic beliefs. Many people have experiences that initially may appear to have a supernatural or anomalistic cause; for example, people may see something out of the corner of their eye that could be interpreted as being ghostly even though it was just a visual illusion. However, it may be that experiential anomalistic believers

are more likely to strongly latch onto the initial anomalistic interpretation and subsequently have increased resistance to changing that belief when presented with disconfirming evidence (e.g., that the experience could have been a perceptual illusion).

We did not find evidence for a relationship between anomalistic belief and the JTC bias, which contrasts with the small amount of previous work (Irwin et al., 2012; Irwin et al., 2014). There are some key differences, though, between the current study and Irwin et al.'s (2012; 2014). One main difference was that the majority of Irwin et al.'s JTC measures focused on self-report (vs. behavioural measures). Further, in both of Irwin et al.'s studies only the Traditional Paranormal Belief factor of the Revised Paranormal Belief Scale was consistently related to the JTC bias. This factor includes items related to belief in things such as heaven/hell, the devil, spells, and witches, and thus some researchers have argued that this factor represents beliefs that are reinforced at a social and cultural level rather than an individual level (Lange, Irwin, & Houran, 2000). Conversely, the focus on psi and extra-terrestrial belief in the ABS makes it more similar to the New Age Philosophy factor of the Revised Paranormal Belief Scale; however, Irwin et al. (2014) found no relationship between New Age Philosophy and a performance measure of JTC (i.e., the beads task). Therefore, the cumulative evidence from both the current and Irwin et al. (2012; 2014) studies suggests that the JTC bias is not related to psi or extra-terrestrial types of anomalistic belief, but instead it may be related only to a specific subset of anomalistic belief (i.e., witches, heaven and hell, the devil, and spells).

Beyond anomalistic belief, the current study also did not find evidence of a relationship between delusion proneness and JTC. This result is somewhat surprising because the relationship between delusions and JTC has been demonstrated in a number of studies (for recent meta-analyses see Dudley, Taylor, Wickham, & Hutton, 2016; Ross, McKay, Coltheart, & Langdon, 2015; McLean et al., 2016). However, Ross et al.'s recent meta-

analysis found that the relationship between delusion proneness and JTC was small and there was moderate heterogeneity. One aspect that may help explain some of the heterogeneity, and why we did not find a significant relationship between delusion proneness and JTC in our study, is the overall level of delusion proneness in the sample. Mean delusion proneness scores for the Total PDI measure in our study were quite low (M = 43.71, SD = 40.42) compared to the norms for healthy participants reported in Peters et al.'s (2004) original paper (M = 58.9, SD = 48.0). Therefore, it may be that the relationship between delusion proneness and JTC is weaker in samples with lower levels of delusion proneness.

The results of the current study suggest several limitations and potential avenues for future research. Previous accounts of delusion formation have proposed separate roles for each of the evidence integration biases investigated in this study. However, even though BADE, BACE, and liberal acceptance were positively correlated with anomalistic belief they were not all unique predictors. One possible explanation for why the biases did not play unique predictive roles is that liberal acceptance was strongly positively correlated with both the BADE and BACE biases. These strong correlations may have limited the ability of any one evidence integration bias to be a significant unique predictor of anomalistic belief. Additionally, we measured pre-existing levels of anomalistic belief: Even if liberal acceptance, BADE, and BACE make unique contributions to the belief formation and maintenance process, these unique contributions may not be reflected in a belief measure taken at a later stage. Therefore, it would be beneficial to examine further the relationships between evidence integration biases and distinctive aspects of the anomalistic belief formation process; for example, the relationship between liberal acceptance and initial anomalistic belief formation and whether BADE predicts resistance to changing an anomalistic belief when presented with counter evidence.

Further work also is needed to examine the relationship between anomalistic belief and the JTC bias. The beads and emotionally salient JTC tasks were chosen for the current study because they are the most commonly used measures of JTC. However, there are some known issues with the standard JTC paradigm; for example, Balzan, Delfabbro, and Galletly (2012) found that many participants miscomprehend the task. Therefore, it would be good for future work to measure the JTC with a different type of "evidence collection" task to help elucidate any relationship between anomalistic belief and JTC.

Overall, the current study adds to the body of evidence that suggests people who are high in anomalistic belief are more prone to certain cognitive biases than nonbelievers (e.g., Dagnall et al., 2016; Prike et al. 2017; Rogers et al. 2016; Wiseman & Watt 2006). The pattern of results from our study also emphasize the importance of using individual scale factors rather than just blunt measures of overall anomalistic belief (Dagnall et al., 2016; Irwin et al., 2014; Prike et al. 2017; Rogers et al. 2016). Finally, the relationships found highlight the potential for liberal acceptance to contribute to the formation of anomalistic beliefs and for BADE to contribute to the maintenance of anomalistic interpretations of experiences.

Footnotes

[1]The lower bound of 15 minutes was chosen based on the time taken to go through the study without doing any reading and the upper bound was chosen because it gave participants ample time to complete the study. Average time taken to complete the study was about 40 min (before participants removed, M = 42:11, SD = 32:55; after participants removed for timing, M = 39:33, SD = 14:03).

[2]The results showed that using the more expansive ASGS and ABS scales, and particularly the factors of the ABS, provided a better understanding of the relationship between anomalistic belief and the BADE and JTC biases than these two overall questions. Therefore, the overall paranormal and extra-terrestrial questions are not discussed further in the Results or Discussion.

[3]Although the education measures were not linear scales, inspection of the scatterplots for the relationships between the education measures and the variables of interest (i.e., all belief and bias measures) did not show any signs of nonlinearity. Therefore, for the purpose of analysis we treated the education measures as continuous variables.

[4]Several of the variables were not normally distributed, however, examination of the normality of the standardized regression residuals showed that they were appropriate for parametric analyses.

[5]Bayes factors could not be calculated in JASP for the repeated-measured ANCOVA with all of the predictors and control variables included. Bayesian analysis requires comparisons between all of the models. Therefore, due to the large number of variables and the four levels of the within-subjects factor variable, the number of model comparisons required was too large to be computed using JASP.

Chapter 5: Understanding the News: The Relationship Between Anomalistic Belief, Political Belief, Thinking Style, and the Interpretation of News Articles

Prike, T., Arnold, M. M., & Williamson, P. (2017). Understanding News: How Anomalistic Belief, Political Belief, and an Analytical Thinking Style Relate to the Interpretation of News Articles. Manuscript in preparation.

The study materials for this chapter can be found in Appendices A and E.

Abstract

News articles are a major information source and they influence people's beliefs. Therefore, it is important that people draw accurate inferences from news articles. Because research has shown that anomalistic (e.g., paranormal) beliefs are associated with evidence assessment biases, the current study investigated whether anomalistic believers draw less accurate inferences from news articles. We also predicted that misleading (vs. congruent) headlines, political conservatism, support for President Trump, and intuitive (vs. analytical) thinking style would be associated with less accurate inferences. Participants read news articles and then answered inferential questions related to each article. Each critical article presented initial misinformation that was then corrected by scientific evidence/opinion, and half of the articles had misleading headlines and the other half had congruent headlines. As predicted, a more intuitive thinking style, greater political conservatism, and support for President Trump were associated with less accurate inferences. However, no relationship was found between inference accuracy and either anomalistic belief or (misleading) headlines. The results suggest that thinking style and political beliefs should be considered when attempting to inform the public through the use of news articles.

Keywords: anomalistic beliefs, non-evidence based beliefs, political beliefs, analytical thinking, evidence integration biases,

Understanding the News: The Relationship Between Anomalistic Belief, Political Belief, Thinking Style, and the Interpretation of News Articles

Anomalistic phenomena, such as psychics, ghosts, or extra-terrestrial visitation, defy scientific understandings of reality, however, anomalistic beliefs are common among the general population (Brotherton & French, 2014; Drinkwater, Dagnall, & Parker, 2012; French, 2001; French & Stone, 2014; Moore, 2005; Shannon-Missal, 2013). Some studies have found that higher anomalistic belief is associated with biases in the interpretation of novel information (Jones & Russell 1980; Prike, Arnold, & Williamson, 2018a; Russell & Jones, 1980; Wiseman, Greening, & Smith, 2003), but thus far no study has investigated whether these biases are present for the interpretation of one of the most common sources of information; news articles. Additionally, research has suggested that misinformation presented in news articles, even when it is as subtle as a misleading headline, can have an influence on the inferences people draw from the article (Ecker, Lewandowsky, Chang, & Pillai, 2014). Therefore, one aim of the current study was to gain a greater understanding of non-evidence based beliefs by examining how they relate to the interpretation of information presented in news articles, and whether people who hold anomalistic beliefs are more prone to being influenced by misinformation.

One proposed explanation for the formation and maintenance of anomalistic beliefs is that certain cognitive differences make some people more prone to developing anomalistic beliefs. For example, higher anomalistic belief has been shown to be related to higher probabilistic reasoning errors such as misperceiving chance and the conjunction fallacy (Dagnall, Drinkwater, Denovan, Parker, & Rowley, 2016; Rogers, Fisk, & Lowrie, 2016). Researchers have argued that poor probabilistic reasoning leads anomalistic believers to be more likely to assign a paranormal or anomalous explanation to events that occurred by chance (Blackmore & Troscianko, 1985; Brugger, Landis, & Regard, 1990). However, there

also is evidence to suggest that other cognitive differences are related to higher levels of anomalistic belief. Specifically, several studies have shown an association between greater anomalistic belief and biases in the evaluation and consideration of evidence (Irwin, Drinkwater, & Dagnall, 2014; Jones & Russell 1980; Prike et al., 2018a; Russell & Jones, 1980; Wiseman, Greening, & Smith, 2003).

One area where a relationship between belief and biased processing has been found is in the conclusions that anomalistic believers draw when viewing a demonstration of anomalistic phenomena. For example, regardless of the actual success of anomalistic demonstrations, believers typically concluded that the demonstrations were successful whereas sceptics accurately distinguished between successful and unsuccessful demonstrations (Jones & Russell, 1980; Wiseman, Greening, & Smith, 2003). However, there is also evidence that the relationship between anomalistic belief and evidence integration biases is not specific to an anomalistic domain (Prike et al., 2018a). Prike et al. examined the relationship between anomalistic belief and evidence integration biases using a series of scenarios with neutral content. They found that higher anomalistic belief was related to greater liberal acceptance, suggesting that those higher in anomalistic belief are more willing to accept explanations that are not well supported by evidence. Further, higher experiential anomalistic belief was associated with both a reduced willingness to reduce endorsement of an answer when presented with new counter-evidence, and a reduced willingness to accept the answer supported by the new evidence. Evidence integration biases could potentially contribute to the formation of anomalistic beliefs because liberal acceptance may make people more willing to accept anomalous explanations for experiences based on very little evidence. Additionally, believers may be more resistant to changing their anomalistic beliefs despite counter evidence, and also be more resistant to accepting alternative, non-anomalistic explanations that are supported by the new evidence.

Higher anomalistic belief may be related to biased inferences made from news articles because anomalistic belief is associated with a more intuitive (vs. analytical) thinking style (Aarnio & Lindeman 2005, 2007; Bouvet & Bonnefon, 2015; Pennycook et al. 2012; Svedholm & Lindeman, 2013; Swami, Voracek, Stieger, Tran, & Furnham, 2014). Thinking style may play an important role because drawing accurate inferences requires people to analyse the information in a news article. For the current study, participants were required to display inferential reasoning for three different types of questions; questions that required accurately interpreting the article, questions that required making a logical inference that was based on the article but extended beyond the actual content, and questions that asked about how they would behave based on the information in the article. Further, because some of our articles had misleading headlines, accurate interpretation required analytical thinking to ensure that inferences were based on the main point of the article rather than the initial misinformation (Pennycook, Fugelsang, & Koehler, 2015b). Relatedly, Irwin, Dagnall, and Drinkwater (2016) found a negative relationship between anomalistic belief and attitudes towards science. Our news articles were constructed so that the main points were presented by an expert, a scientist, and/or a body of experts/scientists, thus people with higher anomalistic belief may be less willing to accept the main points.

News articles, particularly the opinion pieces that are the focus of the current research, serve as a major source of political information and can influence political views (Feldman & Hart, 2017; Mutz & Soss, 1997; Otieno, Spada, & Renkl, 2013; Schemer, 2012; Shen, Ahern, & Baker, 2014). Additionally, after being exposed to the same information, people often reach different conclusions depending on their political ideology (Kahan, 2016; Kahan, Jenkins-Smith, & Braman, 2011; Taber & Lodge, 2006). Thus, the relationships between political belief, anomalistic belief, and interpretation of news articles were also investigated.

We predicted that more conservative political beliefs would be associated with both higher levels of anomalistic belief and drawing less accurate inferences from news articles. There is evidence to suggest that conservatives are less analytical and/or reflective in their thinking style than liberals (Deppe et al., 2015; Lane & Suklikowski, 2017; Pennycook et al., 2012), and that these differences can lead people to reach different political conclusions (Eidelman et al., 2012; Yilmaz & Saribay, 2017). Additionally, several reasoning differences, such as analytical thinking style and bullshit receptivity, have been shown to be related to both greater anomalistic belief and to more conservative political ideology (Fessler, Pisor, & Holbrook, 2017; Pennycook et al., 2012; Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2014; Pfattheicher & Schindler, 2016; Sterling, Jost, & Pennycook, 2016). More negative attitudes towards science and distrust in experts and/or scientists, are also associated with both greater anomalistic belief and more conservative political ideology (Gauchat, 2012; Hamilton, Hartter, & Saito, 2015; Irwin et al., 2016; Lewandowsky, Ecker, & Cook, 2017; Lewandowsky & Oberauer, 2016). Therefore, because a less analytical thinking style, greater cognitive bias, and less trust in experts/scientists are related to political conservatism and are also likely to lead to drawing less accurate inferences from news articles, we predicted a negative relationship between conservative political beliefs and inference accuracy Support for President Trump was also measured separately, and in addition to general political conservatism, because he was an especially divisive candidate, and has publicly encouraged people to distrust news sources and experts (Cillizza, 2017; Trump, 2017). Therefore, we predicted that support for President Trump would be negatively related to inference accuracy for news articles after controlling for the relationship between inferences accuracy and general political conservatism.

News articles are one of the primary ways that people receive information (Mitchell, Gottfried, Barthel, & Shearer, 2016) and therefore provide a useful applied format for

studying evidence integration biases. News articles also provide a useful format for investigating evidence integration biases because, in an attempt to appear balanced, articles often present multiple competing perspectives on an issue (Boykoff & Boykoff, 2004; Clarke, 2008). However, these attempts at balance often lead to equal weight being provided to positions that are not equally justified. Attempts to be "balanced" can have a variety of negative impacts; for example, news organisations often have given equal weight to climate change proponents and sceptics (Boykoff & Boykoff, 2004). These attempts at balance have led to an inaccurate representation of the level of disagreement or contention within the area of climate science and may have reduced the levels of public support for action on the issue (Koehler, 2016; Lewandowsky, Gignac, & Vaughan, 2013). Similar examples can be seen in areas such as vaccination, where the views of immunologists or other experts and the views of vaccine opponents with no or very little relevant expertise are often presented with equal weight in news reports (Clarke, 2008; Dixon & Clarke, 2012). To reach accurate conclusions it is crucial that people assess the amount and strength of the presented evidence, along with the credibility and expertise of the source of the information. Therefore, the current study used the applied format of news articles to test whether anomalistic belief, political belief, and analytical thinking style were related to inferential reasoning accuracy.

News articles are also an important format in which to investigate evidence integration biases because news articles can have important influences on people's beliefs and the perspectives they take on issues (Feldman & Hart, 2017; Mutz & Soss, 1997; Otieno, Spada, & Renkl, 2013; Schemer, 2012; Shen, Ahern, & Baker, 2014). For example, the perspectives presented in news articles can influence people's attitudes about climate change and immigrants (Feldman & Hart, 2017; Schemer, 2012). Additionally, when newspapers consistently present a perspective then it leads readers to think that those views are more prevalent within the community (Mutz & Soss, 1997). Therefore, news articles have the

ability to influence societal and governmental perspectives/decisions through their influence on both community attitudes and perceptions of the consensus view.

Beyond the general interpretation of news articles, it is important to explore how subtle misinformation in the form of misleading headlines influences the inferences that people draw. There is considerable research suggesting that initial misinformation, even if later corrected, can have a continued influence on both memory and inferential reasoning (e.g., Johnson & Seifert, 1994; Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). Headlines are designed to capture the attention of readers, and thus are often misleading and less neutral in tone (either more positive or more negative) than the main article content (Andrew, 2007; Marquez, 1980; Molek-Kozakowska, 2013). This issue of misleading/biasing headlines is particularly evident in the current media landscape that has an increased focus on convincing people to click on articles to generate ad revenue (Blom & Hansen, 2015; Kuiken, Schuth, Spitters, & Marx, 2017). Consistent with the idea that misleading headlines convey misinformation, Ecker et al. (2014) found that technically accurate but misleading headlines have the potential to influence the inferences that people draw from opinion (but not factual) news articles. The current study built on this work by investigating whether the extent to which people are influenced by misleading headlines is associated with anomalistic belief, analytical thinking style, and/or political beliefs.

To test the influence of initial misinformation, we created stimuli that initially presented one perspective and then contradicted this perspective with more credible evidence for the remainder of the article. According to dual process theories of misinformation, if a conflict between misinformation and other information is detected then people can devote cognitive resources to updating their inferences. However, when misinformation is subtle, conflict is less likely to be detected, meaning the misinformation may influence inferential reasoning (Hinze, Slaten, Horton, Jenkins, & Rapp, 2014; Rapp & Kendeou, 2007; 2009; van

den Broek & Kendeou, 2008; Wilson & Brekke, 1994).Each article was presented with either a misleading headline (inconsistent with the main themes of the articles) or congruent headline (consistent with the main themes/evidence in the article). Opinion articles and misleading rather than blatantly false headlines were used to reduce the likelihood that conflict between the initial misleading headline and the counter evidence presented for the remainder of the article would be detected. The hypotheses, study design, statistical analyses, exclusion criteria, and number of participants for this study were preregistered (see: https://aspredicted.org/blind.php?x=sd27fk).

Method

Participants

Four hundred and thirty-three participants were recruited from Mechanical Turk using TurkPrime (Litman, Robinson, & Abberbock, 2017) and were reimbursed $2.25 for their time. Sixty-two participants were removed prior to analyses because they met one or more of the exclusion criteria (e.g., made multiple attempts, took too long, or failed attention checks).[1]

Design and Materials

The design included one within-subjects categorical variable of headline (misleading, congruent) and the remaining primary variables of interest were continuous: (1) agreement with the overall point of the article, measured using three inference questions per article, (2) overall anomalistic belief, (3) level of belief in subtypes of anomalistic belief, (4) political beliefs, (5) support for President Trump, (6) intuitive vs analytical thinking style.

Belief Measures. Anomalistic belief was measured with the ABS (Prike, et al., 2017), which is a 40-item scale that covers a wide range of paranormal and extra-terrestrial anomalistic beliefs and examines both theoretical (e.g., “I believe extra-terrestrials have made contact with human beings”) and experiential (e.g., “I believe that I have had direct contact

with an extra-terrestrial here on earth") belief. The ABS consists of four factors: an experiential factor that covers belief in both paranormal and extra-terrestrial experiences (experiential factor; 14 items), a theoretical paranormal belief factor (PSI factor; 13 items), a theoretical extra-terrestrial belief factor (ET factor, 8 items), and a factor covering both experiential and theoretical life after death beliefs (LAD factor, 5 items). Responses for ABS items are collected using a 7-point scale from 1 = "strongly disagree" to 7 = "strongly agree" and higher scores represent greater anomalistic belief.

The political belief measure was taken from Kahan, Peters, Dawson, and Slovic (2017). Specifically, they created two questions to measure general political belief; a party identification question (response options; "Strong Democrat", "Democrat", "Independent Lean Democrat", "Independent", "Independent Lean Republican", "Republican", "Strong Republican") and a political ideology question (response options; "Very Liberal", "Liberal", "Moderate", "Conservative", "Very Conservative"). We then standardised and combined these two items into a reliable overall political belief measure ($\alpha = .91$), with higher scores representing greater political conservatism/Republican support. Support for President Trump was collected using a "feelings thermometer," with a rating of 0 representing "Very Cold or Unfavorable Feeling" and a rating of 100 representing "Very Warm or Favorable Feeling". Due to the divisive nature of President Trump within the Republican Party (Budowsky, 2017; Danforth, 2017), we kept this rating as a separate measure and did not combine it with the overall political belief measure.

Articles. Twelve articles (8 critical, 4 filler) were constructed to have a length of approximately 320 words ($M = 320.25$, $SD = 17.05$, *Range* = 294 – 343). All critical articles were opinion pieces because we were interested in the inferences that people made based on the articles, and previous research has found that misleading headlines influence inferences only for opinion articles (Ecker et al., 2014). Two headlines were created for each critical

article, one misleading and one congruent. Similar to Ecker et al.'s (2014) stimuli, early in each critical article a perspective was presented by a community member(s) or non-expert(s) and this perspective was then countered for the remainder of the article by arguments and/or evidence from an expert(s), researcher(s), and/or expert/scientific body. Headlines that emphasised the initial perspective of non-expert(s) were considered to be misleading and headlines that were consistent with the main arguments and/or evidence presented in the article were considered to be congruent. Misleading and congruent headlines differed by a maximum of one word in length for each article to ensure similarity in the characteristics of the headlines. Further, overall headline length was constructed to be similar across the misleading (M = 9.13, SD = 2.36, *Range* = 5 – 12), congruent (M = 9.13, SD = 2.10, *Range* = 6 – 12), and filler articles (M = 9.00, SD = 2.45, *Range* = 6 – 11).

For each article the participants answered three attention check questions, three inference questions, and four rating questions. Inference questions consisted of three different types: (1) one interpretation question that could be correctly answered based entirely on the article content, (2) one inference question for which the correct answer was not directly provided within the article but could be inferred based on article content, and (3) one behavioural question that asked participants whether they would behave in a manner in line with the main argument of the article (see Figure 5.1 for examples of the different types of inference question). Participants responded to the inference questions using a visual analogue scale that ranged from 0-100. Responses to the three different inference question types (interpretation, inference, and behavioural) were combined to produce an average level of agreement with the main point of the article (higher scores indicate greater agreement). The four rating questions asked about how interesting the article was (from 1 = "very uninteresting" to 5 = "very interesting"), how easy to read the article was (from 1 = "very difficult" to 5 = "very easy"), how informative the article was (from 1 = "very

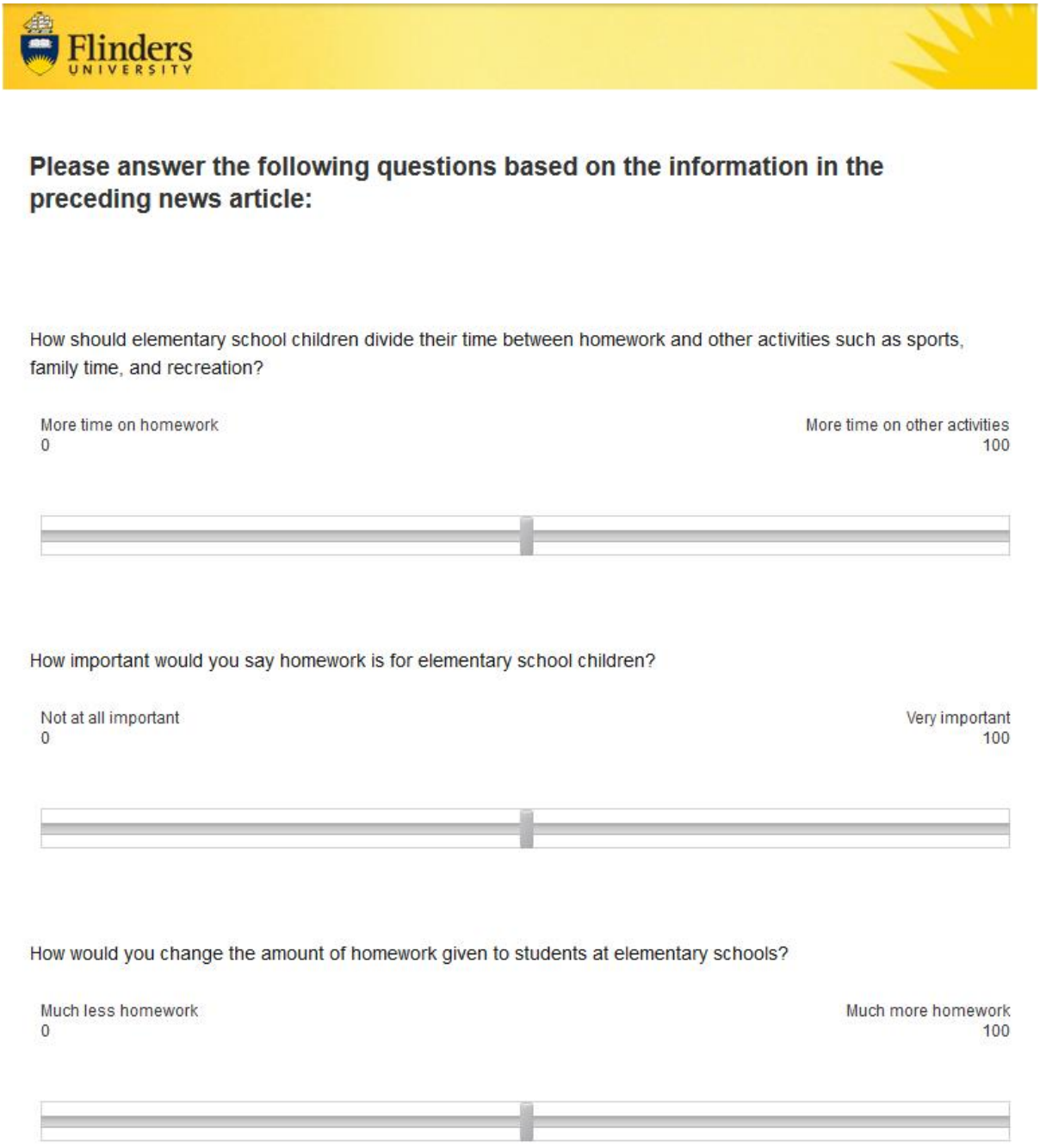


Figure 5.1. Example of three inference questions.

uninformative" to 5 = "very informative"), and how familiar they were with the topic discussed in the article (from 1 = "not at all familiar" to 5 = "very familiar"). Finally, each article also had three four-alternative-choice multiple choice attention check questions that asked about basic details in the articles to ensure that participants had read the article and paid attention (see Figure 5.2 for an example attention check question).

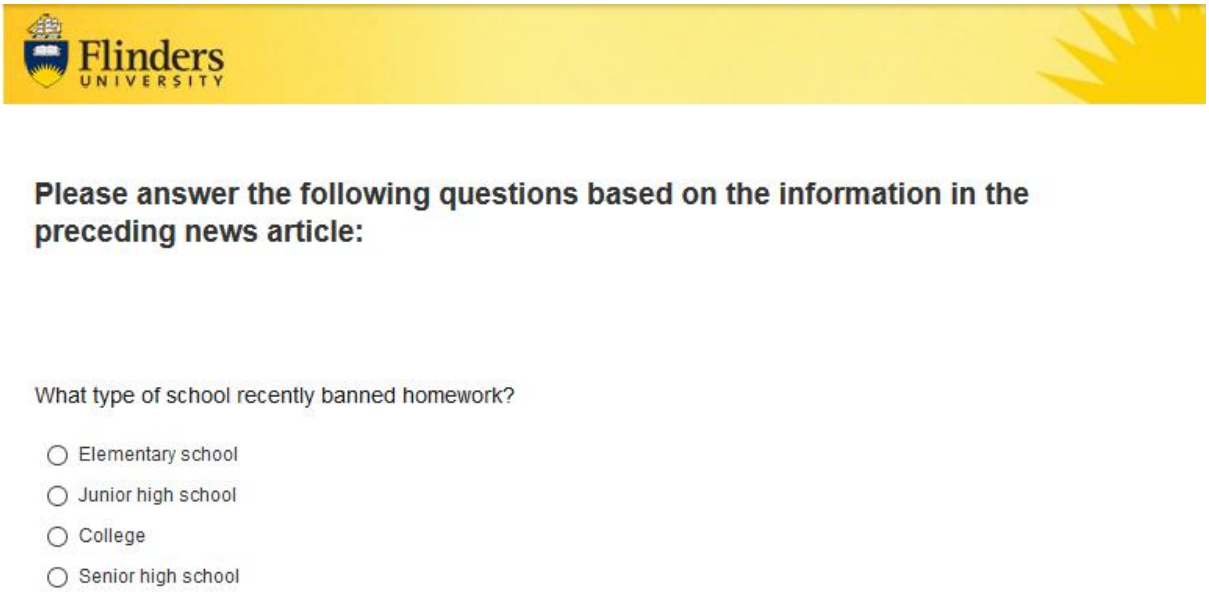


Figure 5.2. Example of an attention check question.

Cognitive Reflection Test (CRT). We used the expanded seven-item version of the CRT to measure whether participants relied on an intuitive or analytical thinking style (Frederick, 2005; Toplak, West, & Stanovich, 2014). For each item on the CRT there is an intuitive but incorrect answer that easily comes to mind. Therefore, the initial intuitive answer must be suppressed, and a participant must engage in analytical thinking to reach the correct answer. Scores are calculated by summing correct answers, with higher scores indicating a more reflective/analytical thinking style.

Procedure

The experiment was designed and administered online using Qualtrics (Qualtrics, 2017). Participants were randomly assigned to one of two counterbalanced conditions, with article order randomized anew per participant in each condition. Both conditions had the same articles, however, critical articles with a misleading headline in one condition were displayed with a congruent headline in the other, and vice versa. Each article was displayed for a maximum of 150 seconds, and participants were given the option to advance once the article had been displayed for at least 90 seconds. After the time limit (or participants chose

to advance), the article disappeared from the screen and participants were shown the three attention check questions related to the article. Participants then completed the three inference questions, followed by the four rating questions. To try to reduce the impact of previously held views on answers, participants were instructed to answer all of the questions based solely on the information in the preceding article.[2] Following the news article task, all participants completed the CRT. Participants then completed the ABS and political belief measures in a randomised order. Finally, participants completed the general demographic and education questions before they were debriefed.

Results

The primary variables of interest in the study were continuous, however, because headline type (misleading, congruent) was a within-subjects variable standard multiple regression analyses could not be used to analyse the relationships between the key predictors and inference accuracy. Therefore, we used a within-subjects regression method outlined by Ruscher (n.d.). This method uses a general linear model repeated measures ANCOVA to accommodate the within-subjects variable of headline type, with the (mean-centred) continuous variables of interest included as covariates. By outputting parameter estimates for this analysis it is possible to see the main effects of headline and the continuous variables as well as the interactions between headline type and the continuous predictors. For analyses that did not show any significant interactions between headline type and the key predictors, we used standard multiple regression to look at the relationship averaged across headline type. Bayes factors are reported alongside traditional null hypothesis significance testing (Wagenmakers, 2007), and were calculated using JASP with default priors (JASP Team, 2017, Version 0.8.2). They are reported in the form BF_{10}, which provides the odds ratio of the alternative/null hypotheses given the data; that is, values greater than 1 indicate support for the alternative, values equal to 1 indicate equal support for the alternative and the null, and

values less than 1 indicate support for the null. Descriptive statistics for inference accuracy and all key predictors are reported in Table 5.1.

Preregistered Analyses

A paired samples t-test was conducted to test for the effect of headline type (congruent, misleading). There was no significant difference in average inference score for articles with misleading headlines and congruent headlines, $t(370) = 1.15$, $p = .25$, $d = .06$, $BF_{10} = 0.11$. Thus, contrary to our predictions, misleading headlines had no influence on the inferences that people made based on the articles.

Correlations were used to analyse the relationships between inference scores, analytical thinking, anomalistic belief, and political beliefs (see Table 5.2). We focused on the relationships for inference scores averaged across headline type, however, the correlations are reported separately in Table 5.2 for misleading and congruent headlines. Higher (i.e., more accurate) inference scores were positively correlated with analytical thinking style, but they were negatively correlated with the overall ABS and with three of the ABS factors; experiential, PSI, and LAD. Also, inference scores were negatively related to conservative political beliefs and support for President Trump. Analytical thinking style was negatively correlated with overall level of anomalistic belief as well as with all of the ABS factors and both political conservatism and support for President Trump. Additionally, we found that anomalistic belief and all ABS factors except for the ET factor were positively correlated with higher levels of support for President Trump, whereas only the LAD factor was positively correlated with political conservatism. Finally, greater political conservatism and support for President Trump were strongly positively correlated.

Two separate within-subjects regressions were run to test the relationships between our key predictors and the accuracy of the inferences drawn from the articles, with headline type as the within-subjects factor and inference accuracy as the dependent variable. The first

Table 5.1.

Descriptive Statistics for Inference Accuracy and Key Predictors

Scales	Mean	SD	Min.	Max.
1. Overall Inference Average	63.06	13.39	23.25	96.13
2. Misleading Headline Inference Average	62.63	15.31	21.42	100.00
3. Congruent Headline Inference Average	63.48	14.97	25.08	98.50
4. CRT	3.15	2.24	0.00	7.00
5. ABS	2.54	1.21	1.00	6.48
6. Experiential Factor	1.51	0.84	1.00	6.57
7. PSI Factor	3.04	1.71	1.00	6.92
8. ET Factor	2.98	1.84	1.00	7.00
9. LAD Factor	3.41	1.85	1.00	7.00
10. Party Identification	3.53	1.81	1.00	7.00
11. Political Ideology	2.73	1.16	1.00	5.00
12. Trump Support	29.41	35.43	0.00	100.00

Note: $n = 371$

regression included the overall ABS score, political belief, support for President Trump, and thinking style as predictors (see Table 5.3). There were no significant interactions between headline type and any of the predictors, all Fs ≤ 1.28, ps $\geq .26$, $\eta_p^2 \leq .003$, range $BF_{10} = 0.08$ - 0.16. Therefore, the reported results are for inference accuracy averaged across headline type. Greater analytical thinking was associated with drawing more accurate inferences from the news articles, whereas both political conservatism and support for President Trump were negatively related to accurate inferences. However, contrary to our predictions, there was no significant relationship between overall anomalistic belief and inference accuracy.

Table 5.2.

Correlations for Inference, CRT, ABS, and Political Beliefs

Scales		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Overall Inference Average											
2. Misleading Headline Inference Average		.89***									
	BF_{10}	1.27×10^{122}									
3. Congruent Headline Inference Average		.88***	.56***								
	BF_{10}	2.97×10^{118}	2.38×10^{29}								
4. CRT		.23***	.18***	.22***							
	BF_{10}	996.95	33.13	483.77							
5. ABS		-.15**	-.15**	-.12*	-.29**						
	BF_{10}	4.50	4.25	0.81	500976.17						
6. Experiential Factor		-.16**	-.15**	-.14**	-.17***	.76***					
	BF_{10}	9.92	4.45	2.43	18.58	6.77×10^{118}					

(continued)

Table 5.2.

Correlations for Inference, CRT, ABS, and Political Beliefs

	Scales		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
7.	PSI Factor		-.15**	-.15**	-.11*	-.26***	.91***	.60***				
		BF_{10}	3.66	5.44	0.51	23711.39	1.26×10^{139}	1.20×10^{34}				
8.	ET Factor		-.06	-.05	-.05	-.21***	.78***	.51***	.54***			
		BF_{10}	0.12	0.10	0.11	249.73	1.27×10^{74}	2.16×10^{22}	1.11×10^{26}			
9.	LAD Factor		-.13**	-.14**	-.09	-.32***	.80***	.47***	.72***	.55****		
		BF_{10}	1.78	2.97	0.31	2.42×10^{7}	8.37×10^{81}	2.77×10^{18}	6.33×10^{56}	1.07×10^{27}		
10.	Political Belief		-.37***	-.33***	-.32***	-.12*	.01	-.03	.01	-.05	.12*	
		BF_{10}	2.87×10^{10}	9.14×10^{7}	3.83×10^{7}	0.87	0.07	0.07	0.07	0.11	1.13	
11.	Trump Support		-.39***	-.33***	-.36***	-.17***	.13*	.12*	.10*	.07	.15**	.73***
		BF_{10}	5.14×10^{11}	7.03×10^{7}	4.58×10^{9}	14.66	1.47	1.15	0.49	0.17	4.24	1.16×10^{60}

* = $p < .05$, ** = $p < .01$, *** = $p < .001$

The second regression was identical except it included the ABS factors instead of the overall ABS score (see Table 5.4). Again, there were no significant interactions between headline type and any of the predictors, all Fs ≤ 0.89, ps ≥ .35, η_p^2 ≤ .002, range BF_{10} = 0.08 - 0.21, and therefore the reported results are for inference accuracy averaged across headline type. We again found that greater analytical thinking was associated with more accurate inferences, and that both political conservatism and support for President Trump were associated with less accurate inferences. Further, we also found that higher experiential anomalistic belief was related to less accurate inferences. None of the other ABS factors were significantly related to inference accuracy.

Exploratory Analyses

One variable that may impact inference accuracy and/or interact with type of headline is whether the article was positive (supported a proposition) or negative (opposed a proposition). Therefore, we ensured when we were creating the stimuli that we had an even balance between articles where the overall point (and thus headline) was positive and negative. We decided to analyze inference accuracy using a 2 (headline: misleading, congruent) × 2 (positivity: positive, negative) within-subjects ANOVA. There were no main effects of positivity or congruence, and the interaction was not significant, all Fs ≤ 1.32, ps ≥ .25, η_p^2 ≤ .004, range BF_{10} = 0.09 - 0.13.

We collected the four ratings questions for each article about interest, ease of reading, informativeness, and familiarity because we were interested in whether these characteristics would influence people's inferences. Although there were significant correlations between ratings and inference accuracy for several of the individual articles, there do not appear to be any consistent patterns in the relationship between the ratings on these four dimensions and inference accuracy (see Table 5.5). Relatedly, paired samples t-tests showed that headline

Table 5.3.

Regressions Predicting Inference Accuracy (Averaged Across Headline Type) using Overall Anomalistic Belief, Political Belief, Trump Support, and Analytical Thinking

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2
Overall Model				<.001	5.09×10^{13}	22.60	.20	.19
Overall Anomalistic Belief (ABS)	-.08	[-.18, .02]	-1.65	.10	.60			
Political Belief	-.20	[-.34, -.07]	-2.92	.004	9.60			
Trump Support	-.20	[-.34, -.07]	-2.90	.004	9.13			
Analytical Thinking (CRT)	.14	[.05, .24]	2.92	.004	9.62			

β represents standardised regression coefficients

Table 5.4.

Regressions Predicting Inference Accuracy (Averaged Across Headline Type) using the ABS Factors, Political Belief, Trump Support, and Analytical Thinking

Variables	*β*	*β CI 95%*	*t*	*p*	BF_{10}	*F*	R^2	*Adj.* R^2
Overall Model				<.001	5.69×10^{12}	13.82	.21	.20
Experiential Factor	-.13	[-.25, -.01]	-2.07	.04	1.63			
PSI Factor	-.08	[-.23, .07]	-1.06	.29	0.36			
ET Factor	.05	[-.07, .17]	0.88	.38	0.31			
LAD Factor	.06	[-.08, .20]	0.81	.42	0.29			
Political Belief	-.22	[-.36, -.08]	-3.10	.002	19.71			
Trump Support	-.19	[-.33, -.05]	-2.66	.008	2.99			
Analytical Thinking (CRT)	.16	[.06, .25]	3.12	.002	21.13			

β represents standardised regression coefficients

Table 5.5.

Correlations between Inference, Informativeness, Ease of Reading, Interest, and Familiarity Separated by Article

Ratings		Article 1 Inference	Article 2 Inference	Article 3 Inference	Article 4 Inference	Article 5 Inference	Article 6 Inference	Article 7 Inference	Article 8 Inference	Average Inference
Interest		.03	.18***	.25***	.38***	-.14**	-.13*	-.25***	.09	.05 (.22)
	BF_{10}	0.08	20.56	10691.99	3.32×10^{11}	2.01	1.39	7739.98	0.29	
Ease of Reading		.12*	.06	.09	.24***	-.01	.03	-.02	.05	.07 (.08)
	BF_{10}	1.05	0.12	0.34	2266.77	0.07	0.08	0.07	0.11	
Informativeness		.05	.10	.16**	.34***	.00	-.14**	-.17***	.14**	.06 (.17)
	BF_{10}	0.11	0.37	7.79	2.80×10^{8}	0.07	2.52	16.37	1.99	
Familiarity		.09	.11*	.16**	.09	-.13*	-.07	-.18***	-.02	.06 (.12)
	BF_{10}	0.28	0.52	10.10	0.32	1.73	0.15	24.71	0.07	

Note. Standard deviation for the average correlation are in parentheses. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

congruence had no significant effect on the ratings, all ts ≤ 0.89, ps ≥ .37, d ≤ .05, range BF_{10} = 0.06 – 0.09.

In the above section we analyzed the average of the three inference questions because we had no a priori predictions about whether there would be differences in the way headline type would influence each individual question. However, we decided to look at whether the type of inference question mattered by running a 2 (headline: misleading, congruent) × 3 (inference type: interpretation, inference, behavioural) within-subjects ANOVA. There was a main effect of inference type, F (2, 740) = 141.80, MSE = 89.62, p < .001, η_p^2 = .28, BF_{10} = 2.37×10^{35}, but no main effect of headline and no interaction between headline and inference type, Fs ≤ 1.99, ps ≥ .14, η_p^2 ≤ .01, range BF_{10} = 0.04 - 0.17. Follow-up paired samples t-tests revealed that responses to the behavioural questions (M = 59.06, SD = 13.41) were significantly less accurate than responses for both interpretation (M = 62.78, SD = 13.77), t(370) = 8.44, p < .001, d = 0.44, BF_{10} = 6.32×10^{12}, and inference questions (M = 67.32, SD = 12.40), t(370) = 15.09, p < .001, d = 0.78, BF_{10} = 1.17×10^{37}. Additionally, responses to the interpretation questions were significantly less accurate than responses to the inference questions, t(370) = 9.47, p < .001, d = 0.49, BF_{10} = 1.16×10^{16}.

Discussion

Overall, we found support for the notion that lower analytical thinking, more conservative political beliefs, and support for President Trump are related to drawing less accurate inferences from news articles. The findings for anomalistic belief, though, were less clear. Although overall anomalistic belief and three of the ABS factors were negatively correlated with inference accuracy, these relationships were not found when anomalistic belief was entered into a regression with the other predictors. Further, even though there was a significant negative relationship between inference accuracy and experiential anomalistic belief, the Bayes factor was close to 1, which suggests there is little evidence in favour of

either the alternative or null hypothesis. We also found no support for our predictions regarding misleading headlines; indeed, the Bayes factor for the effect of headline actually supports the null hypothesis (i.e., no difference in inference ratings between articles with misleading and congruent headlines, $BF_{10} = 1/8.95$).

Although we predicted that anomalistic belief would be related to inference accuracy, these relationships were not significant once conservative political belief and Trump support were entered into the regressions. These findings suggest that anomalistic believers are not less accurate in the inferences that they draw from news articles. Previous work has shown that biases in evidence integration are primarily related to experiential anomalistic beliefs (Prike et al., 2018a). Experiential anomalistic beliefs are claims of either having personal experience of anomalistic phenomena or knowing someone who has had personal experience of anomalistic phenomena. Therefore, because people with higher levels of these beliefs are basing their beliefs on their own personal experiences and the experiences of people they know, even when these experiences are inconsistent with science and experts, it seemed likely that they would also place greater emphasis on the anecdotal opinions of the non-experts that were expressed at the beginning of the articles. However, unlike experiential anomalistic beliefs, the source of the initial perspectives presented in the article was a stranger rather than someone the person knew, and it may be that social connection (or lack thereof) plays a crucial role in the weight that people with greater experiential anomalistic belief give to a perspective. The results also suggest that anomalistic belief may be less associated with a distrust of scientists and experts than initially proposed (Irwin et al., 2016). For all articles the main point was presented by a scientist and/or expert. Therefore, if anomalistic belief was strongly related to distrust of those professions then it seems probable that anomalistic belief would be negatively related to level of agreement with the views and evidence presented by members of those professions.

The negative relationship found between analytical thinking and inference accuracy for news articles further highlights the important role of analytical thinking in our everyday lives (for a review, see; Pennycook, Fugelsang, & Koehler, 2015a). Given that news articles are a major source of information (Mitchell et al., 2016) but also regularly present "false balance" (Boykoff & Boykoff, 2004; Clarke, 2008; Dixon & Clarke, 2012) it is critical that news consumers are able to accurately assess the perspectives and evidence presented in the news articles and reach informed conclusions. Our findings are consistent with previous research that has shown a positive relationship between analytical thinking and the detection of conflict during reasoning (Pennycook et al., 2014) and suggest that analytical thinking also plays a role in detecting and responding to conflict between the perspectives presented in news articles. Because of the importance of drawing accurate inferences from news articles, the results also further highlight the need for efforts that focus on improving analytical and critical thinking to ensure that average members of the population are able to accurately consider and weight the evidence that they receive from the media (Priest, 2013).

Our results showed that political beliefs were related to differences in interpretation, after controlling for any effects due to analytical thinking, even for articles on topics that are not highly politicised. This suggests that the relationship between political belief and interpretation of information is not simply a result of motivated reasoning (Dawson, Gilovich, & Regan, 2002; Kahan, Peters, Dawson, & Slovic, 2017; Kunda, 1990; Stanovich, West, & Toplak, 2013). Rather, it may be that in addition to analytical thinking, there are other differences in the way that people of differing political beliefs interpret information and that these differences lead to divergence in the conclusions they reach. This finding also suggests that the current partisan divergence in opinion on issues may not only be due to differences in the news sources that people of different political beliefs choose to watch (Dellavigna & Kaplan, 2007; Mitchell, Gottfried, Kiley, & Matsa, 2014). In the current study, the news

articles were not affiliated with a particular news source, covered topics that were neither partisan nor highly politicised, and all presented the same information, yet political belief was still associated with reaching different conclusions. If, even when presented with the same non-partisan information, people of different political views do not interpret the information in the same manner, this may serve as a barrier to reaching political consensus on important issues. Additionally, we found that there was a negative relationship between support for President Trump and the accuracy of inferences, and that this relationship existed even after controlling for general political belief. This finding suggests that, consistent with our predictions, support for President Trump is distinct and is not simply subsumed by overall political ideology.

Consistent with previous research, we found that anomalistic belief, political conservatism, and support for President Trump were all negatively correlated with analytical thinking (Aarnio & Lindeman 2005, 2007; Deppe et al., 2015; Lane & Suklikowski, 2017; Pennycook et al., 2012; Svedholm & Lindeman, 2013). This finding for anomalistic belief is unsurprising because, by their very nature, anomalistic beliefs are not well supported by evidence and may therefore appeal to people who prefer intuition and/or "trusting your gut" rather than engaging in effortful and systematic thinking to reach a conclusion (Aarnio & Lindeman, 2005; 2007, Pennycook et al., 2012). The negative relationship found between analytical thinking and conservative political belief is perhaps less self-explanatory. One potential explanation is that there are several prominent features of conservative political ideology, such as a preference for hierarchy, structure, and avoidance of uncertainty (Deppe et al., 2015; Jost, Glaser, Kruglanski, & Sulloway, 2003; Jost, 2017) that are more consistent with an intuitive style of thinking. In contrast, liberal ideology tends to place greater emphasis on cognitive complexity, is more willing to accept uncertainty, and is often opposed to rigid rules or structure, and all of these processes require more reflective and analytical

thinking (Deppe et al., 2015; Jost et al., 2003; Jost, 2017). However, it is also important to keep in mind that the Bayes factor for the relationship between analytical thinking and conservative political ideology did not suggest there was strong evidence in favour of either the alternative or null hypothesis.

We also found a negative relationship between analytical thinking and support for President Trump. Although this relationship can likely be explained on similar grounds to the general negative relationship between political conservatism and analytical thinking, there are also specific characteristics of President Trump that may make this relationship more prominent. For example, in a recent linguistic analysis of the primary and presidential debates that lead up to the 2016 election, Jordan and Pennebaker (2017) found that Donald Trump was by far the least analytical candidate, more than 3 standard deviations below the average of both Republican and Democratic candidates. Therefore, one component that may contribute to the negative relationship between support for President Trump and analytical thinking is that President Trump's less analytical/more intuitive personal linguistic style makes him more likely to appeal to, and be supported by people, who have a more intuitive and less analytical thinking style.

One potential limitation that is important to keep in mind is that experts and scientists were used to present the evidence-based conclusion and supporting evidence for each article. There is already evidence to suggest that conservative political belief is related to holding more negative views of scientists and experts (Gauchat, 2012; Hamilton et al., 2015; Lewandowsky et al., 2017; Lewandowsky & Oberauer, 2016). Therefore, one potential explanation for the differences in the inferences drawn from the articles is that more politically conservative participants were simply less willing to accept the views of the scientists and experts. However, if news articles were constructed that avoided the confound of experts or scientists then contradicting views would instead have to be presented by non-

experts. But in a situation where non-experts are simply presenting their opinions it is unclear how the participants should weight the different perspectives presented or which views participants should rely on for drawing their own conclusions. For participants to properly consider the opinions presented by non-experts, they would likely have to rely on their own knowledge and expertise with the domain, meaning that their inferences would largely be a reflection of their views prior to reading the article. Additionally, it is impossible to have expertise across all issues and therefore participants will not have relevant expertise and domain knowledge for every issue that is covered in news articles. Therefore, in both reality and the current study, there is no option other than to rely on experts with relevant knowledge.

There are several key differences between the current study and the original Ecker et al. (2014) paper that may explain the different findings for the effect of headlines. One potentially important difference is the number of articles included in the studies. Ecker et al. used four articles, whereas twelve articles were used in the current study. The increased number of articles in the current study may have led participants to focus less of their attention on the headlines. This issue may have also been exacerbated because after each article participants were required to complete three recognition questions that served as attention checks. However, these recognition questions may have lead participants to further divert their attention away from the headlines to ensure that they could accurately answer the attention checks. Another possibility is that misleading headlines only impact inferences for certain topics. Ecker et al. looked at the influence of headlines on inferences for opinion articles that covered the controversial topics of fluoride in drinking water and the safety of genetically modified foods. However, because we were also interested in relationships between inference accuracy and both anomalistic and political beliefs we tried to ensure that we did not include highly politicised topics. The purpose of choosing non-politicised topics

was to reduce the likelihood that participants' inferences would be influenced by their prior beliefs, but it may also be the case that misleading headlines only influence inferential reasoning for controversial topics.

The inclusion of misinformation within the body of the article may also help to explain why headline had no impact. That is, because the headlines were designed to be misleading rather than factually inaccurate, they relied on cherry picking from within the article. This means that as well as being presented in the headline, the misleading information is also presented within the initial paragraph(s) of the actual article. Therefore, even in the articles with a congruent headline, the misinformation is still present at the beginning of the article and this presence alone may be enough to influence the inferences that people draw. If the mere presence of misinformation is indeed enough to influence the accuracy of inferences, then this would make the addition of a misleading headline that highlights the misinformation redundant. However, this feature of the articles was carried over from the previous work by Ecker et al. (2014) so although it may explain why no effect of headline was found, it does not explain the divergence in results between the studies.

Even after acknowledging the limitations, our study has several important implications for journalists and news editors. Although we did not find any influence of headlines, we did find that analytical thinking and political belief influenced the conclusions that people drew from the news articles. Therefore, it may be important to consider the potential that news articles will be interpreted in different ways by different audience segments and to further consider the content and framing of news articles to ensure that the article is conveying the desired message. Building on the current study, future research could examine whether there are specific characteristics of news articles that influence the extent to which readers reach divergent conclusions. For example, it may that the relationships between inference accuracy and analytical thinking, political belief, and Trump support exist

for articles that contain conflicting views but not for those that only present the evidence backed perspective. This would suggest that in instances where only one of the perspectives is well supported and evidence based, the more responsible route for journalists may be to avoid “false balance” and simply present the well supported perspective along with the supporting evidence.

The key findings from this study were that analytical thinking and political belief (but not anomalistic belief) were related to the accuracy of the inferences that people make based on news articles. Although we did not find any effect of misleading headlines on the inference accuracy, our study differed in several important ways from previous work by Ecker et al. (2014). Therefore, there is considerable scope for future work to establish whether there are specific circumstances in which misleading headlines do and do not influence inferential reasoning. Additionally, because there was no effect of misleading headlines, whether anomalistic beliefs, political beliefs, and/or analytical thinking are related to a greater susceptibility to misinformation are still open question for exploration in future research. Overall, our findings highlight the importance of considering political belief and analytical thinking when using news articles to inform people and further demonstrate the difficulty of communicating science and evidence backed perspectives to the public, even for non-politicised topics.

Footnotes

[1]See the preregistration for a complete list of exclusion criteria.

[2]Due to a technical issue, the instruction to "Please answer the following questions based on the information in the preceding news article" was randomised along with the 3 inference questions. However, a paired-samples t-test showed there was no significant difference in inference ratings for trials where the instruction appeared first ($M = 63.01$, $SD = 19.89$) and trials where it appeared after one or more of the inference questions ($M = 63.12$, $SD = 14.59$), $t(332) = 0.10$, $p = .92$, $BF_{10} = 0.06$. The Bayes factor suggests that the data are 16.19 times more likely under the null hypothesis and therefore it is unlikely that the technical issue influenced participant's inference ratings.

Chapter 6: What Do Non-Evidence Based Beliefs Have in Common? Examining the Potential Underlying Role of Evidence Integration Biases and Thinking Style

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The study materials for this chapter can be found in Appendices A and D.

Abstract

People who endorse one form of non-evidence based belief are more likely to also hold other non-evidence based beliefs, however, little research has examined potential psychological characteristics that might contribute to these relationships. The current study investigated whether analytical thinking and evidence integration biases were underlying cognitive characteristics that could explain the relationships between anomalistic beliefs, conspiracist beliefs, delusion proneness, political conservatism, and support for President Trump. The specific evidence integration biases measured were bias against disconfirmatory evidence (BADE), bias against confirmatory evidence (BACE), and liberal acceptance. Scenarios measured the evidence integration biases by giving participants three pieces of information, one at a time, and requiring them to rate four alternative explanations. Relationships were found between anomalistic, conspiracist, and delusion prone beliefs, but political conservatism and support for President Trump were not consistently related to the other beliefs. Although lower analytical thinking and higher liberal acceptance were related to greater endorsement of several of the beliefs measured, neither analytical thinking nor evidence integration biases explained a significant proportion of the relationships between the beliefs. Therefore, future work is needed to further examine if there are shared psychological characteristics that can explain the relationships between non-evidence based beliefs.

Keywords: Beliefs, analytical thinking, evidence integration biases, non-evidence based beliefs

Relationships Between Non-Evidence Based Beliefs: Examining the Potential Underlying Role of Evidence Integration Biases and Thinking Style

Beliefs are widely held that directly contradict the best available evidence and/or are not well supported by evidence (Chapman University, 2017; Moore, 2005; French & Stone, 2014; Shannon-Missal, 2013). We examined whether several common non-evidence based beliefs were related, and whether there are shared underlying cognitive tendencies that may make people more prone to a variety of non-evidence based beliefs; specifically, analytical thinking style and evidence integration biases. We focused on anomalistic beliefs, conspiracy theory beliefs, political beliefs, and delusional beliefs because studies have shown they are positively related (Darwin, Neave, & Holmes, 2011; Galliford & Furnham, 2017; Hergovich, Schott, & Arendasy, 2008; Prike, Arnold, & Williamson, 2018a). However, the existing body of research primarily has examined the relationships between two of these beliefs in isolation, or the relationship between an individual type of non-evidence based belief and one or more psychological characteristics. Therefore, the current study focused on the relationships between all four of these beliefs within the same study and tested whether biases in evidence integration and a less analytical thinking style explained the relationships found between these non-evidence based beliefs.

Relationships between a variety of non-evidence based beliefs have been found; for example, research has consistently shown a positive relationship between anomalistic beliefs and belief in conspiracy theories (Dagnall, Denovan, Drinkwater, Parker, & Clough, 2017; Darwin et al., 2011; Swami et al. 2011). Similarly, both anomalistic and conspiracist beliefs regularly have been shown to be related to delusion proneness (Cella, Vellante, & Preti, 2012; Dagnall, Drinkwater, Parker, Denovan, & Parton, 2015; Darwin et al., 2011). The links between the aforementioned belief types and political belief are less well established, however, several studies have shown links between conspiracy theory beliefs and more

conservative political beliefs (Bruder, Haffke, Neave, Nouripanah, & Imhoff, 2013; Galliford & Furnham, 2017), and between greater levels of anomalistic belief and more conservative political belief (Canetti & Pedahzur, 2002; Prike, Arnold, & Williamson, 2018b; see also Schlenker, Chambers, & Le, 2012, who found the opposite relationship).

One key component that ties the above beliefs together is their non-evidence based nature. Specifically, anomalistic beliefs contradict current scientific understandings of reality (French, 2001; French & Stone, 2014), and conspiracist beliefs reject mainstream explanations and instead seize on speculative claims of conspiracy and cover up that are not well supported by evidence (Douglas, Sutton, & Cichocka, 2017; Lewandowsky, Oberauer, & Gignac, 2013). Similarly, delusion proneness is a type of non-evidence based belief because delusions are unrepresentative of reality and are held despite contradictory evidence (Anandakumar, Connaughton, Coltheart, & Langdon, 2017; Moritz et al., 2017). Political beliefs are not necessarily non-evidence based, however, there is considerable evidence that political beliefs are resistant to change even when presented with counter evidence. Further, political beliefs also are associated with motivated reasoning (Kahan, Peters, Dawson, & Slovic, 2017; Kraft, Lodge, & Taber, 2015; Taber & Lodge, 2006), and conservative political beliefs in particular are related to increased mental rigidity, resistance to change, and rejection of cognitive complexity (Jost, Glaser, Kruglanski, & Sulloway, 2003). Conservative political beliefs also are associated with a distrust of scientists and experts, which may lead to less reliance on scientific evidence (Gauchat, 2012; Hamilton, Hartter, & Saito, 2015; Lewandowsky, Ecker, & Cook, 2017; Lewandowsky & Oberauer, 2016). Relatedly, because the current study was conducted in the United States, it is important to consider level of support for President Trump because he regularly promotes non-evidence based views and policies (Lewis, 2017) and has encouraged his supporters to distrust scientists, the media, and experts (Cillizza, 2017; Trump, 2017). President Trump also expresses himself in a more

intuitive, and less rational and analytical manner than other politicians from both the Republican and Democratic parties (Jordan & Pennebaker, 2017).

Given the above noted links between the four beliefs, it is highly plausible that they have at least some overlap between their underlying cognitive constructs. Further, there are several cognitive characteristics that have been shown to be related to more than one of these forms of belief. For example, greater anomalistic and conspiracist belief have been found to be related to ontological confusions (Lobato, Mendoza, Sims, & Chin, 2014) and the conjunction fallacy (Brotherton & French, 2014; Rogers, Davis, & Fisk, 2009). Studies also have shown that anomalistic belief and delusion proneness have a positive relationship with evidence integration biases (McLean, Mattiske, & Balzan, 2016; Prike et al., 2018a), and that higher conspiracist belief, anomalistic belief, and delusion proneness are related to hyperactive agency detection (Douglas, Sutton, Callan, Dawtry, & Harvey, 2016; van der Tempel & Alcock, 2015). Finally, political conservatism, anomalistic beliefs, and delusion proneness have all been shown to be negatively related to the need for cognition (Colbert & Peters, 2002; Irwin, Dagnall, & Drinkwater, 2012; Jost, 2017; Jost et al., 2003; McKay, Langdon, & Coltheart, 2006).

One underlying psychological characteristic that is important to investigate is analytical (vs. heuristic/intuitive) thinking style because it is negatively correlated with anomalistic belief (Aarnio & Lindeman 2005, 2007; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012; Prike et al., 2018b), belief in conspiracy theories (Ståhl & van Prooijen, 2018; Swami, Voracek, Stieger, Tran, & Furnham, 2014), delusion proneness (Ross, Hartig, & McKay, 2017; Wolfradt, Oubaid, Straube, Bischoff, & Mischo, 1999), conservative political ideology (Deppe et al., 2015; Jost, 2017; Lane & Suklikowski, 2017), and support for President Trump (Prike et al., 2018b). For example, Bouvet and Bonnefon (2015) found that less analytical thinkers were more likely to accept supernatural explanations of uncanny

events. Analytical thinking also is a broad measure of general thinking disposition and is related to performance on a battery of heuristic and bias tasks (Toplak, West, & Stanovich, 2011). Therefore, it is important to include an analytical thinking measure because it potentially is a core underlying cognitive characteristic that makes people less likely to endorse any form of non-evidence based belief. Additionally, Pennycook et al. (2012) proposed that analytical thinking may increase the likelihood of noticing the inconsistencies and/or non-evidence based nature of beliefs and subsequently lead people to reduce their level of belief.

Evidence integration biases were chosen as another potential underlying cognitive characteristic because a core shared feature of anomalistic, conspiracist, and delusional beliefs is that they are not well supported by evidence. As previously outlined, although political beliefs are not necessarily unsupported by evidence, they are highly resistant to change and are associated with motivated reasoning (Kahan, et al., 2017; Kraft, Lodge, & Taber, 2015; Taber & Lodge, 2006). Further, both motivated reasoning and resistance to belief change are likely to lead to greater bias in the interpretation of evidence. Thus, we chose to examine three evidence integration biases; bias against disconfirmatory evidence (BADE), bias against confirmatory evidence (BACE), and liberal acceptance. BADE and BACE biases are both related to updating beliefs or judgements when presented with new evidence. People exhibit a BADE when they are less willing to reduce their initial belief or judgement when presented with counter evidence, whereas BACE is bias against accepting a new alternative explanation that is supported by the new evidence. Liberal acceptance is also an evidence integration bias, however, it is a bias towards accepting conclusions or explanations that are highly implausible and/or have very little supporting evidence.

Previous research has demonstrated that both BADE and BACE are related to anomalistic belief (Prike et al., 2018a) and delusion proneness (Buchy, Woodward, & Liotti,

2007; McLean et al., 2016; Woodward, Buchy, Moritz & Liotti, 2007). Building on these findings, we proposed that non-evidence based beliefs more broadly were related to BADE because such beliefs are held despite the availability of considerable disconfirming evidence. That is, we predicted that people with higher levels of non-evidence based beliefs are less willing to reduce their initial beliefs when presented with disconfirming evidence, and that this resistance makes them especially prone to holding onto their non-evidence based beliefs despite the availability of counter evidence. Like BADE, we predicted that BACE is not only related to delusion proneness and anomalistic belief but also more broadly to other non-evidence based beliefs. We hypothesized that, because the same evidence that counters non-evidence based beliefs also often offers plausible alternative explanations, people who hold non-evidence based beliefs may exhibit a stronger BACE. That is, people higher in non-evidence based beliefs also are likely to be less willing to accept an alternative explanation to the one they initially believed, even when presented with evidence that supports the alternative explanation.

Liberal acceptance also has been shown to be related to both anomalistic belief (Prike et al., 2018a) and delusion proneness (Buchy et al., 2007; McLean et al., 2016; Woodward et al., 2007). However, we propose that it is highly plausible that liberal acceptance also is related to both conspiracy theory and political beliefs. Liberal acceptance leads to an increased likelihood of considering unlikely, non-evidence based explanations for experiences or events (Moritz et al., 2017). Because one core shared feature of the various beliefs we are investigating is that they are non-evidence based and/or are related to placing less emphasis on evidence (particularly scientific evidence), liberal acceptance is likely to play a role in whether people are willing to accept beliefs that are not well supported by evidence.

Based on both the previous research and the theoretical arguments outlined above, we predicted that there would be positive correlations between anomalistic belief, conspiracist belief, delusion proneness, conservative political belief, and support for President Trump. Further, we expected these belief measures would be negatively related to analytical thinking and positively related to BADE, BACE, and liberal acceptance. Most crucially, we predicted that analytical thinking, BADE, BACE, and liberal acceptance would explain a significant proportion of the variance explained by relationships between anomalistic belief, conspiracist belief, delusion proneness, conservative political belief, and support for President Trump.

Method

Participants

Two hundred and eight participants (66.2% female; 79.0% Caucasian) were recruited from Amazon's Mechanical Turk via TurkPrime (Litman, Robinson, & Abberbock, 2017) and reimbursed $2.00 for their time. Twenty-seven participants were removed prior to data analysis because they met one or more of the pre-set exclusion criteria (i.e., timing, multiple attempts, or failed attention checks).

Design and Materials

A correlational design was used, and the key belief measures were: (1) overall anomalistic belief (average score on the Anomalistic Belief Scale), (2) specific types of anomalistic belief (factors of the Anomalistic Belief Scale), (3) conspiracist belief, (4) delusion proneness, (5) political belief, and (6) support for President Trump. The key performance measures were: (1) BADE, (2) BACE, (3) liberal acceptance, and (4) analytical thinking.

Belief Measures.

Anomalistic Belief. We measured anomalistic belief using the Anomalistic Belief Scale (ABS; Prike et al., 2017), which contains 40 items and is a psychometrically valid

measure with good reliability (α = .97). The ABS covers both experiential (e.g., "I believe I have personally exerted psychokinesis on at least one occasion") and theoretical anomalistic beliefs (e.g., "I believe in the existence of ESP"; Prike et al., 2017), and it has four factors; an experiential belief factor that covers both paranormal and extra-terrestrial experiential beliefs (experiential factor, 14 items), a theoretical paranormal belief factor (PSI factor, 13 items), a theoretical extra-terrestrial belief factor (ET factors, 8 items), and a life after death factor that covers both theoretical and experiential life after death beliefs (LAD factor, 5 items). Responses for the ABS are collected using a 7-point scale (from 1 = "strongly disagree" to 7 = "strongly agree") and were averaged to provide an overall ABS score as well as separate average scores for each of the four factors. Thus, higher values for the overall ABS and factor scores indicate greater anomalistic belief.

Conspiracist Belief. Conspiracist beliefs were measured using the Generic Conspiracist Beliefs Scale (GCBS; Brotherton, French, & Pickering, 2013) and the Belief in Conspiracy Theories Inventory (BCTI; Swami, Chamorro-Premuzic, & Furnham, 2010). The GCBS has 15 items that measure general conspiracist ideation (vs. endorsement of specific conspiracy theories); that is, it measures the core underlying components or shared features of conspiracist ideation using items such as "A small, secret group of people is responsible for making all major world decisions, such as going to war." Participants responded to items on the GCBS using a 5-point scale (from 1 = "definitely not true" to 5 = "definitely true") and responses were averaged to provide an overall GCBS score, with higher scores indicating greater conspiracist ideation. In contrast, the BCTI is a 15 item measure that covers a wide range of commonly endorsed conspiracy theories such as "The Apollo moon landings never happened and were staged in a Hollywood film studio" and "The assassination of John F. Kennedy was not committed by the lone gunman, Lee Harvey Oswald, but was rather a detailed, organised conspiracy to kill the President". Responses to the BCTI were recorded on

a 9-point scale (from 1= “completely false” to 9 = “completely true”) and were averaged to provide an overall BCTI score, with higher scores indicating greater endorsement of specific conspiracy theories.[1]

Delusion Proneness. Delusion proneness was measured using the Peters et al. Delusions Inventory (PDI; Peters et al., 2004). The PDI contains 21 items and is a widely used and psychometrically sound measure of subclinical delusion proneness in the general population (Peters et al., 2004; Zawadski et al., 2012). The PDI measures endorsement of a variety of delusion relevant items (e.g., “Do your thoughts ever feel alien to you in some way?”) using “yes” and “no” responses. Whenever a participant responded “yes” to a PDI item, three follow up questions were asked; the level of distress caused by the belief (from 1 = “not at all distressing” to 5 = “very distressing”), how often they think about the belief or experience (from 1 = “hardly ever think about it” to 5 = “think about it all the time”), and the extent to which they think the belief is true (from 1 = “don't believe it's true” to 5 = “believe it is absolutely true”). The total number of yes responses and total scores for the follow-up questions were summed to provide an overall measure of delusion proneness (Total PDI), with a potential range of 0 to 336 and higher scores indicating greater delusion-proneness (Peters et al., 2004).

Political Beliefs. Political belief was recorded with two different measures. First, it was measured using Lewandowsky et al.’s (2013) Conservatism-Liberalism scale (Con-Lib) that contains 7 items related to the endorsement of ideologically relevant political positions (e.g., “I cannot see myself ever voting to elect conservative candidates”). Participants responded on a 5 point scale (from 1= “strongly disagree” to 5 = “strongly agree”), and responses were averaged to provide an overall score, with higher scores indicating greater political conservatism. Second, political belief was measured using two questions taken from Kahan et al. (2017); one question asked about participants’ support for political parties

(response options: “Strong Democrat”, “Democrat”, “Independent Lean Democrat”, “Independent”, “Independent Lean Republican”, “Republican”, “Strong Republican”), and one that asked about endorsement of political ideology (response options: “Very Liberal”, “Liberal”, “Moderate”, “Conservative”, “Very Conservative”). These two questions were standardised and combined to form the PIPI (political ideology party identification) measure of political belief, with larger values indicating more conservative political beliefs. On the same screen as the PIPI we measured support for President Trump using a feelings thermometer that ranged from 0 (“Very Cold or Unfavorable Feeling”) to 100 (“Very Warm or Favorable Feeling”). However, support for President Trump was kept as a separate measure from the overall political measures due to his divisive nature within the Republican Party (Budowsky, 2017; Danforth, 2017).

Performance Measures.

Thinking Style. Analytical thinking style was measured using a 7-item version of the Cognitive Reflection Test (CRT; Frederick, 2005; Toplak, West, & Stanovich, 2014). Each item on the CRT cues an immediate intuitive but incorrect response. Therefore, to answer the items correctly participants must override that intuitive response and engage in deliberative analytical thinking. The CRT was scored by summing the number of correct responses, with higher scores indicating a more analytical thinking style.

Evidence Integration Scenarios. Twenty-four scenarios (18 critical, 6 filler; Woodward et al. 2007) were used to measure evidence integration biases. For each scenario participants were presented with three pieces of evidence, one at a time. After receiving each piece of evidence participants made an independent likelihood rating on a 0-100 scale for four separate response options (i.e., could place all options at 0, all at 100, or anywhere in between; see Figure 1). These ratings were made after each piece of evidence, allowing participants to increase or decrease their likelihood ratings in response to the new evidence.

For the critical trials the four response options were: (1) a neutral lure, (2) an emotional lure, (3) an absurd option, and (4) a true option. The lure options were equally or more likely than the true option after the first piece of evidence was provided. However, once the second and third piece of evidence were provided the lure options became much less likely and it became clear that the true option was the correct answer. The absurd option was not supported by any of the evidence provided and therefore remained unlikely throughout the procedure.

Measures of BADE, BACE, and liberal acceptance were calculated based on the methods recommended in McLean et al.'s (2016) recent meta-analysis of evidence integration biases. BADE was measured separately for the emotional and neutral lures by subtracting the likelihood rating for the lures after the third piece of evidence from the lure likelihood rating after the first piece of evidence. However, because these two ratings were highly positively correlated (r = .96), and there was no important theoretical reason to distinguish between BADE for neutral and emotional lures, we averaged across the neutral and emotional lures to form an overall BADE measure. Therefore, the BADE measure shows the amount that participants reduced their likelihood rating for the lures in response to the disconfirmatory evidence. BACE was measured by subtracting the likelihood rating for the true option after the first piece of evidence from the likelihood rating for the true option after the third piece evidence. Thus, BACE shows the amount that the likelihood rating for the true option increased in response to the confirmatory evidence. Liberal acceptance was calculated by averaging the likelihood rating for the absurd option across the three ratings (one after each piece of evidence) to provide a measure of how willing participants were to endorse absurd options that were not supported by any evidence.

Additional Measures. Basic demographic information such as age and gender were collected along with participants' overall level of education and their level of education in the specific disciplines of psychology, statistics, and mathematics.

Procedure

Participants completed the study online using Qualtrics software (Qualtrics, 2017). Participants first completed the 24 evidence integration scenarios, presented in a randomised order. They were instructed that they would be shown three statements, one at a time, and that each statement would provide additional information about the person or event being described. Participants were told their task was to provide an independent rating for each of the four response options based on how consistent the response option was with the person or event described in the statement(s), and to reconsider the response options after each new statement was shown. Participants then completed the CRT under the instructions that for each question they should consider the provided information and enter the answer they believed to be correct. Following the performance measures, participants completed the belief measures (ABS, BCTI, GCBS, delusion proneness, Conservatism-Liberalism, PIPI, and Trump support) in a randomised order. Participants were instructed that there were no right or wrong answers for the belief measures, and that they should select the response that best represents what they truly think for each question. Finally, participants completed the demographic and education questions.

Results

We have included both standard null hypothesis significance testing and Bayes factors that were calculated using JASP with default priors (Wagenmakers, 2007; JASP Team, 2018, Version 0.8.6). Bayes factors are reported in the form BF_{10} to provide an odds ratio of the alternative hypothesis compared to the null hypothesis, given the data. Therefore, values greater than 1 indicate greater support for the alternative hypothesis, values less than 1 indicate greater support for the null hypothesis, and 1 indicates that there is equal support for both the alternative and the null hypothesis. Descriptive statistics for all belief measures are reported in Table 6.1.

Table 6.1.

Descriptive Statistics for Beliefs

Scales	Mean	SD	Min.	Max.
1. ABS	2.55	1.22	1.00	6.75
2. Experiential Factor	1.65	1.00	1.00	6.71
3. PSI Factor	2.93	1.64	1.00	6.85
4. ET Factor	2.98	1.77	1.00	7.00
5. LAD Factor	3.41	1.79	1.00	7.00
6. GCBS	2.69	1.05	1.00	5.00
7. BCTI	3.77	1.96	1.00	9.00
8. Groups Conspiring	2.47	2.28	0.00	9.00
9. Total PDI	38.59	36.15	0.00	184.00
10. Conservatism-Liberalism	3.07	1.02	1.00	5.00
11. Party Identification	3.75	1.78	1.00	7.00
12. Political Ideology	2.87	1.17	1.00	5.00
13. Trump Support	36.75	35.75	0.00	100.00

Note: $n = 371$

Correlations Between the Performance Measures

Correlations between the performance measures are reported in Table 6.2. There were no significant correlations between analytical thinking and any of the evidence integration biases. For the evidence integration biases, liberal acceptance was positively correlated with both BADE and BACE, however, the relationship between liberal acceptance and BACE was very strong whereas the relationship between liberal acceptance and BACE was only weak-medium. BADE and BACE were significantly negatively correlated.

Correlations Between Performance Measures and Belief

The correlations between belief and the performance measures show that some, but not all of the beliefs, were significantly related to analytical thinking and evidence integration biases (see Table 6.3). Specifically, analytical thinking style was negatively correlated with

Table 6.2.

Correlations Between Thinking Style and the Evidence Integration Biases

Performance Measure		1.	2.	3.
1. CRT				
2. BADE (Average)		-.05		
	BF_{10}	0.11		
3. BACE		-.11	-.29***	
	BF_{10}	0.25	176.16	
4. Liberal Acceptance		-.11	.24**	.75***
	BF_{10}	0.28	19.75	2.63×10^{30}

Note. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

all of the measures of conspiracist belief, all measures of general political belief, and support for President Trump. However, although analytical thinking was significantly negatively correlated with the experiential and LAD factors of the ABS, it was not significantly correlated with overall anomalistic belief, or with the PSI or ET factors. There also was no significant relationship between analytical thinking and delusion proneness.

BADE was significantly positively correlated only with overall anomalistic belief and the experiential factor of the ABS. BACE also was positively correlated with overall anomalistic belief and the experiential factor, however, BACE also was significantly positively correlated with the PSI factor and the BCTI conspiracist belief measure. Finally, liberal acceptance was significantly positively correlated with the ABS and all of its factors, as well as with both the GCBS and BCTI conspiracist belief measures.

Correlations Between the Beliefs

Consistent with our hypotheses, we found that all measures of anomalistic belief, conspiracist belief, and delusion proneness were significantly positively correlated. However, the findings for political belief were more mixed. The Con-Lib political belief measure was not significantly correlated with any of the belief measures, whereas the PIPI measure was

Table 6.3.

Correlations Between Thinking Style, Evidence Integration Bias, and Beliefs

	ABS	Experiential Factor	PSI Factor	ET Factor	LAD Factor	GCBS	BCTI	Groups Conspiring	Delusion Proneness	Con-Lib	PIPI	Trump Support
CRT	-.14	-.20**	-.10	-.03	-.18*	-.28***	-.25***	-.15*	-.13	-.24**	-.30***	-.28***
BF_{10}	0.58	3.61	0.22	0.10	1.76	136.15	23.47	0.68	0.40	14.61	293.40	158.27
BADE (Average)	.18*	.41***	.13	-.01	.02	.11	.09	-.05	-.01	.01	.04	.13
BF_{10}	1.45	855790	0.42	0.09	0.10	0.28	0.20	0.12	0.09	0.09	0.11	0.42
BACE	.28***	.36***	.20**	.23	.13	.13	.25***	.08	.01	-.12	-.08	-.04
BF_{10}	120.84	14667.7	2.99	11.64	0.43	0.45	24.47	0.16	0.10	0.36	0.17	0.11
Liberal Acceptance	.39***	.57***	.28***	.26***	.17*	.22**	.32***	.04	.06	-.10	-.05	.04
BF_{10}	229093	1.25×10^{14}	125.39	40.05	1.11	7.55	1497.07	0.11	0.13	0.23	0.12	0.11

Table 6.4.

Correlations Between Beliefs: Zero-order and Partial Correlations Controlling for Thinking Style and Evidence Integration Biases (bottom diagonal) and Difference in r^2 Between Zero-order and Partial Correlations (top diagonal)

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. ABS		.05	.01	-.01	-.03	.04	.07**	.00	-.01	.00	.00	.01
Partial *r*												
2. Experiential Factor	.76***		.04	-.01	-.01	.06*	.09*	.00	-.01	.00	.00	.02
Partial *r*	.73***											
3. PSI Factor	.91***	.58***		.02	.00	.03	.05*	.00	.00	.00	.00	.00
Partial *r*	.91***	.54***										
4. ET Factor	.81***	.48***	.61***		.01	.00	.02	.00	.00	.00	.00	.00
Partial *r*	.81***	.49***	.58***									
5. LAD Factor	.81***	.44***	.73***	.61***		.04	.04	.01	.01	.00	.01	.01
Partial *r*	.83***	.46***	.73***	.60***								
6. GCBS	.55***	.35***	.45***	.57***	.47***		.02	.00	.01	.01	.02	.03*
Partial *r*	.51***	.26***	.41***	.57***	.42***							
7. BCTI	.60***	.46***	.45***	.64***	.46***	.85***		-.01	.01	.00	.01	.02
Partial *r*	.54***	.35***	.40***	.63***	.42***	.84***						
8. Groups Conspiring	.31***	.09	.28***	.38***	.29***	.59***	.57***		.01	.01	.01	.01
Partial *r*	.32***	.09	.28***	.39***	.27***	.59***	.58***					

(continued)

Table 6.4.

Correlations Between Beliefs: Zero-order and Partial Correlations Controlling for Thinking Style and Evidence Integration Biases (bottom diagonal) and Difference in r^2 Between Zero-order and Partial Correlations (top diagonal)

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
9. Delusion Proneness	.35***	.21**	.31***	.33***	.33***	.41***	.37***	.28***		.00	.01	.01
Partial *r*	.36***	.24***	.31***	.32***	.31***	.40***	.36***	.27***				
10. Con-Lib	-.02	-.05	.00	-.08	.11	.13	.05	.18*	.08		.01	.01
Partial *r*	.00	-.04	.01	-.05	.09	.09	.03	.16*	.05			
11. PIPI	.07	.05	.07	-.01	.13	.26***	.20**	.27***	.14	.88***		.03
Partial *r*	.07	.04	.07	.01	.10	.21**	.18*	.25***	.11	.88***		
12. Trump Support	.13	.20**	.08	.01	.18*	.24**	.22**	.16*	.09	.73***	.76***	
Partial *r*	.09	.16*	.05	.00	.14	.17*	.17*	.14	.06	.72***	.74***	

Note. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

significantly positively correlated with conspiracist belief. Further, support for President Trump was positively correlated with conspiracist belief and with both the experiential and LAD factors, but not with any other of the belief measures.

To test whether analytical thinking style and evidence integration biases explained a significant proportion of the variance explained by the relationships between the beliefs, we compared the zero-order correlations between the beliefs with the corresponding partial correlations after controlling for analytical thinking style, BADE, BACE, and liberal acceptance (see Table 6.4). Cohen and Cohen (1983) show that a partial correlation is a correlation between two variables from which the variance explained by another variable(s) has been partialled (p. 92). That is, a partial correlation is the correlation between the residuals of the two variables. Therefore, the variance explained by analytical thinking, BADE, BACE, and liberal acceptance was partialled out from each belief variable to produce standardized residuals. Thus, the correlation between the standardized residuals are equal to the partial correlations. As a consequence, this allowed the zero order correlations to be compared with the corresponding partial correlations using Steiger's (1980) method for comparing the magnitude of correlations taken from the same sample.

In general, we only found limited support for our prediction that thinking style and evidence integration biases would explain a significant proportion of the relationships between the various beliefs. We did find that analytical thinking style, BADE, BACE, and liberal acceptance explained a significant proportion of the relationships between the BCTI and certain forms of anomalistic belief, namely the overall ABS, the experiential factor, and the PSI factor. Analytical thinking style and the three evidence integration biases also explained a significant proportion of the relationship between the GCBS conspiracist belief measure and the experiential factor, as well as between the GCBS and support for President Trump. However, there were no other significant differences between the strength of the zero-

order and partial correlations for any of the other relationships between the beliefs. It also is important to note that we compared the strength of 66 pairs of correlations, and none of the previously outlined differences between the zero-order and partial correlations would be significant at the Bonferroni adjusted level of $p < .00076$.

Discussion

There was mixed evidence for the predicted relationships between analytical thinking style, evidence integration biases, and non-evidence based beliefs. The results suggest that analytical thinking and liberal acceptance are more consistently related to non-evidence based belief than either BADE or BACE. However, even analytical thinking and liberal acceptance were not related to all the measured beliefs. Additionally, although we found evidence for relationships between some of the beliefs and analytical thinking style and evidence integration biases, we did not find support for the prediction that analytical thinking style and evidence integration biases would explain a significant proportion of the relationship between the various non-evidence based beliefs. Taken together, these results suggest that analytical thinking and liberal acceptance may be positively related to a variety of non-evidence based beliefs, but they do not explain the relationships between these beliefs (i.e., they do not explain what these beliefs share in common).

Consistent with previous research, we found positive correlations between the various beliefs that most clearly fit the non-evidence based definition; that is, anomalistic, conspiracist, and delusion prone beliefs. These three beliefs correlated regardless of the subtype of anomalistic belief or the measure of conspiracist belief that was used. Further, most of the relationships between anomalistic belief and conspiracist belief were strong or very strong, whereas delusion proneness was consistently related to both anomalistic and conspiracist beliefs at a medium strength. There is considerable variation in the content of anomalistic, conspiracist, and delusion prone beliefs (e.g., beliefs in 9/11, belief in

psychokinesis etc.), and yet positive relationships are consistently found both in the current study and in previous research (Cella et al., 2012; Dagnall et al., 2015; Darwin et al., 2011), which may suggest that it is the non-evidence based nature of these beliefs that links them together.

Political belief was not consistently related to the other non-evidence based beliefs, which suggests that even though conservative political belief is related to aspects such as mental rigidity and resistance to change (Jost et al., 2003), more conservative political belief is not related more broadly to greater levels of non-evidence based beliefs. However, even though our political belief measures were not related to non-evidence based beliefs in general, both greater conservatism on the PIPI measure and support for President Trump were related to higher levels of conspiracist belief. One potential explanation for these relationships is the political nature of many conspiracy theories (Miller, Saunders, & Farhart, 2016; Oliver & Wood, 2014). Specifically, people higher in political conservatism and support for President Trump may be more motivated than liberals to reinforce their worldview by endorsing conspiracy theories (Blank & Shaw, 2015; Jost et al., 2003; Miller et al., 2016). Additionally, President Trump and some conservative political commentators have promoted conspiracy theories (Andersen, 2018; DelReal, 2016; Finnegan, 2016; Schwartz, 2018), which may have encouraged Trump supporters and conservatives to endorse conspiracy theories and/or encouraged conspiracist believers to support President Trump (and/or become more politically conservative). Therefore, conspiracist beliefs may be related to political belief because they provide a political and/or identity supportive function rather than because they are non-evidence based. A promising avenue for future research on the relationship between political and non-evidence based beliefs is the effect of the strength or extremism of political beliefs. van Prooijen, Krouwel, and Pollet (2015) found that political extremism was related to greater endorsement of conspiracy theories, regardless of whether

the political views were left or right leaning. In future research, rather than focusing on political conservatism, it may be worthwhile exploring whether political extremism is related to non-evidence based beliefs more broadly.

Anomalistic and delusion prone beliefs are typically less politically relevant and therefore may not provide the same motivated reasoning and/or identity supportive function (Kahan et al., 2017; Kunda, 1990; Miller et al., 2016) for political conservatives and supporters of President Trump that conspiracist beliefs do. The non-political nature of anomalistic and delusion prone beliefs may explain why, even though anomalistic, delusion prone, and conspiracist beliefs are all non-evidence based, only conspiracist beliefs were related to greater political conservatism. The role of identity also may help to explain why no significant relationship was found between conspiracist beliefs and the Con-Lib political belief measure. That is, the Con-Lib measure contains a series of ideologically relevant questions; for example, by asking about views on socialism and capitalism (Lewandowsky et al., 2013). Therefore, in comparison to the PIPI and measure of support for President Trump, the Con-Lib scale has less focus on support for a specific political party/political figure. Support for political parties and individuals may be the most identity relevant aspects of political belief and therefore the most likely to lead to motivated reasoning (Kahan et al., 2017).

One characteristic shared by President Trump (Decker, 2017; Terris, 2018) and claims of experiencing anomalistic phenomena that may help explain the positive relationship we found between them is that they both place greater emphasis on the role of personal experience and individual claims over broader scientific and expert consensus/views. That is, this shared valuing of personal experiences over scientific and expert views may explain why the people who are more supportive of President Trump also have greater experiential anomalistic belief. Support for President Trump also was related to anomalistic beliefs about

life after death, which potentially can be explained by his high level of support from religious groups, particularly white evangelicals (Smith, 2017). Although there are differences between anomalistic and traditional religious beliefs about life after death, there is still a non-trivial overlap in belief content, and both types of life after death beliefs may be motivated by a desire for an afterlife (Thalbourne, 1996).

Of the cognitive characteristics investigated, analytical thinking and liberal acceptance may be the most promising potential underlying cognitive characteristics that lead to a variety of non-evidence based beliefs. In terms of analytical thinking, our results are consistent with the notion that greater analytical thinking leads people to notice the inconsistencies or non-evidence based nature of the beliefs and reduce their level of belief (Pennycook et al., 2012). The results for liberal acceptance also showed some limited support for our prediction that it may be one of the underlying mechanisms leading to non-evidence based beliefs, with higher levels of both anomalistic and conspiracist belief associated with an increased endorsement of unlikely non-evidence based explanations. We found less support for the idea that BADE and BACE contribute to the maintenance of a variety of non-evidence based beliefs, with the results showing that BADE and BACE were primarily only related to anomalistic beliefs.

Our failure to find a relationship between delusion proneness and the analytical thinking, liberal acceptance, BADE, or BACE measures was somewhat surprising because previous research has found that delusion proneness is related both to analytical thinking and evidence integration biases (Ross et al., 2017; Wolfradt et al., 1999). Further, relationships between delusion proneness and liberal acceptance, BADE, and BACE are particularly well established (for a recent meta-analysis see McLean et al., 2016), with liberal acceptance proposed as one mechanism in the formation of delusions (Moritz et al., 2017). However, the overall level of delusion proneness in our sample was quite low (M = 38.6, SD = 36.2, range

= 0 - 184), especially when compared to Peters et al.'s norms (*M* = 58.9, *SD* = 48.0, range = 0 - 291; 2004). This low level of delusion proneness in our sample may have limited our ability to detect relationships between delusion proneness and thinking style or evidence integration biases. Therefore, based on the cumulative evidence (McLean et al., 2016; Moritz et al., 2017), it is still likely that these relationships exist, but the current study highlights that these relationships may only be present at clinical and/or high levels of nonclinical delusion proneness.

Another surprising finding was that analytical thinking style was not significantly related to liberal acceptance in the current study, which is somewhat inconsistent with Bouvet and Bonnefon's (2015) finding that less analytical people were more willing to accept non-evidence based explanations. However, Bouvet and Bonnefon's experiments examined whether participants would accept paranormal explanations, and thus it may be that analytical thinking specifically reduces willingness to accept paranormal explanations but that it is not related to liberal acceptance more broadly. Additionally, we found a negative relationship between the BADE and BACE biases, suggesting that people who were less willing to adjust their initial ratings for the lures when presented with disconfirmatory evidence were more willing to accept the answer supported by the new evidence. The negative relationship between BADE and BACE may reflect an increased willingness of some participants to accept multiple explanations as plausible rather than updating their beliefs to align with the true option (Moritz & Woodward, 2004). This explanation of the BADE and BACE relationship is supported by the finding that both BADE and BACE were positively correlated with liberal acceptance. However, previous research has not found any significant correlation between BADE and BACE (Prike et al., 2018a; Veckenstedt et al., 2011) and therefore the relationship between BADE and BACE should be interpreted cautiously.

For the sake of simplicity, we chose to focus on a small number of cognitive characteristics; that is, only analytical thinking and evidence integration biases. However, belief is a highly complex and multifaceted area and therefore there are likely to be a considerable number of characteristics, psychological and otherwise, that are shared by non-evidence based beliefs (Connors & Halligan, 2015). Based on the findings for conservatism and political belief, it may be useful to explore the role of motivation in the endorsement of non-evidence based beliefs. For example, it may be that lower analytical thinking does contribute to the formation of non-evidence based beliefs, but only for people with a social network that is supportive of the non-evidence based beliefs and/or when the beliefs fulfil a psychological need, such as by providing meaning (Graeupner & Coman, 2017).

Because of their non-evidence based nature, thinking style and evidence integration biases seemed like good candidates for broad cognitive characteristics that explain the relationships between a variety of non-evidence based beliefs. However, even though analytical thinking style and liberal acceptance were often related to the various non-evidence based beliefs, they did not explain a significant proportion of the relationships between the various non-evidence based beliefs. Even in the limited number of cases where we found that thinking style and evidence integration biases significantly reduced the strength of the relationships between the beliefs, only a small proportion of the relationship was explained. Further, these effects were no longer significant once a correction was applied for multiple comparisons. Therefore, even if analytical thinking style and evidence integration biases are related to greater endorsement of a variety of non-evidence based beliefs, they do not explain what these beliefs share in common. Thus, it is important to continue exploring the similarities and distinctions between various non-evidence based beliefs to establish whether there are shared psychological characteristics, cognitive or otherwise, that can explain the relationships between these beliefs.

Footnotes

[1]In addition to the overall conspiracist belief measures, we also included a question from Uscinski, Klofstad, and Atkinson (2016) at the end of the GCBS. The question asked what groups conspire against us. We have included the results for this measure (total number of groups selected) in Tables 6.3 and 6.4, however, for brevity and focus we do not discuss this question further.

Chapter 7: General Discussion

General Discussion

This thesis investigated the relationships between anomalistic beliefs, probabilistic reasoning, and cognitive bias. Overall, the results showed that anomalistic beliefs were significantly related to poorer performance on conjunction fallacy, misperception of chance, and base rate fallacy reasoning tasks, as well as to greater bias when assessing and integrating evidence. The research in this thesis also used the Anomalistic Belief Scale (ABS) factors to perform more fine-grained analyses on specific subtypes of belief to show there is an important distinction between experiential and theoretical anomalistic beliefs. Specifically, the majority of the findings showed that experiential anomalistic beliefs typically were more strongly related to poorer probabilistic reasoning and greater cognitive bias.

Theories of Belief

The findings from the current thesis have several important implications for the formation and maintenance of anomalistic beliefs. Consistent with Brugger, Landis, and Regard (1990) and Blackmore and Troscianko (1985), the results showed that greater anomalistic belief was related to poorer probabilistic reasoning, supporting the claim that a poorer understanding of probability leads people to interpret everyday coincidences and chance events as having an anomalistic cause/explanation. Further support for this account comes from the finding that the negative relationships between anomalistic belief and performance for both misperception of chance and the conjunction fallacy were only present for experiential anomalistic beliefs. Because deficits in probabilistic reasoning are proposed to lead people to interpret chance events or coincidences (i.e., experiences) as having an anomalistic cause, the theory implies that the relationship between anomalistic belief and probabilistic reasoning primarily occurs for experiential anomalistic beliefs. Relatedly, the positive relationships between anomalistic belief and liberal acceptance, bias against disconfirmatory evidence (BADE), and bias against confirmatory evidence (BACE) can be

integrated to help explain how poorer probabilistic reasoning may make some people more likely to interpret chance events as being anomalistic, which combines with liberal acceptance to increase the likelihood that they will accept unlikely anomalistic explanations as true. Further, having accepted an anomalistic explanation, a stronger BADE may then serve to protect the anomalistic belief from being discredited and BACE may prevent alternative non-anomalistic explanations from being considered and/or accepted.

Theories of belief formation can provide a useful framework for grounding the key findings of this thesis and relating them back to the literature on belief formation and revision. However, there are very few psychological theories of belief formation or revision, with most developed to explain delusional beliefs. Two delusional belief frameworks that are relevant for cognitive explanations of anomalistic belief are the two-factor theory of delusions (Coltheart, Langdon, & McKay, 2011; Langdon & Coltheart, 2000) and the two-stage cognitive theory of the positive symptoms of psychosis (subsequently referred to as the two-stage cognitive theory; Moritz et al., 2017). The two-factor theory proposes that delusions are formed when there is both a neuropsychological pathology that leads to anomalous experiences or perceptions (Factor 1) and deficits in belief evaluation that lead people to consider and accept delusional explanations (Factor 2; Coltheart, Langdon, & McKay, 2011; Langdon & Coltheart, 2000). In contrast, the two-stage cognitive theory proposes that liberal acceptance leads to the initial development of delusions at Stage 1, and then at Stage 2 confirmation biases and BADE strengthen the delusional beliefs and make them resistant to change.

Both the two-factor theory and two-stage cognitive theory of delusions share several key features with the previously discussed claim that a combination of probabilistic reasoning and cognitive bias contributes to the formation of anomalistic beliefs. For example, the conjunction fallacy, misperception of chance, base rate fallacy, analytical thinking, and liberal

acceptance are all belief evaluation deficits that relate to Factor 2 of the two-factor theory of delusions. Additionally, within the two-stage cognitive theory framework it may be that the conjunction fallacy, misperception of chance, base rate fallacy, analytical thinking, and liberal acceptance contribute to the initial formation of anomalistic beliefs at Stage 1. Subsequently, at Stage 2, BADE and BACE may contribute to the maintenance of these non-evidence based beliefs despite the availability of disconfirmatory evidence and plausible non-anomalistic explanations.

One important limitation to applying either the two-factor or two-stage cognitive theories of delusions to anomalistic beliefs is that they do not allow for a satisfactory explanation of how the process of anomalistic belief formation begins. For example, the application of the two-factor theory is limited by its claim that a neuropsychological pathology leads to anomalous experiences or perceptions; that is, in the case of anomalistic and other non-evidence based beliefs (and even for a large number of delusional beliefs), it does not seem likely that the first step in belief formation is a specific neuropsychological pathology. In contrast, the two-stage cognitive theory starts with the premise that liberal acceptance causes a lowered decision threshold and greater willingness to entertain and accept unlikely explanations. However, this theory does not define *how* or *why* the initial belief formation process begins. That is, although liberal acceptance may lead to greater consideration and acceptance of delusional or anomalistic beliefs, the two-stage cognitive theory does not specify why people are attempting to generate beliefs or explanations in the first place, nor what are the relevant inputs that motivate the formation of a belief.

To the best of my knowledge, the only cognitive framework for general belief formation is Connors and Halligan's (2015) five-stage account of belief. One advantage that Connors and Halligan's framework has over the frameworks developed with a specific focus on delusions is that it provides greater consideration of the variety of stages that likely are

related to belief, whereas the other theories tend to focus only on narrow aspects of the belief formation process. Additionally, the stages of Connors and Halligan's framework are more flexible and therefore can more easily encompass the complex nature of belief. In Connors and Halligans framework, the five stages of belief are: (1) precursor, (2) search for meaning, (3) candidate belief evaluation, (4) accepting or holding the belief, and (5) consequential effects of holding the belief. These five stages are discussed below and the findings from this thesis are integrated into the framework to provide greater insight into how cognitive bias and reasoning relate to anomalistic beliefs.

The first stage of the five-stage account involves a precursor that initiates the process of belief formation. A precursor can come in a wide variety of forms, such as personal experience, social interaction, consumption of information, and/or introspection. For example, experiencing a strange coincidence that does not seem easily explainable or watching a documentary about a haunted house are both potential precursors for the formation of an anomalistic belief. The experiments in the current thesis were not primarily focused on the precursor stage of belief; that is, the measures included did not generally relate to precursors. However, in Chapters 4 and 6 relationships were found between anomalistic beliefs and delusion proneness, and greater delusion proneness may generate precursors to anomalistic belief by increasing the likelihood that someone will have a strange experience(s). These strange experiences may then serve as a precursor for the formation of anomalistic beliefs, particularly experiential anomalistic beliefs. Support for this idea comes from previous research that has found that personal experience with seemingly anomalistic phenomena is related to anomalistic belief, suggesting that these experiences are a common precursor for the formation of anomalistic beliefs (Clarke, 1995; Glicksohn, 1990). Relatedly, social interactions and information received from the media are other reasons that people cite

for their anomalistic belief, and therefore are also likely precursors for anomalistic belief (Clarke, 1995).

The second "search for meaning" stage occurs in response to the first precursor stage. Within this second stage potential beliefs (i.e., candidate beliefs) are generated that potentially can account for the precursor. Because the candidate beliefs are generated in response to a precursor, the characteristics of the precursor and any other relevant information available are likely to strongly influence the number and content of the candidate beliefs that are generated. An important aspect of this belief stage is that candidate beliefs are not generated within a vacuum, and therefore, candidate beliefs are likely to be highly reliant on prior beliefs and knowledge. For example, if you already hold one anomalistic belief, then this belief may make you more likely to generate further anomalistic candidate beliefs in response to future belief precursors. Across the chapters of this thesis it consistently was shown that anomalistic beliefs were positively correlated with other non-evidence based beliefs. Thus, because candidate beliefs are reliant on prior beliefs, it is plausible that holding other non-evidence based beliefs influences the type and content of candidate beliefs that are generated in response to a precursor. Through this process, holding non-evidence based beliefs may subsequently increase the likelihood of forming further anomalistic belief or other non-evidence based beliefs.

Probabilistic reasoning also is likely to play a role when generating candidate beliefs because a better understanding of probability allows for the generation of non-anomalistic, probability-based, candidate beliefs. For example, a better understanding of chance increases the likelihood that if someone has a strange coincidence described to them by a friend, they will generate the candidate belief that the coincidence was the result of chance. BADE and BACE biases and analytical thinking also may influence whether people are willing to generate a variety of candidate beliefs for consideration or instead stick with their initially

generated candidate belief that is more intuitive and/or more consistent with their pre-existing beliefs. For example, someone who is more intuitive may be less likely to take the time to reflect on their candidate belief and generate additional, alternative candidate beliefs. Stronger BADE and BACE biases may also limit the candidate beliefs generated because of a decreased willingness to generate candidate beliefs that challenge their pre-existing beliefs (i.e., only belief supporting candidate beliefs are generated).

The third "candidate belief evaluation" stage involves the assessment of the potential beliefs generated during the second stage. This stage is most directly related to the research in this thesis. Probabilistic reasoning, thinking style, and cognitive bias are all likely to influence the assessments of the likelihood and suitability of both anomalistic and non-anomalistic candidate beliefs. For example, if you have the strange experience of thinking of a friend and then having that person unexpectedly call you, then understanding both the likelihood of two events co-occurring (the conjunction fallacy) and the base rate likelihood of those events (the base rate fallacy) is important for assessing an anomalistic candidate belief and comparing it with a chance-based candidate belief. Additionally, stronger BADE and BACE biases may increase the emphasis placed on how well the candidate beliefs cohere with pre-existing beliefs, leading to an increased weighting of belief-coherent candidate beliefs. There also is a potential influence of analytical thinking because people with greater analytical thinking may be more willing and able to engage in deliberative systematic evaluation of the candidate beliefs, rather than relying on initial intuitive/heuristic responses. Finally, consistent with the two-stage cognitive theory, liberal acceptance may make someone more willing to consider absurd or highly unlikely candidate beliefs (Moritz et al., 2017).

The fourth stage involves "accepting or holding the belief". Liberal acceptance leads to lowered decision thresholds and therefore is likely to exert a strong influence on the fourth belief acceptance stage. Because of lowered decision thresholds, less evidence is required

before a belief is accepted. Therefore, if an anomalistic candidate belief is produced, liberal acceptance may mean that these belief candidates reach the decision threshold and are accepted even if they are not well supported by evidence. It is worth noting that there is considerable overlap between stages 4 and 5 of the five-stage account of belief and stages 1 and 2 of the two-stage cognitive theory (Moritz et al., 2017). However, one key difference is that stage 2 of the two-stage theory focuses specifically on the development of delusional conviction, whereas stage 5 of the five-stage account considers the effects of belief more broadly.

The fifth and final stage of the five-stage account is the "consequential effects of holding the belief" stage. This stage relates to the flow on effects that come from accepting and holding a belief. One of the most likely consequences of accepting a belief is that people stop generating new candidate beliefs (Mortiz et al., 2017). Additionally, to protect this newly formed belief, people are likely to engage in confirmation bias and process new information in a way that is congruent with, and supportive of, their belief. The finding that BADE and BACE biases are related to anomalistic belief suggests that, having accepted a belief, people with greater anomalistic beliefs may be more protective of their newly formed belief. Therefore, anomalistic believers may be more likely to dismiss evidence that does not conform to their pre-existing belief(s) and be less willing to consider alternative explanations. Although not directly assessed within this thesis, there are a variety of other consequential effects of holding anomalistic beliefs such as an increased vulnerability to psychic scams (Australian Competition and Consumer Commission, 2018; Cohn, 2016). For example, because pre-existing beliefs influence belief formation, someone who holds an anomalistic belief will subsequently be more likely to believe that an individual claiming to be psychic actually possesses psychic abilities.

One important question that remains unanswered is which specific stages of belief are and are not influenced by probabilistic reasoning and cognitive biases. For example, although it seems most likely that poor probabilistic reasoning contributes to the search for meaning and candidate belief evaluation stages, it also is possible that probabilistic reasoning plays a role at the precursor stage. If a coincidence is experienced as strange regardless of probabilistic reasoning ability, then probabilistic reasoning is likely to influence only the candidate beliefs generated and the assessment of those candidate beliefs. However, poorer probabilistic reasoning may also influence whether the initial experience of a coincidence seems strange and becomes a precursor for belief formation.

There is a small amount of previous work that has attempted to distinguish between having experiences that potentially could be interpreted as anomalistic (e.g., accurately foretelling a future event) and assigning anomalistic interpretations to those experiences (e.g., the foretelling was premonition or ESP vs. it was just good judgement or a coincidence; Irwin, Dagnall, & Drinkwater, 2013; Ross, Hartig, & McKay, 2017). Although Irwin et al. did not investigate the role of probabilistic reasoning, they found that reality testing, emotion-based reasoning, and schizotypy were related both to having potentially anomalistic experiences and to the likelihood of assigning anomalistic explanations to those experiences. However, these relationships were tested separately and there was a positive correlation between anomalistic experiences and assigning anomalistic explanations. Therefore, it may be that the relationship for one of the anomalistic variables (i.e., either anomalistic experiences or anomalistic explanations) is spurious and caused by the relationship between the other anomalistic variable and reality testing, emotion-based reasoning, and schizotypy.

Ross et al. used the same measure as Irwin et al. (2013) to distinguish between anomalistic experience and assigning anomalistic explanations to those experiences. They found that analytical thinking style was not related to having anomalistic experiences but was

significantly related to the likelihood of assigning anomalistic explanations to those experiences. Ross et al.'s finding is supportive of the notion that probabilistic reasoning and cognitive bias are more strongly related to later stages of belief than to the precursor stage. However, it would be beneficial in future work to more clearly distinguish between the various stages of belief to allow for further investigation of whether psychological characteristics relate differently to the various belief stages. Establishing that specific psychological characteristics are related to different stages of belief has the potential to provide greater insight into both anomalistic belief and belief more broadly. For example, if it can be clearly established that probabilistic reasoning plays a key role in the evaluation of anomalistic candidate beliefs, there may be a stage within belief assessment more broadly that involves the probabilistic evaluation of candidate beliefs.

Experiential Versus Theoretical Distinction

The findings throughout this thesis were generally supportive of the assertion that there is an important distinction between experiential and theoretical anomalistic beliefs. For most of the reasoning and bias tasks investigated, experiential anomalistic beliefs either were the type of belief most strongly related to poorer performance or were the only type of anomalistic belief significantly related to performance. These findings may provide a potential explanation for the mixed findings in the literature (see Chapters 1, 2, and 3 for a more detailed discussion of these mixed findings; Blackmore & Troscianko, 1985; Blackmore, 1997; Blagrove, French, & Jones., 2006; Brugger et al., 1990; Dagnall, Parker, & Munley, 2007; Musch & Ehrenberg, 2002; Rogers, Davis, & Fisk, 2009; Stuart-Hamilton, Nayak, & Priest, 2006; Wiseman & Watt 2006). That is, previous research typically has relied on broad overall measures of anomalistic belief without considering the specific type of the anomalistic beliefs held within the sample. The findings in this thesis suggest that there may be important distinctions between someone with a mid-range average anomalistic belief score

that is due to endorsing theoretical beliefs and someone who has the same overall level of belief but also endorses experiential anomalistic belief. However, this distinction cannot be detected in measures that do not include a sufficient number of both theoretical and experiential belief items

It is important to consider potential explanations for why experiential anomalistic beliefs frequently were found to be more strongly related to poorer reasoning and greater bias. One reason for the distinction between experiential and theoretical anomalistic beliefs may be that experiential anomalistic beliefs involve additional belief claims that are stronger and more concrete. That is, both types require the belief that anomalistic phenomena are possible, however, experiential anomalistic beliefs require the additional belief that either you personally or someone that you know has experienced anomalistic phenomena. Thus, it may be that it is the willingness to accept anomalistic explanations for experiences and make these additional claims that leads experiential anomalistic beliefs to be more strongly related to poorer probabilistic reasoning and greater cognitive bias. In contrast, purely theoretical anomalistic beliefs may be reflective of general open mindedness and a willingness to entertain the possibility of unlikely and unconventional phenomena (Smith, Johnson, & Hathway, 2009) and therefore may not involve deficits in probabilistic reasoning and/or greater cognitive bias. Theoretical anomalistic beliefs do not require someone to interpret any specific incident or experience as evidence for the existence of anomalistic phenomena. Rather, they simply have to be open to the notion that anomalistic phenomena are possible/plausible.

Another potential explanation for the distinction between experiential and theoretical anomalistic beliefs is that experiential anomalistic beliefs share greater overlap and similarity with delusion proneness than theoretical anomalistic beliefs. That is, because delusion proneness and/or hallucinations can cause weird or strange experiences to occur in the first

place, experiential anomalistic beliefs may be more closely related to delusion proneness. Consistent with this explanation, in Chapter 4 we found that experiential anomalistic beliefs were more strongly related to delusion proneness than theoretical beliefs. This finding was not replicated in Chapter 6, however, the level of delusion proneness in the Chapter 6 sample was particularly low which may have limited the ability for the relationship to be detected. Future research should established whether experiential (vs. theoretical) anomalistic beliefs are more closely related to delusion proneness and whether this relationship with delusion proneness contributes to the stronger associations between experiential anomalistic belief and both probabilistic reasoning and cognitive biases.

Other researchers studying anomalistic belief also have highlighted the importance of considering individual factors of belief rather than relying just on broad overall scales (Dagnall, Drinkwater, Denovan, Parker, & Rowley, 2016; Irwin, Drinkwater, & Dagnall, 2014; Rogers, Fisk, & Lowrie, 2016). In recent work using the Revised-Paranormal Belief scale, Dagnall et al. and Irwin et al. analysed the two factors, New Age Philosophy and Traditional Paranormal Beliefs, separately rather than just looking at the overall anomalistic belief score. Similarly, Rogers et al. (2016) conducted analyses using the ESP, psychokinesis (PK), and life after death factors of the Australian Sheep-Goat Scale rather than just relying on an overall averaged score. As discussed in Chapters 2, 3, and 4, the findings from these studies further demonstrate the importance of distinguishing between different types of anomalistic belief. However, one disadvantage of the factor structure of the Australian Sheep-Goat Scale and the Revised-Paranormal Belief scale is that the factors are differentiated based on belief content. The ABS also has three factors that differentiate based on belief content – the theoretical PSI factor, the theoretical ET factor, and the theoretical and experiential LAD factor – however, the ABS also has the experiential factor that is differentiated based on whether the anomalistic belief is theoretical or experiential rather than based on belief

content. One important caveat is that a confirmatory factor analysis has not yet been conducted on the ABS. The test-re-test reliability of the ABS has also not yet been established. Therefore, a high priority for future work is to further establish the validity and reliability of the ABS.

Recent research into the relationship between political belief and analytical thinking provides further evidence that it is important to consider the dimensionality and subtypes of belief rather than relying on overall measures (Deppe et al., 2015; Yilmaz & Saribay, 2017). Previous research had produced mixed results for the relationship between lower analytical thinking and political conservatism (Kahan, 2013; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012). However, recent research has revealed that one of the key reasons for these mixed findings is that the negative relationship between analytical thinking and conservative political beliefs varies depending on whether the beliefs are socially or economically conservative (Deppe et al., 2015; Yilmaz & Saribay, 2017). Specifically, higher socially conservative political beliefs were found to be related to lower levels of analytical thinking, but there was no significant relationship between economically conservative political beliefs and analytical thinking. Therefore, one contributor to the inconsistency in the previous findings was that broad overall measures of political belief had primarily been used, without consideration of whether participants with higher levels of conservative political beliefs were socially or economically conservative.

Although the specific focus of this thesis is anomalistic belief, the distinction found between experiential and theoretical anomalistic beliefs is also potentially important for other forms of non-evidence based beliefs. The theoretical/experiential distinction is easily applicable to some other forms of non-evidence based belief, such as belief in complementary and alternative medicine. Many people have had experience with complementary and alternative medicines such as aromatherapy or homeopathy, and thus future research could

examine the distinction between beliefs in the theoretical efficacy of complementary and alternative medicine and beliefs in personal experience that demonstrates the efficacy. However, applying the theoretical/experiential distinction to other non-evidence based beliefs, such as conspiracy theory beliefs is not as straight forward. Although belief in conspiracy theories is common, people tend to believe in the same conspiracy theories that are based on major world events and news stories that they have no personal experience of (Swami et al., 2011). For example, large numbers of people believe that 9/11 was an inside job but it seems unlikely that they also believe that they or someone they know was personally involved in conspiring to commit 9/11.

Beyond looking at just a theoretical/experiential distinction, another approach that future research can take is to examine the distinction between theoretical beliefs (i.e., a belief that something is plausible or exists) and claiming that there is evidence to support the belief. This approach is consistent with the "stronger claim" explanation for why probabilistic reasoning and cognitive bias were more strongly related to experiential anomalistic beliefs. There are numerous forms of evidence other than personal experience or the experience of a social connection that someone could use as a justification for a belief or as evidence of a belief's veracity. For example, someone may claim that there is evidence for the existence of an anomalistic phenomena based on a documentary that they have seen or an article that they read. Therefore, there is considerable scope for future research into anomalistic beliefs, as well as non-evidence based beliefs more broadly, to examine whether there are distinctions in the cognitive characteristics of people who hold theoretical beliefs and those who claim to have evidence to support a non-evidence based belief.

The Role of Causation

One important limitation of our research, and of research within the field of belief more generally, is that correlational designs are primarily used to establish the relationships

between anomalistic belief and cognitive characteristics because of the difficulty of manipulating belief, reasoning ability, and cognitive bias. However, there is a limited ability to make causal claims because these correlational designs only examine existing relationships. There are theoretical arguments to support both causal directions and therefore, without experimental manipulation of either belief or the cognitive predictor variables, it is difficult to clearly establish whether cognitive characteristics lead to belief or vice versa.

One explanation is that holding anomalistic beliefs causes people to develop poorer reasoning and greater cognitive bias. As discussed in Chapter 3, research into motivated reasoning has clearly established that pre-existing beliefs can influence reasoning and bias (Dawson, Gilovich, & Regan, 2002; Kahan, Peters, Dawson, & Slovic, 2017; Kunda, 1990; Stanovich, West, & Toplak, 2013). Therefore, it is possible that anomalistic beliefs (and other non-evidence based beliefs more broadly) are related to poorer reasoning performance and cognitive biases because reasoning poorly and displaying stronger cognitive bias serves to protect and support the non-evidence based beliefs. However, although research into the effect of context has produced inconsistent findings, in general there is limited evidence to suggest that deficits in probabilistic reasoning are heightened for problems framed in an anomalistic context (Chapter 3; Dagnall, Drinkwater, Parker, & Rowley, 2014; Dagnall et al., 2016; Rogers et al., 2009; Rogers et al., 2016; Rogers, Fisk, & Wiltshire, 2011). Additionally, throughout the current thesis and the anomalistic belief literature in general, relationships between anomalistic belief and both greater cognitive bias and poorer probabilistic reasoning have been found for stimuli presented in a neutral context. Overall, the cumulative findings seem more supportive of the notion that cognitive characteristics (e.g., poorer reasoning and cognitive bias) cause people to develop anomalistic and other non-evidence based beliefs.

There also is some previous work that has used experimental paradigms to examine the relationship between anomalistic belief and analytical thinking. Several researchers have

shown that certain manipulations of analytical thinking can lead to a reduction in supernatural (Gervais & Norenzayan, 2012; Shenhav, Rand, & Greene, 2012) and conspiratorial beliefs (Swami, Voracek, Stieger, Tran, & Furnham, 2014). For example, Gervais and Norenzayan and Swami et al. found that participants who unscrambled sentences containing analytical words subsequently displayed greater analytical thinking and reduced religious (Gervais & Norenzayan) and conspiracist beliefs (Swami et al.). These findings may be taken as evidence of the causal effect that analytical thinking has on anomalistic beliefs. However, subsequent work has found that manipulations of analytical thinking used in these studies do not replicate, with no differences in analytical thinking found between experimental groups (Deppe et al., 2015; Sanchez, Sundermeier, Gray, Calin-Jageman, 2017). Bouvet and Bonnefon (2015) also used an experimental paradigm, however, rather than manipulating analytical thinking they showed that baseline analytical thinking was predictive of how likely participants were to accept an anomalistic explanation for a potentially anomalous experience. Bouvet and Bonnefon presented participants with Barnum statements and informed them that they were personality profiles generated based on the participant's astral theme. In follow up experiments, they used a confederate and a code system to make it seem as though telepathy was occurring. In both paradigms, base line analytical thinking predicted how likely participants were to accept an anomalistic explanation of the phenomena, even after controlling for base line anomalistic belief. Therefore, Bouvet and Bonnefon's findings provide tentative evidence that analytical thinking plays a causal role in the formation of experiential anomalistic beliefs.

Although there is some evidence to support the causal role of analytical thinking in anomalistic beliefs, there is no experimental evidence to support the causal roles of probabilistic reasoning or cognitive bias. However, there are a variety of methods that potentially could be used in future research to try to establish the causal role of probabilistic

reasoning and cognitive bias. Several studies have shown that it is possible to use magic tricks to present participants with experiences/demonstrations that appear to be anomalistic (Benassi, Singer, & Reynolds, 1980; Mohr, Koutrakis, & Kuhn, 2015; Subbotsky, 2004; Wiseman, Greening, & Smith, 2003). Magic tricks have been used to expose participants to fake psychic demonstrations (Benassi et al., 1980; Mohr et al., 2015) and also demonstrations of other anomalistic phenomena such as the transformation of an object after a spell is cast (Subbotsky, 2004). Alternatively a completely new and novel anomalistic belief could be introduced, similar to Swami et al.'s (2011) fictitious Red Bull conspiracy theory, either in written form or through a magic demonstration. If anomalistic belief, probabilistic reasoning, and cognitive bias were measured prior to using a magic trick to induce anomalistic belief it would be possible to control for base line anomalistic belief and test whether base line probabilistic reasoning and cognitive bias predicted increases in anomalistic belief in response to the belief inducing manipulation. It would also be possible to test whether inducing anomalistic belief via these demonstrations leads to poorer probabilistic reasoning and greater cognitive bias at follow up. Conducting experiments such as these would have the potential to provide greater insight into the causal relationships between anomalistic belief, probabilistic reasoning, and cognitive bias.

Conclusion

The research presented in this thesis advances our understanding of anomalistic beliefs as well as non-evidence based beliefs more broadly. The findings demonstrate that probabilistic reasoning, cognitive bias, and analytical thinking are related to anomalistic belief and may play a role in the formation and maintenance of beliefs. Additionally, a new measure of anomalistic belief was developed, the ABS, which allowed for more detailed examination of the distinction between experiential and theoretical anomalistic beliefs. The experiential/theoretical distinction was found to be important, with results frequently showing

that experiential anomalistic beliefs were more closely related to deficits in probabilistic reasoning and greater cognitive bias. Future research is still necessary to establish whether reasoning and bias play a causal role in the formation and maintenance of anomalistic belief, as well as to develop a more comprehensive understanding of the relationships between non-evidence based beliefs. However, the findings from this thesis clearly highlight several reasoning deficits and cognitive biases that potentially play a causal role in the formation and maintenance of anomalistic beliefs.

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Appendix A

Anomalistic Belief Scale

Instructions:

Below are a series of questions that ask you about various extraordinary beliefs and experiences. Before the start of the questions we have provided definitions for some of the terms, so please have a quick read of the terms, and then feel free to refer back to them if you are unsure what a specific question is asking about.

There are no right or wrong answers, so please provide a response for each question that best represents what you truly think.

For each item indicate your attitude using the 7-point rating scale that ranges from "strongly disagree" to "strongly agree". Again, there are no right or wrong answers, and it is just important to use the full range of the scale to best represent what you think for each question.

Definitions:

Ghost: disembodied spirit of a deceased person (especially one believed to be similar in bodily likeness to living persons) that may or may not haunt a particular location or person.
Spirit of the dead: disembodied spirit of a deceased person.
Soul: the spiritual or immaterial part of a human being or animal, regarded as immortal.
Extra-sensory perception (ESP): acquisition of information about an external object or event (past, present, or future) without the use of the known sensory channels.
Extra-terrestrial (i.e., alien): any being who does not originate on earth.
Psychokinesis (PK): the alleged ability to mentally move or influence objects in the outside world without the mediation of any known physical energy.
Psychic healing: the alleged ability to cure or treat disease by mental influence alone without the use of physical curative substances or procedures.
Telepathy: direct mind-to-mind contact without the use of known sensory channels.
Tarot cards: a set of cards bearing representations, primarily used for fortune telling.
Crystals: a clear, transparent mineral or glass resembling ice.
Unidentified flying object (UFO): any object seen in the sky that cannot be identified as a known (e.g., airplane, blimp, balloon, etc.) object.

1. I believe in the existence of ESP.
2. I have had at least one vision that was not a hallucination and from which I received information that I could not have otherwise gained at that time and place.
3. I believe I have personally exerted psychokinesis on at least one occasion.
4. I believe that it is possible to gain information about the future that does not depend on rational prediction or normal sensory channels through the use of certain objects (e.g., tarot cards, tea leaves, crystals, etc.).
5. I believe that I have a "sixth sense".
6. I have had at least one dream that came true and which (I believe) was not just a coincidence.
7. I have personally known someone who has had an illness that was treated or cured through the use of psychic healing.
8. I believe that sometimes the spirits of the dead (or souls, ghosts, etc.) remain here attached to a particular place or person.
9. I believe I have had at least one experience of telepathy between myself and another person.
10. I believe that some people have a "sixth sense" that allows them to know things that do not depend on normal sensory channels.
11. I believe that it is possible to gain information about the thoughts, feelings or circumstances of another person, in a way that does not depend on rational prediction or normal sensory channels.
12. I believe I am psychic.
13. I believe that some people can contact spirits of the dead.
14. I believe in life after death (e.g., souls, spirits of the dead, ghosts, etc.).

15. I have personally known someone who, on at least one occasion, has had an experience with spirits of the dead (or souls, ghosts, etc.).
16. I believe I have had personal experience of ESP.
17. I believe that, on at least one occasion, inexplicable disturbances of an apparently psychokinetic origin have occurred in my presence.
18. I believe everyone has at least some ESP ability, but that only people open to the possibility of ESP can have a personal experience of ESP.
19. I believe I have marked psychokinetic ability.
20. I believe that, on at least one occasion, I have had personal experience with spirits of the dead (or souls, ghosts, etc.).
21. I believe it is possible to gain information about the future before it happens, in ways that do not depend on rational prediction or normal sensory channels.
22. I have had at least one premonition about the future that came true and which (I believe) was not just a coincidence.
23. I have had at least one experience with psychic healing that helped treat or cure an illness that I was suffering from.
24. I believe that it is possible to send a 'mental message' to another person (i.e., telepathy), or in some way influence them at a distance, by means other than the normal channels of communication.
25. I believe that at least some sightings of unidentified flying objects (UFOs) in the sky are the space ships of extra-terrestrials.
26. I believe extra-terrestrials have visited earth.
27. I believe that I have had direct contact with an extra-terrestrial here on earth.
28. I personally know of someone who has been taken aboard the space ship of extra-terrestrials and then returned back to earth.

29. I personally know someone who has had an experience that I believe is evidence of the existence of extra-terrestrials.
30. I believe that extra-terrestrials have left objects or relics here on earth (e.g., the pyramids).
31. I believe extra-terrestrials have made contact with human beings.
32. I believe that, on at least one occasion, I have been taken aboard the space ship of extra-terrestrials and then returned back to earth.
33. I believe that extra-terrestrials have taken humans aboard their space ships and then returned them back to earth
34. I personally know of someone who has had direct contact with an extra-terrestrial here on earth.
35. I believe that, on at least one occasion, I have had an experience that is evidence of the existence of extra-terrestrials.
36. I believe in the existence of extra-terrestrials somewhere in the universe.
37. I believe that concrete evidence of extra-terrestrials (e.g., crashed space ship) has been hidden from the general public.
38. I believe that, given the large number of personal accounts that have been reported over the years of extra-terrestrial contact, at least some of those accounts must be true.
39. I personally know of someone who I believe has seen a UFO in the sky that was an extra-terrestrial space ship.
40. I have seen at least one UFO in the sky that I believe was an extra-terrestrial space ship.

Reverse Scored Attention Check Questions

1. I believe that I have never witnessed someone use an object or objects (e.g. tarot cards, tea leaves, crystals, etc.) to gain information about the future.
2. I believe that it is impossible to gain information about the future through the use of certain objects (e.g. tarot cards, tea leaves, crystals, etc.).
3. I believe that psychic healing is fake and cannot be used to treat or cure disease.
4. I believe that psychokinesis is fake, that is, that people cannot mentally move or influence objects using their minds.

Appendix B

Conjunction Fallacy Items

Rank Order Instructions:

You are going to be presented with a series of scenarios, one at a time, and you will be asked to provide an answer to each one. Every scenario will have a list of options for you to consider, and your job is to move the options around until you are satisfied with your answer. Please read each scenario and its options carefully, and then think about your answer.

Try to read and answer each scenario within 1 min 30 seconds. A timer will appear below each scenario so that you can see how much time you have to read and answer each scenario. To ensure that people are reading through the scenario and fully considering the options before they answer, the computer will not allow you to move forward until a minimum amount of time has gone by. That is, the button to move to the next scenario will not appear until a minimum amount of time has passed.

Feel free to take the entire 1 min 30 seconds to respond, but if you have not answered when the 1 min and 30 seconds has run out, then please finish and move to the next scenario.

Please start by clicking the yellow arrow box below.

Likelihood out of 100 Instructions:

You are going to be presented with a series of scenarios, one at a time, and you will be asked to provide an answer to each one. Every scenario will have a list of options for you to consider, and your job is to rate how likely you think each option is out of 100 until you are satisfied with your answer. Please read each scenario and its options carefully, and then think about your answer.

Try to read and answer each scenario within 1 min 30 seconds. A timer will appear below each scenario so that you can see how much time you have to read and answer each scenario. To ensure that people are reading through the scenario and fully considering the options before they answer, the computer will not allow you to move forward until a minimum amount of time has gone by. That is, the button to move to the next scenario will not appear until a minimum amount of time has passed.

Feel free to take the entire 1 min 30 seconds to respond, but if you have not answered when the 1 min and 30 seconds has run out, then please finish and move to the next scenario.

Please start by clicking the yellow arrow box below.

1) Andrew is a 26 year old man who lives with another man called Steven. Andrew is a fan of Abba and George Michael and regularly attends football matches. In his spare time he makes videos of football trick shots.

- Andrew is a gay man.
- Andrew is a gay man who is a football fan.
- Andrew plays football for a local football team.
- Andrew is a football fan.

2) Mary was involved from very early childhood in sport activities. She was the fastest runner in her suburb. In primary school, she was by far the best of her class in throwing and catching a ball. At university, she decided to study sport science. Mary particularly enjoyed the social interactions of team sports.

- Mary plays in a hockey league.
- Mary swims for exercise and plays in a hockey league.
- Mary is a legal secretary.
- Mary swims for exercise.

3) Jodie is a single woman who lives with her mother. Jodie works part time and has been in her job for eight years. Jodie does not have many hobbies although she visits her local community centre regularly.

- Jodie has a learning disability.
- Jodie is employed as an administration clerk with the state government.
- Jodie is employed as an administration clerk with the state government and has a learning disability.
- Jodie plays chess for a hobby.

4) A heart health survey was conducted by the Pensioners Insurance Agency and the Heart Foundation that targeted a sample of adult males of all ages and occupations. Both initial and repeated heart attacks are more common in older people.

- Percentage of the men surveyed who are over 55 years of age.
- Percentage of the men surveyed who have had one or more heart attacks.
- Percentage of the men surveyed who had suffered from severe allergies.
- Percentage of the men surveyed who are both over 55 years of age and have had one or more heart attacks.

5) Later this year (2015) there will be a United Nations conference on climate change in Paris. One of the aims of the conference is to have countries commit to a plan to reduce their emissions.

- The United States of America will commit to a 28% reduction in emissions by 2030.
- The European Union will commit to a 40% reduction in emissions by 2030.
- The United States of America will commit to a 28% reduction in emissions by 2030 and the European Union will commit to a 40% reduction in emissions by 2030.
- Mexico will commit to a 25% reduction in emissions by 2030.

6) Sarah is 31 years old, single, outspoken, and very bright. She took a degree in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

- Sarah works in a bookshop.
- Sarah is active in the feminist movement.
- Sarah is a post office worker.
- Sarah is a post office worker and is active in the feminist movement.

7) Justin is 34 years old. He is intelligent, but unimaginative, compulsive, and generally lifeless. Justin enjoys jazz music in his spare time and is a fan of Cleo Laine. At school, he was strong in mathematics and music but weak in social studies and humanities.

- Justin is an accountant.
- Justin plays jazz for a hobby.
- Justin is a reporter.
- Justin is an accountant who plays jazz for a hobby.

8) Gordana is an immigrant from Slovakia and has lived in Australia for one year. She works a minimum wage job and studies part time to gain her Australian nursing qualification.

- Gordana is a qualified nurse in Slovakia.
- Gordana works as a cleaner.
- Gordana is blonde.
- Gordana is a qualified nurse in Slovakia who works as a cleaner.

9) Consider women who have doctoral degrees in social sciences. Below are some categories to which such women might belong. Surveys have shown that it is common for these women to be employed in education and/or have children.

- Are a mother.
- Are employed in higher education.
- Are a mother and employed in higher education.
- Own a business.

10) Cate Blanchett is expected to be nominated for a BAFTA for Best Actress and for an Academy Award for Best Actress for her role in Carol. As the BAFTAs are presented shortly before the Academy Awards, they are known for being a good indicator of who is likely to win Academy Awards.

- Cate Blanchett will win the BAFTA for Best Actress.
- Cate Blanchett will win the Academy Award for Best Actress.
- Cate Blanchett will win the BAFTA for Best Actress and the Academy Award for Best Actress.
- Charlize Theron will win the Academy Award for Best Actress.

11) Celine Dion will release a new album in 2016. Her last five albums have sold enough copies to be awarded platinum status and Celine is the biggest selling Canadian artist of all time. She has also had a residency at a large Las Vegas hotel for the last 10 years.

- Celine Dion will get divorced.
- Celine Dion will have a number one hit in Canada and perform a sell-out concert in Las Vegas.
- Celine Dion will perform a sell-out concert in Las Vegas.
- Celine Dion will have a number one hit in Canada.

12) Tanya is a hardworking English Literature student who enjoys her college work and wants to get a good career in the media. The exam day is hot and sunny and Tanya occasionally suffers from hay fever.

- Tanya's hay fever is bad on the day of her final exam.
- Tanya does poorly in her final exam.
- Tanya's hay fever is bad on the day of her final exam and Tanya does poorly in her final exam.
- Tanya forgets to bring a pen to her final exam and has to borrow one from her friend.

13) Mike goes to the horse racing at the weekend. He looks at the odds for the horses running that day and places bets on two horses with good odds running in separate races, one at 11am and the other at 1pm. He is aware that these are two separate races and that the outcome of one will not affect the other.

- Mike's horse running at 11am wins its race.
- Mike's horse running at 1pm wins its race.
- Mike's horse running at 11am wins its race and Mike's horse running at 1pm wins its race.
- Mike drinks champagne at the horse racing.

14) Robert goes to a seafood restaurant for dinner with his friends. They have not eaten there before, but they don't have much time and are hungry so they decide to try it. The restaurant is an unclean, grubby, rundown place which generally gets few customers. It sells food at cheap prices.

- The crab is off.
- Robert is ill the next day.
- The crab is off and Robert is ill the next day.
- A waiter trips and spills a glass on Robert.

15) A group of students go to a popular pub after a lecture. The pub is only a five minute walk from the university and it is also close to town. There is a beer garden outside the pub.

- It is a warm summer's day.
- There are people sitting in the beer garden.
- It is a warm summer's day and there are people sitting in the beer garden.
- There is a special on beer.

16) A group of people have gathered at a protest. The people there were part of the Occupy Wall Street movement and are deeply concerned with issues of social inequality and tax avoidance.

1. It is a loud protest.
2. It is a protest against corporations.
3. It is a loud protest and it is a protest against corporations.
4. It is a protest to save a rainforest.

17) David is a rugby fan and works in the local sports shop. David regularly goes to watch the local rugby team, who have been playing fairly well recently, winning many matches both home and away.

1. David's team finish the season at the top of their league.
2. Sales of the team shirt double by the end of the season.
3. David's team finish the season at the top of their league and sales of the team shirt double by the end of the season.
4. David's team loses in the finals.

18) A group of friends are going on holiday to Japan. They are flying from the main airport in the city, which is constantly busy, with crowds of people passing though and waiting for flights. They arrive early in the afternoon, which is a particularly busy time of day.

1. Their flight is delayed.
2. There is a queue for the coffee machine.
3. Their flight is delayed and there is a queue for the coffee machine.
4. The group of friends purchase magazines to read on the flight.

19) ‘The Flames’ are an aggressive band who put a lot of energy into their performances. They play loud, fast music and their songs are often politically motivated. They play gigs regularly, wearing tatty clothes.

1. ‘The Flames’ are a punk band.
2. There is a fight at their gig.
3. ‘The Flames’ are a punk band and there is a fight at their gig.
4. They play a song about war.

20) There is a small café in the middle of a busy town. Nearby there are high schools, shops, building sites and offices. The café is on the main street of the town, with a constant flow of people passing by each day.

- There are students in the café on a weekday lunchtime.
- There are builders in the café on a weekday lunchtime.
- There are students in the café on a weekday lunchtime and there are builders in the café on a weekday lunchtime.
- The café has a range of sandwiches that are very popular.

Appendix C

Probabilistic Reasoning Items

Instructions:

In this part of the study you will be presented with several scenario questions, each shown one at a time. Each question will be presented with some possible alternatives, and one those alternatives is the correct response.

Please read each question and then choose the alternative you believe is the correct answer.

Click the yellow button to start.

Base Rate Fallacy Items:

Control Context:

Sammy just met with his doctor who informed him that he has tested positive for a typically fatal disease. To make things worse, this test is accurate 95% of the time. The prevalence of the disease is 1 in 1000. Which is more likely?

- Sammy has the disease
- Sammy does not have the disease

Oxford University accepts 6% of applicants each year. Amelia works really hard at her studies and rarely goes out on weekends. She volunteers, working in a homeless shelter serving soup and also collects donations for SIDS. Her mum is convinced that she is brilliant and will succeed at whatever she tries. Which is more likely?

- Amelia will be accepted at Oxford
- Amelia will be rejected by Oxford

John is a man who usually wears spandex clothing and trainers, gets regular spray tans, and has more than one gym membership. John is more likely to be a:

- Professional body-builder
- Fast-food worker

Sarah is responsible for the safety of large groups of people, loves to travel, and enjoys flight simulation games. Which is more likely?

- Sarah is a police officer
- Sarah is a pilot

Matthew was active, enjoyed surfing, and swimming at the beach. Matthew died unexpectedly. Which is more likely?

- Matthew died due to a heart attack
- Matthew died due to a shark attack

Alex works in construction, is highly competitive, plays amateur football, and goes to the pub for a few beers with mates on the weekend. Alex has been diagnosed with an autoimmune disease that is 3 times more common in women. Which is more likely?

- Alex is female
- Alex is male

Tom is an opera buff who enjoys touring art museums when on vacation. Growing up, Tom enjoyed playing chess with family and friends. Which is more likely?

- Tom plays trumpet for a major symphony orchestra
- Tom is a farmer

One thousand people were tested in a study, of which 995 were nurses and 5 were doctors. Jake is a randomly chosen participant of this study. Jake is 34 years old, is well spoken, and very interested in politics. He lives in a beautiful home in a posh suburb and he invests a lot of time in his career. Which is more likely?

- Jake is a nurse
- Jake is a doctor

A taxi is involved in a hit and run accident at night. An eye-witness reports the taxi as being blue. However eye-witnesses are accurate less than 50% of the time, but this eye-witness is sure the taxi was blue. There are two colours of taxi in the city. 85% of the taxis in the city are green, the remainder are blue. Which is more likely?

- The taxi is blue
- The taxi is green

Tamara works long hours, her job involves working with children, she wears glasses and her hair in a bun, and she loves books. Which is more likely?

- Tamara is a librarian
- Tamara is a child care worker

Anomalistic Context:

Daniel's mum visits a psychic to discuss Daniel's chances of getting into Harvard University. Daniel's mum tells the psychic that Daniel works hard, volunteers, has been dreaming of attending Harvard for years, and is a brilliant kid. Harvard University accepts only 8% of applicants each year, however, the psychic assures Daniel's mum that Daniel will have a place at Harvard. Which is more likely?

- Daniel will be accepted at Harvard
- Daniel will be rejected by Harvard

Storm is a young woman who wears long flowery skirts, has long blonde hair, and believes in horoscopes and the healing properties of crystals. Storm is more likely to be a:

- Retail assistant
- Psychic medium

Jason lives in an old manor style house by himself. A woman lived in the house before him and died unexpectedly. Some people think that the house is haunted by her ghost, and occasionally Jason hears strange noises in the night that he cannot explain. Which is more likely?

- The woman who lived in the house before Jason was murdered
- The woman who lived in the house before Jason died of a brain aneurysm

At the Mind, Body, and Soul expo 1000 people filled in a short survey that asked if they believed in any or all of the following: ghosts, witchcraft, psychics, aliens, God(s). The results showed 995 believed in at least one of those things, and 5 were total sceptics. Michelle is randomly chosen from the crowd later in the day. Michelle has been seen taking photos at various stands and giggling uncontrollably. Michelle has mentioned that she has a PhD in the social sciences and works as a research analyst for the government. Which is more likely?

- Michelle is a believer
- Michelle is a sceptic

Claire visits a psychic regularly. Many of the psychic's clients believe she has been very accurate in her readings of them. Given that she has stated to know Claire's mother's name starts with an 'S', which is more likely?

- Claire's mother's name starts with an 'S'
- Claire's mother's name starts with a letter other than 'S'

A psychic has a vision of a car accident involving a taxi that takes place at night. The psychic reports the taxi as being black. However, the vision was dark and the psychic's visions are accurate less than 50% of the time, although she insists that the car was black. There are two colours of taxi in the city where the vision occurred, with 85% of the taxis being purple and the rest being black. Which is more likely?

- The taxi is purple
- The taxi is black

Clara enjoys watching TV shows (dramas, documentaries, histories) and movies about witchcraft, ghosts and paranormal experiences. She has a black cat, and in the past she has purchased tarot cards, a crystal ball, candles, and an altar cloth. Which is more likely?

- Clara is a fortune teller
- Clara is a school teacher

Jamie is 5 foot 7 inches and willowy, works in retail, enjoys drinking wine with friends after work, and loves fashion. Jamie visited a fortune teller who predicted poor health for Jamie in the near future. At Jamie's next doctor's appointment Jamie was found to be suffering from Alport's syndrome, which is 3 times more common in men. Which is more likely?

- Jamie is female
- Jamie is male

Psychic healing works, although not all the time, especially when one's faith is not strong enough. Unbiased, empirical tests demonstrate that a small but noticeable percentage of people are cured of incurable diseases such as cancer. Claudia believes that psychic healing works and her cancer has gone into remission. Which is more likely?

1. Psychic healing worked because Claudia believed it would
2. Claudia spontaneously recovered

Gerald loves science fiction movies, believes he has a sixth sense, and has always been interested in books about extra-sensory perception and telepathy. Which is more likely?

1. Gerald works in IT
2. Gerald manages the annual psychic fare

Misperception of Chance Items:

Control Context:

An unbiased coin is tossed 5 times (H = heads, T = tails). The following sequence was the outcome from the 5 tosses: H, H, H, H, H. What is the chance that the next toss will also be heads?

- Over 90%
- 25%
- 50%
- 75%
- Under 10%

Three sets of the letters of the alphabet are placed in a hat. Five letters are picked from the hat. After each pick, the letter is replaced. Which pattern is most likely?

- L, L, L, X, K
- V, X, Y, Z, A
- A, B, A, B, A
- J, P, V, C, I
- All are equally likely

Five cards are drawn from a deck of playing cards, made up of 52 cards. The deck included 4 suits (Hearts, Clubs, Spades, Diamonds) with 13 cards in each suit (numbered 2-10, Ace, Jack, Queen and King). Each card was replaced after drawing. The sequence – 2 of Clubs, 5 of Clubs, Queen of Clubs, 10 of Clubs, 7 of Clubs – has just been drawn. Approximately, what is the chance of drawing 4 of Diamonds next?

- 3%
- 1%
- 0%
- 2%
- 4%

There are 100 people at a party. Fifty guests are lawyers and 50 guests are doctors (L = lawyer, D = doctor). Four guests are randomly chosen, by pulling names out of a hat, to participate in a game. Which combination is most likely?

- L, D, L, D
- L, D, D, L
- D, D, L, L
- D, L, L, D
- All equally likely

The blood group of 200 people is distributed as follows: 50 have Type A, 50 have Type B, 50 have Type O and 50 have Type AB. Five people are selected at random. The following group has been selected: AB, A, A, B. Approximately, what is the chance that the next person drawn will be O?

- 15%
- 5%
- 35%
- 25%
- 45%

Five cards are drawn from a deck of playing cards, made up of 52 cards. The deck included 4 suits (Hearts, Clubs, Spades, Diamonds), with 13 cards in each suit (numbered 2-10, Ace, Jack, Queen and King). Each card was replaced after drawing. Which combination is the most likely?

- 8 of Clubs, 3 of Hearts, 8 of Diamonds, 3 of Spades, 8 of Hearts
- 8 of Clubs, 9 of Clubs, 10 of Clubs, Jack of Clubs, Queen of Clubs
- 4 of Diamonds, 5 of Spades, 4 of Diamonds, 6 of Clubs, 7 of Hearts
- 3 of Spades, Ace of Clubs, 7 of Hearts, 7 of Clubs, 5 of Diamonds
- All are equally likely

Three sets of the letters of the alphabet are placed in a hat. Five letters are picked from the hat. After each pick, the letter is replaced. The following letters have just been selected: H, G, F, E, D. Approximately, what is the chance that the next letter selected will be an E?

- 0%
- 2%
- 8%
- 4%
- 6%

The blood group of 200 people is distributed as follows: 50 have Type A, 50 have Type B, 50 have Type O and 50 have Type AB. Four people are selected at random. Which pattern is more likely?

- A, O, A, O
- A, B, B, A
- O, AB, O, AB
- B, O, O, B
- All equally likely

There are 50 people at a party. Twenty-five guests are lawyers and 25 guests are doctors (L = lawyer, D = doctor). Five guests are randomly chosen, by pulling names out of a hat, to participate in a game. The following group has been selected: L, D, L, D, L. Approximately, what is the chance that the next person selected will be a doctor?

- 25%
- 75%
- 50%
- 60%
- 40%

An unbiased coin is tossed 6 times (H = heads, T = tails). Which pattern is most likely?

- H, H, H, H, H, H
- H, H, H, T, T, T
- H, T, H, H, T, T
- H, T, H, T, H, T
- All equally likely

Anomalistic Context:

A psychic tosses an unbiased coin 6 times, predicting the outcome before each toss (C = correct, I = incorrect). Which pattern is more likely?

- I, I, I, C, I, C
- C, C, C, C, C, C
- C, I, C, I, C, I,
- C, C, C, I, I, I
- All equally likely

A new paranormal museum recently opened, and the beliefs of the first 200 visitors are distributed as follows: 50 believe in ghosts (G), 50 believe in psychics (P), 50 believe in telepathy (T), and 50 are sceptics (S). Four people are selected at random. Which pattern of beliefs is most likely?

- P, G, P, G
- T, P, T, P
- P, S, P, S
- S, G, G, S
- All equally likely

There are 50 people visiting a haunted castle. Twenty-five visitors believe in ghosts and 25 visitors are sceptics (B = believer, S = sceptic). Five visitors are to be randomly chosen to enter the most haunted room. The following group has been selected: B, B, B, S, S. Approximately how likely is it that the next selection will be a believer?

- 75%
- 40%
- 50%
- 25%
- 60%

Five cards are drawn from a pack of Italian tarot cards, made up of 78 cards. The deck included 4 suits (Swords, Cups, Coins and Wands) each with 14 cards each (numbers 1-10, Jack, Knight, Queen, King), 21 trump cards and 1 fool card. Each card is replaced after drawing. Which combination is the most likely?

- Trump, Trump, 6 of Swords, Trump, Trump
- Trump, 2 of Cups, Trump, 10 of Coins, Trump
- Trump, Trump, Trump, Trump, Trump
- 10 of Swords, Queen of Cups, 8 of Coins, 3 of Wands, Jack of Coins
- All are equally likely

A new paranormal museum recently opened, and the beliefs of the first 200 visitors are distributed as follows: 50 believe in ghosts (G), 50 believe in psychics (P), 50 believe in telepathy (T), and 50 are sceptics (S). Five people are selected at random, producing the following group: G, T, G, S. Approximately, what is the chance that the next person drawn will be a P believer?

- 35%
- 15%
- 25%
- 5%
- 45%

Five cards are drawn from a pack of Italian tarot cards, made up of 78 cards. The deck included 4 suits (Swords, Cups, Coins and Wands) each with 14 cards (numbers 1-10, Jack, Knight, Queen, King), 21 trump cards and 1 fool card. Each card is replaced after drawing. The sequence 3 of Swords, 3 of Cups, 3 of Coins, 3 of Wands has just been drawn. Approximately what is the chance of drawing a Trump card next?

- 10%
- 25%
- 40%
- 75%
- 60%

A psychic tosses an unbiased coin 5 times, predicting the outcome before each toss (C = correct, I = incorrect). The following sequence was the outcome from the 5 tosses: C, C, I, C, C. What is the chance that the next response will be incorrect?

- 25%
- 50%
- 75%
- Over 90%
- Under 10%

Three Ouija (spirit) boards are placed on a table. Ouija boards contain each of the letters of the alphabet. Blindfolded, five people are asked to point to a place on any of the three Ouija boards. Which pattern of letters is most likely?

- B, B, B, R, T
- H, E, A, R, T
- A, A, X, X, J
- I, X, K, D, S
- All are equally likely

There are 100 people visiting a haunted castle. Fifty visitors believe in ghosts and 50 visitors are sceptics (B = believer, S = sceptic). Four visitors are randomly chosen to enter the most haunted room. Which combination is most likely?

- S, B, S, B
- S, S, B, B
- B, S, S, B
- S, B, B, S
- All equally likely

Three Ouija (spirit) boards are placed on a table. Ouija boards contain each of the letters of the alphabet. Blindfolded, five people are asked to point to a place on any of the three Ouija boards. The following letters have been selected: Q, M, E, Y, U. Approximately, what is the chance that the 6th person would choose the letter V?

- 0%
- 2%
- 8%
- 4%
- 6%

Appendix D

Evidence Integration Items

Within each trial the pieces of information are listed in the order shown to participants (i.e., 1 shown first, 2 shown second, 3 shown last). The four response options for each trial are shown below this list of pieces of information. True answers are marked T, neutral lures are marked NL, emotional lures are marked EL, and absurd answers are marked A.

Instructions:

You will be shown three statements, presented one at a time, describing an event or person. Each new statement will provide additional information about the event or person that is being described.
Below the statements, you will also see four interpretations about the event or person being described in the statement(s).
Each interpretation has its own scale (from 0-100%), where you will be asked to rate the likelihood that the interpretation is consistent with the statement(s) about the event or person. Rate how well each one relates, on its own, to the event information provided in the statement(s).
It is important to rate each of the four interpretations independently from one another. Do not compare the interpretations to each other.

As each new statement is shown, reconsider the ratings you have assigned to each interpretation.
Ratings for each interpretation can be changed as much or as little as you like, or can be kept the same if you feel that they have not changed with the addition of a new statement.
It is possible that none or many of the interpretations will be a good fit for the statements. Some interpretations may be related to the statements, some may not be related.
You will make your rating by dragging the slider next to each interpretation. Remember that for each interpretation, you are rating the likelihood that the interpretation is consistent with the statement(s) about the event or person.
Click the arrows at the bottom of the screen to see the next statement.
You will now complete 2 practice trials before completing the main block of trials.

Practice Trial 1

1. Danielle is very unreliable.
2. Danielle does not like criticism.
3. Danielle was rude to her boss.

Danielle often forgets her homework. NL
Danielle is a poor mother. EL
Danielle is not a very good cook. A
Danielle has been fired from her job. T

Practice Trial 2

1. Cindy is dancing.
2. Cindy is wearing a small dress.
3. The men clap and whistle when Cindy dances.

Cindy is at a party. NL
Cindy is high on drugs at a rave. EL
Cindy is a member of a famous pop group. A
Cindy is a stripper. T

Trial 1

1. Andrea has made some new friends.
2. Andrea's new friends control every single aspect of her life.
3. Andrea has very suddenly cut off all contact with her family.

Andrea is a kind and caring person. EL
Andrea loves to be photographed. A
Andrea has just started going to university. NL
Andrea has joined a cult. T

Trial 2

1. Nicholas is driving his car very fast.
2. Nicholas did not stop at the red light.
3. Nicholas injured a little girl with his car.

Nicholas' wife is in labor. EL
Nicholas hates going for walks. A
Nicholas is a hit and run offender. T
Nicholas is running late for work. NL

Trial 3

1. Tom and Mike are screaming.
2. Tom and Mike feel nauseous.
3. Tom and Mike ate too much cotton candy today.

Tom and Mike are at a basketball game. NL
Tom and Mike have found a dead body in the alley. EL
Tom and Mike enjoy being in the spotlight. A
Tom and Mike are having fun on a roller-coaster. T

Trial 4

1. Jenny can't fall asleep.
2. Jenny can't wait until it is finally morning.
3. Jenny wonders how many presents she will find under the tree.

Jenny loves her bed. A
Jenny is excited about Christmas morning. T
Jenny is nervous about her exam the next day. NL
Jenny is worried about her ill mother. EL

Trial 5

1. Richard sometimes wears make-up.
2. Richard spends most of his time in the theatre.
3. Richard went to acting school.

Richard is self conscious about his scars. EL
Richard is a drag queen. NL
Richard wishes he had a wife. A
Richard is an actor. T

Trial 6

1. Stella answers the phone at work.
2. Stella is a powerful woman.
3. Stella went to law school.

Stella is a secretary. NL
Stella is a 911 phone call operator. EL
Stella is a baby-sitter. A
Stella is a lawyer. T

Trial 7

1. Dan is very lucky.
2. Dan has always wanted this to happen.
3. Dan will always remember the day he proposed to her.

Dan got married. T
Dan got tickets to see his favourite band. NL
Dan just won the lottery. EL
Dan slipped and fell on his banana peel. A

Trial 8

1. Amanda is very thin.
2. Amanda has a difficult life.
3. Amanda doesn't even have a home.

Amanda is a runway model. NL
Amanda has lost her fake teeth. A
Amanda has an eating disorder. EL
Amanda is homeless. T

Trial 9

1. The picnic came to an abrupt end.
2. Everyone went home stunned from the picnic's outcome.
3. By the time the ambulance arrived it was too late.

The volcano began to erupt. A
Audrey died from an allergic reaction to a bee sting. T
The families began to argue with one another. EL
It started to rain unexpectedly. NL

Trial 10

1. Michael's job is to entertain people.
2. Michael is a little shy sometimes.
3. Michael sits in front of a computer writing all day long.

Michael is a famous magician. NL
Michael works as a clown entertaining sick children in the hospital. EL
Michael is a gambler. A
Michael's job is to write novels. T

Trial 11

1. Gary is responsible for many lives.
2. Gary's work can get to be quite boring and repetitive.
3. Gary's route is one of the busiest.

Gary is a clown. A
Gary is a bus driver. T
Gary is an army general. NL
Gary is a surgeon. EL

Trial 12

1. Eric often carries binoculars with him.
2. Eric always has an unpredictable schedule.
3. Eric tries to solve mysteries.

Eric is a private detective. T
Eric is a bird expert. NL
Eric is a stalker. EL
Eric is an astronaut. A

Trial 13

1. Heather loves her dog.
2. Heather takes her dog everywhere.
3. Heather is unaware of her surroundings without her dog or her cane.

Heather is a dog trainer. NL
Heather's dog is very ill. EL
Heather is afraid of cats. A
Heather needs a guide dog because she is blind. T

Trial 14

1. Andrew is not allowed to date women.
2. He cannot socialize with members of the community.
3. Andrew is being punished for his crimes.

Andrew is married. EL
Andrew is a priest and vowed to a life of celibacy. NL
Andrew is in prison. T
Andrew is a cat. A

Trial 15

1. Lisa goes home earlier than normal.
2. Lisa feels miserable.
3. Lisa had worked in the firm for more than 20 years.

Lisa was expelled from school. NL
Lisa is skipping school. EL
Lisa was fired. T
Lisa's watch is broken. A

Trial 16

1. Hank is very creative.
2. Hank has a team of helpers.
3. Hank's restaurant is the most popular in the city.

Hank is a painter. NL
Hank is a con-artist. EL
Hank is a chef. T
Hank is a farmer. A

Trial 17

- Martin has a specialized education.
- Martin inspects his equipment before he begins the task.
- Martin would hate to fall off the cliff due to equipment failure.

Martin loves to rock climb. T
Martin is an electrician. NL
Martin works as a surgeon. EL
Martin practises jumping over frogs. A

Trial 18

41. George negotiated what he thought was fair.
42. George was in the meeting for a long time.
43. He celebrated his new job with the other staff members.

George is defending a criminal on trial. EL
George is the newest member of a team. T
George is trying to get a bank loan. NL
George is not interested in business. A

Filler Trial 1

5. Veronica is afraid of her classmates.
6. Veronica does not have many friends.
7. Sometimes Veronica goes home in tears.

Veronica is always overly dramatic. NL
Veronica is experiencing side effects of new medication. EL
Veronica likes to water the plants with her tears. A
Veronica is bullied at school. T

Filler Trial 2

4. Gord is physically exhausted and needs to return to the base.
5. Gord has reached the peak.
6. He will record this date in his journal.

Gord is a mountain climber. T
Gord has a best-selling novel. NL
Gord has a bad temper. EL
Gord is an ice-cream on a long stick. A

Filler Trial 3

- Everyone at the meeting was upset after the manager gave his speech.
- The staff are worried about their future.
- The staff will have to start looking for other employment.

The business will be closing. T
The staff are losing their jobs. T
The manager introduced new policies. NL
The staff are cheering and dancing. A

Filler Trial 4

1. Carla has received some flowers.
2. She always looked forward to this day.
3. Carla has a gift to open as well.

Carla's celebrating a wedding anniversary. T
Carla is having a birthday. T
Carla has won a beauty contest. NL
Carla pretends she is a bee. A

Filler Trial 5

1. Chris is shocked and gets up quickly.
2. He didn't hear the alarm.
3. He grabs a snack before he leaves for work.

Chris has overslept. T
Chris is going to visit his mother. EL
Chris is a firefighter on duty. NL
Chris likes static electricity. A

Filler Trial 6

1. Emily has been waiting for her date to arrive for hours.
2. Emily stays home for the night.
3. Emily feels that men are unreliable.

Emily has an invitation to a party. NL
Emily has been stood up by her date. T
Emily has an infection. EL
Emily always wears her pajamas. A

Appendix E

News Article Stimuli

Misleading: Ban on Homework at Local School Disadvantaging Students

Congruent: Researchers Say There Are No Benefits of Homework

A local elementary school has recently taken the step of banning homework. The school believes that it is not in the interests of younger students to spend their time outside of school engaging in additional schoolwork.

This announcement has outraged some parents at the school, with many arguing that homework is an important part of a child's education. One local father, David, is particularly concerned about the decision, claiming that he received many benefits from completing homework as a child. David stated that "homework gives kids a solid work ethic and keeps them focused on work rather than distractions." Another worry noted by both David and other parents is that the ban on homework at the school will lead to students being disadvantaged compared to students at neighbouring schools. Anne, a mother who has two children at the school, said she is concerned that the kids at the next school over would do better if they are doing more work.

However, in contrast to the concerns outlined by the parents, the principal of the school argued that there is little to no evidence in support of giving homework to elementary school children. Instead, the principal said that giving elementary school children homework takes away time that could be spent more productively on sports, family time, and recreation activity. This argument was backed up by Harris Cooper, an expert in homework from Duke University. Based on an analysis that covered a large number of studies into the effects of homework, Cooper concluded that "There is no evidence that any amount of homework improves the academic performance of elementary students." Further these conclusions from the principal and Harris Cooper are backed up by other education experts, who agree with the position that, for younger children, homework provides no benefit.

Misleading: Risks of Allowing Immature Teens to Vote in Elections

Congruent: Lowering the Voting Age has Potential Benefits for Democracy

It has recently been proposed that the voting age should be lowered to 16 to allow for greater engagement with the political system by teenagers. Proponents of the move have said that it will allow teenagers to have a greater say in political outcomes, many of which have the potential to affect them in the future.

This idea of lowering the voting age has been met with heavy criticism by some members of the voting public. Joshua Willard does not believe that teenagers should be allowed to vote. He argued that they lack the life experience and knowledge required to cast a meaningful vote in an election. Joshua, and many other members of the public, have also raised the issue of young people being able to vote when they have not yet contributed to society. When asked about the prospect of sixteen year olds voting, one local businessman commented that “sixteen year olds are mostly living at home with their parents, and haven’t yet worked hard enough or contributed enough to society to be entitled to a vote.”

Although they do not entirely dismiss concerns raised by members of the public, many politicians and political scientists have suggested that the move to lower the voting age could be beneficial. Politician Barry Crickell has said that his experience visiting schools has shown that many teenagers are highly engaged with politics, and hold strong, well informed opinions across many political issues. This view has been backed up by the Society of Political Scientists, who said that based on their research teenagers between the ages of sixteen and eighteen are just as likely to be well informed and politically engaged as other age ranges. Additionally, the society has argued that there is substantial evidence to suggest that it is beneficial for both teenagers and the whole of democracy to allow teenagers to vote. Evidence from countries with lower voting ages suggests that having a lower voting age leads to an overall increase in engagement with politics and more positive views about the democratic process.

Misleading: Self-driving cars likely to have little benefit

Congruent: Self-driving cars likely to have wide-ranging benefits

In the last several years, self-driving cars have become a major area of discussion and development. There are a wide range of viewpoints on self-driving cars and on other related issues, such as when self-driving cars will be introduced and what impacts they will have.

The idea of self-driving cars becoming widespread is strongly opposed by several community members, such as Michael Kertin. Michael, who identifies as an automobile buff, told us that he does not believe that self-driving cars will be of much benefit to society and that they will pose many safety risks. Michael also does not believe that self-driving cars are likely to be on the road any time soon or that they will become popular once they are available. Indeed, he argues that "people enjoy driving and the feelings it gives them, they aren't going to give up those feelings for a self-driving car."

Experts in automobile research disagree with Michael and believe that self-driving cars will be beneficial for society and that a large uptake of self-driving cars will occur soon. They argue that because mistakes made by human drivers are responsible for over 75% of all accidents, self-driving cars will be able to greatly reduce the number of accidents on the road. Also in support of this notion is the evidence from the preliminary testing of self-driving cars, which showed that the self-driving cars were involved in far fewer accidents than human driven cars under the same conditions. Experts believe self-driving cars will become widespread soon after reaching the market because they will allow people to have much more enjoyable and productive commutes, without having to worry about parking at the end destination. In fact, so far, a large number of self-driving cars are already on the road in places like Pittsburgh in the US and Milton Keynes in the UK, and there was recently a doubling of the number of companies licensed to test self-driving cars in California.

Misleading: Potential problems with genetic tests that reveal risks of developing disease

Congruent: Genetic testing for risk of developing disease a potential life saver

Researchers are constantly looking for ways to improve people's health and prevent diseases as early and effectively as possible. Recently, analyzing genetic risk has been considered as an effective tool for helping to target treatments and prevent diseases. Genetic risk refers to how predisposed an individual is to experiencing a disease based on their genome.

Some have argued that analyzing genomes to determine which diseases people are at risk of developing will lead to negative outcomes. Alana Planter is one person who does not think that it will be beneficial to analyze genomes and discover which diseases people are at risk of. Alana is worried that once people know that they are prone to a disease they will become disheartened and this will worsen their health. People like Alana also question the point of looking at genetic risk because unlike other risks you cannot change genetics.

Health experts disagree with the claim that genetic risk will not be beneficial for preventing disease and keeping people healthy. They argue that, by understanding genetic risk, people will be able to make changes that reduce their likelihood of developing the disease. Health experts believe that by understanding which diseases people are at a heightened risk of developing they will be better able to target early interventions and prevent them from developing the disease in the first place. For example, by understanding that someone is at a high genetic risk of heart disease, they can construct diet and exercise programs to counteract the risk and reduce the likelihood of developing the disease. Psychology researchers also support the idea, and argue there is evidence to show that having this knowledge will not lead to people becoming disheartened or negative, but instead will motivate them and allow them to focus their efforts on the areas that are most likely to be beneficial for their health and reduce their risk of developing disease.

Misleading: Knee Arthroscopy is Able to Reduce Pain and Restore Mobility

Congruent: Recent Review Finds Little Evidence to Support Knee Arthroscopies

Knee arthroscopy is a surgery that involves inserting a camera (called an arthroscope) and surgical tools through a small incision, preventing the need for larger and more invasive cuts. Some sufferers of degenerative knee conditions claim that this surgery has provided them with major benefits.

Melissa Campbell, who suffered significant degeneration in her right knee, underwent arthroscopic surgery last year. Melissa claims that the surgery has massively reduced the symptoms that she was suffering and that she would strongly recommend the surgery to others suffering from degenerative knee conditions. Following the operation, Melissa said "the pain in my knee was greatly reduced following surgery, and I now have much greater mobility in my knee joint, which allows me to engage in activities that I previously found too difficult and painful to do."

A recent review into the benefits and risks of knee arthroscopies, however, was much less optimistic about the benefits of knee arthroscopy. A team of researchers from Denmark and Sweden analysed a number of studies into the alleged benefits of arthroscopic surgery and found that, although patients who undergo a knee arthroscopy may report feeling slightly less pain in the short term, after six months there was no difference in the level of pain reported between those who underwent the surgery and patients who did not undergo surgery. They also found no improved physical functioning for those who underwent the arthroscopic surgery. Further, the review pointed out that, although they rarely occur, there are several risks associated with undergoing a knee arthroscopy, such as deep vein thrombosis, pulmonary embolism, infection, and death. Based on the results of this recent review, the researchers and several representative bodies for surgeons suggest that knee arthroscopy is unlikely to be beneficial for people with degenerative knee conditions.

Misleading: Hands-Free Cell Phone Kits a Life Saver for Talking While Driving

Congruent: Hands-Free Cell Phone Kits Don't Make It Safe to Talk While Driving

In a bid to reduce the number of car accidents, several politicians are calling for more people to use hands-free cell phone kits. Many accidents are at least partially attributable to drivers being distracted by using their cell phone while driving. The politicians have suggested subsidies for hands-free cell phone kits be offered to increase the uptake of the kits among the population.

This idea is strongly supported by James who works as a courier and has used a hands-free cell phone kit for years. James told us that the kit has allowed him to safely make phone calls while driving. He commented that "phone calls are a crucial element of my job because during my deliveries I am often required to contact both customers and my manager to receive information and delivery instructions." Like James, several other transport workers whom we spoke with supported the use of hands-free kits for improving safety.

Experts in road safety agree that using a cell phone while driving greatly increases the risk of having an accident. However, they disagree that using a hands-free cell phone kit will address the problem of accidents caused by cell phone use. They cited crash statistics involving cell phones that showed that people who were using a cell phone with a hands-free kit were still at much greater risk of being involved in an accident than other drivers. Stephanie Morey, a psychologist who studies attention, distraction, and multitasking, agreed that using a hands-free cell phone kit does not make it safe to use a cell phone while driving. Stephanie stated that "holding a conversation over the phone requires mental effort, which reduces driving ability because people are no longer fully concentrating on the driving task." She explained that engaging in a cell phone conversation while driving, even if using a hands-free device, increases the likelihood that people will not see potential road hazards and it also slows their reaction time, which means they are at a far greater risk of being in an accident.

Misleading: Brain Training Makes You Smarter

Congruent: Brain Training Doesn't Make You Smarter

Recently there has been a lot of interest in the use of brain training games to improve memory, attention, and speed of thinking. Some people have claimed that using brain training programs has led to improvements in their ability to do a variety of cognitive tasks, such as improve their memories.

Julie Turner has been using brain training for several months now and is a big believer in the ability of brain training to improve cognitive functioning. Julie claims that since she began to use a brain training app several times a week she has had large improvements in her memory and finds it easier to keep her attention focused on tasks. Among the other benefits that Julie believes she has received from brain training are the ability to think more quickly and to more effectively solve puzzles and problems. Since beginning to engage in brain training, Julie stated that "I have seen benefits in my daily life, such as finding it easier to remember which items I need when shopping."

In contrast to the enthusiasm for brain training shown by Julie and other users, neuroscientists and cognitive researchers are much more skeptical about the claimed benefits of brain training. A statement recently released by the Stanford University Center on Longevity and the Berlin Max Planck Institute for Human Development said that there is no solid scientific evidence to back up the promises made by brain training companies. Signed by 70 of the world's leading neuroscientists and researchers in cognition, the statement does not mince words: "The strong consensus of this group is that the scientific literature does not support claims that the use of software-based 'brain games' alters neural functioning in ways that improve general cognitive performance in everyday life, or prevent cognitive slowing and brain disease." Although brain training companies and some individual users of brain training may claim that there are major benefits of brain training, the scientific consensus does not support these claims.

Misleading: Increasing product range will lead to sales boost for local grocery store

Congruent: Increasing product range unlikely to increase sales for local grocery store

In a bid to entice customers and increase sales, a local grocery store has announced that they are massively increasing the number of products they have available. They believe that this increased choice will lead both to more customers shopping at their store and to more overall purchases by their customers.

A recent survey showed that many shoppers believe that having more options greatly increases their likelihood of shopping at the store and making purchases. That is, people who were surveyed in the suburbs neighboring the grocery store indicated that the increased range of products would make them more likely to shop at the grocery store and to purchase more products there. One potential shopper, local man Thomas Fletcher, commented that "of course I'll be more likely to shop at a store with a larger range of options, it's good to have more choice, it's just common-sense."

Marketing experts, however, do not believe the local store's strategy will be successful. Contrary to what many people intuitively believe, studies have found that providing too many options can lead to people finding it too hard to choose which option is best and therefore they are less likely to choose any of the options. Marketing researchers have pointed out that "one of the major problems with stocking too many options within a specific product category is that it makes it very difficult for customers to properly compare the different products and make a decision they are happy with." Therefore, by having too many options, a store may actually lose sales because customers are overwhelmed and decide the decision is too difficult. Support for this claim comes from a large grocery store chain that has stated that they have resisted pushes to increase the range of items they stock because in the past they have found that once the number of choices becomes too great sales in that area tend to reduce rather than increase.

Filler Articles:

Gates Foundation's latest giveaway: $279 million

The Bill and Melinda Gates Foundation just wrote a $279 million check to a University of Washington project that tracks health and cause-of-death data around the world. The donation is one of the largest ever for the Gates Foundation, and it's the largest private donation in the university's history.

The money is going to UW's Institute for Health Metrics and Evaluation (IHME), which provides rigorous measurement and analysis of the world's most prevalent and costly health problems and evaluates strategies to address them. Gates Foundation CEO Sue Desmond-Hellman said in a blog post Wednesday that the public may never have heard of the IHME, but it has been a game-changer in global health. She further stated that before the IHME began its work a decade ago, data on global health trends were typically inconsistent and thus not especially reliable.

The research conducted by the IHME helps the Gates Foundation identify what the world's most pressing health-related issues are. Desmond-Hellman stated that the Gates foundation “is among many organizations that have benefited hugely from the IHME's insights as we decide where we can have the greatest impact”. The Gates' latest grant will provide funding for the institute over the next 10 years. The University of Washington is no stranger to the foundation's generosity. The Gates, who are Seattle natives, have given more than 250 grants totaling about $1.25 billion to the school. "We feel lucky that our local university is also on the leading edge of innovation globally, and we are grateful that it has chosen to innovate to help the poorest people in the world," Melinda Gates said in a statement Wednesday.

Bill Gates, the co-founder of Microsoft, and his wife Melinda have committed to give more than half of their $84 billion fortune away during their lifetimes. Gates and investing powerhouse Warren Buffett launched the Giving Pledge in 2010 to encourage the world's billionaires to boost their philanthropic donations. Health is one of the Gates Foundation's primary focus areas. The foundation made headlines in 2015 for backing the world's first malaria vaccination.

Weather Bureau warns Brisbane, south-east Queensland face flooding from ex-Cyclone Debbie

Hundreds of thousands of school kids have been sent home as ex-Cyclone Debbie nears south-east Queensland, bringing flash flooding with more than a month's worth of rain in a single day. More than 1,500 schools, universities, and child care centers have been closed from Agnes Waters in central Queensland to the southern border, and out west to Nanango, affecting 300,000 state school students.

Brisbane’s central business district is forecast to get 200 millimeters of rain, which is more than the average monthly fall, however authorities have warned that up to 500mm could fall in 24 hours in some more regional areas. In three hours, 122mm has fallen in Aspley and 130mm in Alderley. However, the worst is yet to come. Damaging winds up to 120kph will be felt, which is the same force as a category one cyclone.

Deputy Premier Jackie Trad said if parents had already dropped their kids at school, they would be looked after. "But if you can make plans to pick up your children earlier than school closing time, then we encourage you to do so," Ms Trad said. She stated that what they don't want is for parents and children to be on the road in 90kph weather or heavy rainfall, and that peak hour will be a nightmare. Flash flooding will be an issue today from the Whitsundays to the New South Wales border. Ms Trad remains confident the public transport system in the south-east will remain up and running. Public transport travel is free today. All non-essential public servants have also been asked to go home, to keep the roads clear. Police Commissioner Ian Stewart said "we can't afford to have inexperienced young kids walking home from school at a time where there could be flash flooding".

US state department official charged with accepting bribes from Chinese spies

A US state department official has been arrested and charged in a federal court after allegedly accepting tens of thousands of dollars worth of payments and gifts from Chinese spies in return for information. Candace Claiborne appeared in court in Washington DC on Wednesday charged with lying to the FBI and concealing frequent contacts with two Chinese intelligence officials over several years. Claiborne, a 60-year-old administrative official with a top secret security clearance, is accused of receiving an Apple laptop, an iPhone, and thousands of dollars in cash from the Chinese officials, despite privately acknowledging that they were “spies”. An unidentified relative of Claiborne also allegedly received gifts and benefits from the Chinese officials, and was even protected from a police investigation when he allegedly committed a serious crime while studying in China in August 2013.

Mary McCord, the acting assistant attorney general for national security, said in a statement on Wednesday that “Claiborne used her position and her access to sensitive diplomatic data for personal profit”. Claiborne faces up to 25 years in prison if convicted. Prosecutors said that Claiborne had admitted to passing information to the Chinese officials but insisted that it was always unclassified. The 58-page complaint did not accuse Claiborne of disclosing classified information but said she told investigators that she had given the Chinese officials “information about a dissident who was being secretly housed” at the US embassy. The blind Chinese civil rights activist, Chen Guangcheng, arrived at the embassy after escaping house arrest in April 2012, causing a brief diplomatic crisis. US authorities said the Chinese spies, whose names were redacted by prosecutors, were agents of the Shanghai state security bureau, a branch of China’s Ministry of State Security (MSS), the country’s civilian intelligence and security agency.

The agents are said to have preyed on Claiborne’s complaints of financial woes and her inability to fund the “overseas educational and career goals” of the unidentified relative on her state department salary alone.

Academy Awards retains PricewaterhouseCoopers despite Best Picture mix-up

PricewaterhouseCoopers accountants won't be allowed to have their cellphones backstage during future Oscar telecasts. Film academy president Cheryl Boone Isaacs sent an email to academy members Wednesday detailing the new protocols for announcing Oscar winners developed after the best-picture flub at last month's Academy Awards. Academy of Motion Picture Arts and Sciences spokeswoman Teni Melidonian confirmed the authenticity of the email.

The academy's Board of Governors discussed its ongoing relationship with PwC, formerly known as PricewaterhouseCoopers, and established the new controls at a meeting Tuesday night. Besides banning cellphones, the academy is adding a third balloting partner to the telecast, and bringing in PwC's U.S. chairman to provide oversight. PwC, which has handled Oscar balloting and other academy business for 83 years, has claimed responsibility for the biggest mistake in Oscar history. Balloting partner Brian Cullinan tweeted a photo of Emma Stone backstage moments before handing presenters Warren Beatty and Faye Dunaway the wrong envelope for best picture. They announced "La La Land" as the winner, though "Moonlight" actually won.

Boone Isaacs blamed Cullinan's distraction for the error. PwC said that both he and partner Martha Ruiz failed to follow established protocols that night and did not act quickly enough to correct the error. Traditionally, two PwC partners have overseen Oscar balloting and are the only two people who know the winners before they are announced live onstage. They're stationed on opposite sides of the Dolby Theatre stage, each with an identical set of winners' envelopes for the show's 24 categories. Boone Isaacs said in her email Wednesday that a third balloting partner with knowledge of the winners will sit with the telecast director going forward. Balloting partners will also be required to participate in Oscar rehearsals, she said. She called the 89th Academy Awards "the most extraordinary and memorable Oscars ceremony in decades" and said that academy officials have been working since then to develop the new protocols adopted Tuesday.