**Analytic cognitive style predicts paranormal explanations of anomalous experiences but not the experiences themselves: implications for cognitive theories of delusions**

**Abstract**

*Background and Objectives:* It has been proposed that delusional beliefs represent an attempt to explain anomalous experiences. Why, then, do anomalous experiences induce delusions in some people but not in others? One possibility is that people with delusions have reasoning deficits that result in them failing to reject implausible candidate explanations for anomalous experiences. We examine this hypothesis by studying paranormal interpretations of anomalous experiences.

*Methods:* In a predominantly student sample, we examined whether analytic cognitive style (i.e. the willingness or disposition to critically evaluate outputs from intuitive processing and engage in effortful analytic processing) predicted anomalous experiences and paranormal explanations for these experiences after controlling for demographic variables and cognitive ability.

*Results:* Analytic cognitive style predicted paranormal explanations for anomalous experiences, but not the anomalous experiences themselves.

*Limitations:* We did not study clinical delusions. Our attempts to control for cognitive ability may have been inadequate. Our sample was predominantly students.

*Conclusions:* Analytic cognitive style might play a role in the formation and maintenance of delusions.

**Keywords**

Analytic cognitive style; delusion; dual process; paranormal; reasoning

**1. Introduction**

In a series of influential publications (e.g., Maher, 1974, 1988, 1999), Maher defended the hypothesis that delusional beliefs are generated by attempts to explain anomalous experiences. Given that anomalous experiences are widespread in the general population (Bell, Halligan, & Ellis, 2006; Bell, Halligan, Pugh, & Freeman, 2011; Pechey & Halligan, 2011), a topic of considerable debate is why only a small minority of people develop clinical delusions. One possibility is that people with delusions have reasoning deficits that result in them failing to reject implausible candidate explanations for anomalous experiences (Coltheart, Langdon, & McKay, 2011; Stone & Young, 1997). Although this proposal has considerable promise, no clear consensus has emerged concerning what specific reasoning deficits, if any, are involved (Coltheart, Menzies, & Sutton, 2010; Davies & Egan, 2013; Dudley, Taylor, Wickham, & Hutton, 2016; Garety & Freeman, 2013; Maher, 1999; McKay, 2012; McLean, Mattiske, & Balzan, 2016; Ross, McKay, Coltheart, & Langdon, 2015; So, Siu, Wong, Chan, & Garety, 2016).

Recently, it has been proposed that relationships between reasoning deficits and delusions can be elucidated using dual process theories of normal reasoning (Aimola Davies & Davies, 2009; Freeman, Evans, & Lister, 2012; Freeman, Lister, & Evans, 2014; Gold & Gold, 2014; Ross et al., in press; So et al., 2016; Speechley & Ngan, 2008). According to dual process theories, the human mind utilizes two qualitatively different reasoning processes (Evans, 2010; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2011): Type 1 or “intuitive” processes that do not require working memory, are relatively fast, high capacity, automatic, and operate in parallel; and Type 2 or “analytic” processes that require working memory, are relatively slow, low capacity, deliberative, and operate serially. An important assumption of dual process theories is that Type 1 processes provide default responses that can be altered if Type 2 processes intervene (Evans, 2007; Pennycook, Fugelsang, & Koehler, 2015b). Consider, for instance, the “bat and ball problem” (Frederick, 2005): “A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?” On first encountering this problem, an intuitively appealing response comes to mind: 10 cents. However, engaging in effortful analytic thinking reveals that this response is incorrect and the solution is actually 5 cents. Research using the bat and ball problem and other problems with intuitively appealing, yet incorrect, lures supports the hypothesis that people not only vary in terms of cognitive ability, but also in “analytic cognitive style”—their *willingness* or *disposition* to re-examine intuitive outputs from Type 1 processing using effortful Type 2 processing (Stanovich, 2011; Stanovich & West, 2008; Toplak, West, & Stanovich, 2011, 2013). Furthermore, analytic cognitive style has been implicated in a variety of everyday outcomes from religious belief, to creativity, to smartphone use (Pennycook, Fugelsang, & Koehler, 2015a; Pennycook, Ross, Koehler, & Fugelsang, 2016).

A large body of evidence points to psychotic experiences being on a continuum with psychosis-like phenomena in the general population (Heriot-Maitland & Peters, 2015; Larøi, Raballo, & Bell, 2015; Linscott & van Os, 2013). Of particular relevance to cognitive theories of delusions is evidence that anomalous experiences and delusion-like beliefs tend to co-occur (Bell et al., 2006). Nevertheless, this association does not demonstrate that anomalous experiences play a *causal role* in the establishment of delusion-like beliefs, and some scholars have argued that anomalous experiences are not in fact necessary (Bell, Halligan, & Ellis, 2008). Unfortunately, it is difficult to rigorously examine the evidence for a causal relationship using existing measure of delusion-like belief since they do not ask frank questions about whether delusion-like beliefs are responses to anomalous perceptual experiences. Consider the Peters et al Delusions Inventory (PDI; Peters, Joseph, Day, & Garety, 2004; Peters, Joseph, & Garety, 1999), the most widely used measure of delusion-like beliefs suitable for use with non-clinical populations. The PDI was developed by rewording items from a clinical measure of psychosis, with the language about beliefs being intentionally “toned down” and made indirect, typically by adding the expression “as if” to descriptions of clinical delusions (Peters et al., 1999). For example, one item from the PDI asks, “Do you ever feel as if you are being persecuted in some way?” This is not a direct inquiry about beliefs, so it is not clear how participants interpret the question (David, 2010). Participants might interpret the question as concerning imaginings or perceptual experiences, rather than beliefs. One of the three follow up questions of the PDI probes beliefs more directly, but no inquiries are made about whether the beliefs are grounded in abnormal experiences.

A potentially productive approach to studying the relationship between anomalous experiences and delusion-like beliefs is to frame questions for participants in terms of paranormal beliefs. Delusion-like beliefs and paranormal beliefs share overlapping cognitive foundations (Cella, Vellante, & Preti, 2012; Irwin, Dagnall, & Drinkwater, 2012a, 2012b; Irwin, Drinkwater, & Dagnall, 2014; Lawrence & Peters, 2004). In fact, in empirical research, the distinction between the two categories is somewhat porous, with measures of delusion-like belief and paranormal belief frequently including overlapping items. Recently, scholars have begun to tease apart the relationship between anomalous experiences and paranormal beliefs in the context of dual process theories of reasoning. A study of anomalous experiences generated in the laboratory found that participants who were low in analytic cognitive style were more likely to endorse paranormal explanations for these experiences (Bouvet & Bonnefon, 2015). This is an important result. Nevertheless, it is not certain that anomalous experiences generated in the laboratory and transient beliefs about the causes of these experiences adequately model the formation and maintenance of long-standing paranormal beliefs. Recently a survey has been developed that is well-suited to this task: the Survey of Anomalous Experience (SAE) teases apart anomalous experiences and beliefs about the causes of these experiences picked up from regular life (Irwin, Dagnall, & Drinkwater, 2013). For each item in this survey participants are asked to report whether they have ever had a particular anomalous experience (e.g., dreams that subsequently turned out to be accurate). If they indicate that they have had the experience then they are asked to choose between a paranormal explanation for that experience (e.g., telepathy or E.S.P.) and a naturalistic explanation (e.g., coincidence) as being the most probable. A recent study using this survey found that “intuitive-experiential thinking style” (roughly, a propensity to engage in Type 1 processing) predicted both anomalous experiences and paranormal explanations for these experiences, but “rational thinking style” (roughly, a propensity to engage in Type 2 processing) [[1]](#footnote-1) predicted neither (Irwin & Wilson, 2013). This research ought to be treated with a degree of caution. A self-report measure was used to index cognitive style, and the extent to which people have introspective access to their reasoning style is uncertain (Hodgkinson & Sadler-Smith, 2014). Indeed, due to concerns about self-report measures, contemporary scholarship on analytic cognitive style and its everyday consequences tends to focus on performance-based measures (Pennycook et al., 2015a; Pennycook et al., 2016).

In the present study, we investigated whether performance-based measures of analytic cognitive style predicted paranormal explanations for anomalous experiences indexed using the SAE. Deficit-based cognitive theories of delusions predict that reasoning deficits play a role in the interpretation of anomalous experiences, but not in the generation of anomalous experiences themselves (Coltheart et al., 2011). For this reason we hypothesized that analytic cognitive style would predict paranormal explanations for anomalous experiences more strongly than it would predict anomalous experiences themselves. In addition, we examined the relationship between analytic cognitive style and the PDI. Because the PDI does not clearly tease apart experience and belief (David, 2010), we hypothesized that analytic cognitive style would predict paranormal explanations for anomalous experiences indexed using the SAE more strongly than it would predict PDI scores.

**2. Methods**

*2.1. Participants*

Participants were recruited via the Online Recruitment System for Economic Experiments (ORSEE; Greiner, 2015) of the Laboratory for Decision Making & Economic Research (EconLab) at Royal Holloway, University of London. Approximately 99% of people in this participant pool are students. More than 90% of the students are undergraduates who are majoring in a diverse range of disciplines. An a priori decision was made to run group testing sessions until data from least 220 participants had been collected. In total 238 participants were recruited. Data were collected for the present study and an unrelated study during the same testing sessions. Participants received a base payment of £4 for participation in both studies (which could vary depending on outcomes in the other study). Sessions lasted approximately 45 minutes. Four participants were removed from analysis: one who did not report their age correctly (reported age as 94 years old and no participants of that age were present in the corresponding testing session) and three who reported their gender as “other” (gender was used as a predictor in all analyses because it is a strong predictor of scores on measures of analytic cognitive style, and a group of three participants is too small for statistical analysis). A total of 234 participants (157 females and 77 males; mean age = 20.38, SD age = 2.48) were thus retained for analysis.

*2.2. Materials*

We used two measures of analytic cognitive style. The first was the Cognitive Reflection Test (CRT; Frederick, 2005). The CRT consists of three simple mathematical problems, including the bat and ball problem, that stimulate intuitively appealing but incorrect responses. Correct responses were summed to create a CRT score (minimum = 0; maximum = 3). We found that the scale had acceptable internal consistency: Cronbach’s α = .72. Some participant populations have been widely exposed to the CRT, which creates difficulties for testing hypotheses about analytic cognitive style (Chandler, Mueller, & Paolacci, 2013; Chandler, Paolacci, Peer, Mueller, & Ratliff, 2015). Consequently, after completing the CRT we presented participants with the CRT again and asked them how many questions and solutions they had been exposed to previously.

The second measure of analytic cognitive style we used was the Cognitive Reflection Test Two (CRT-2; Thomson & Oppenheimer, 2016). The CRT-2 consists of four simple problems that, like the CRT, are designed to stimulate intuitively appealing but incorrect responses. Correct responses were summed to create a CRT-2 score (minimum = 0; maximum = 4). The paper that introduced the CRT-2 was published in January 2016 and data collection for the present study occurred during February and March 2016. Consequently, an important advantage of the CRT-2 over the CRT is that participants are very unlikely to have been exposed to the CRT-2 before. We found that the scale had poor internal consistency: Cronbach’s α = .57.

Solving items in the CRT requires both analytic cognitive style and cognitive ability (Pennycook & Ross, 2016), so we used a three-item basic numeracy test (Schwartz, Woloshin, Black, & Welch, 1997) to control (in part) for cognitive ability, as has been done in a number of earlier studies (Pennycook et al., 2015a). Each item in this numeracy test comprises of a simple mathematical problem. For example, “Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?” Scores on this test are strongly associated with scores on a longer 7-item numeracy test (Lipkus, Samsa, & Rimer, 2001). We found that the scale had poor internal consistency: Cronbach’s α = .47.

We measured delusional ideation using the 21-item version of the Peters et al. Delusions Inventory (PDI; Peters et al., 2004; Peters et al., 1999). For each item, participants are asked if they ever felt as if they have had a particular delusion-like experience (no = 0; yes = 1). For example, one item asks, “Do you ever feel as if things in magazines or on TV were written especially for you?” For each item endorsed participants are asked to rate (using a 5-point Likert scale) the associated distress (1 = not at all distressing; 5 = very distressing), preoccupation (1 = hardly ever think about it; 5 = think about it all the time), and conviction (1 = don’t believe it’s true; 5 = believe it is absolutely true). Scores from the initial question and the three subscales are summed to generate a composite score (minimum = 0; maximum = 336). We found that the scale had excellent internal consistency: Cronbach’s α = .93.

We measured anomalous experiences and paranormal explanations for these experiences using the 20-item Survey of Anomalous Experiences (SAE; Irwin et al., 2013). For each item, participants are asked if they have ever had a specific anomalous experience. For example, “I have had the impression of a figure nearby, yet nobody could possibly have been there”. For each item participants have three response options. Option 1, they can report that they have had the experience and that they interpret the experience in terms of a paranormal explanation. For example, “Yes, and it was probably an apparition or ghost”. Option 2, they can report that they have had the experience and interpret the experience in terms of a naturalist/scientific explanation. For example, “Yes, but it was probably just an illusion or misperception”. Option 3, they can indicate that they have not had that experience by selecting “no”. We lightly edited the wording of the original survey (see supplementary materials for our edited version of the survey). Following Irwin et al. (2013) responses were used to index two dimensions of individual variation. First, the anomalous experience measure is indexed as the number of “yes” responses (i.e., Option 1 or Option 2; minimum = 0; maximum = 20). Second, the paranormal explanations for experience measure is indexed as the proportion of “yes” responses that includes a paranormal explanation [i.e., Option 1/(Option 1 + Option 2); minimum = 0; maximum = 1]. We also collected demographic data on age and gender.

*2.3. Procedure*

The study was presented using z-Tree 3.5.1 (Fischbacher, 2007) on PC computers in individual testing booths in the EconLab at Royal Holloway, University of London. The order of presentation of tasks was as follows: numeracy test, CRT-2, CRT, SAE, PDI, questions about previous exposure to the CRT, gender, and age. The Psychology Department Ethics Committee of Royal Holloway, University of London approved the study.

**3. Results**

Correlations among variables are reported in Table 1 (raw data and descriptive statistics are reported in supplementary materials Tables 1 and 2). A mixture of categorical, ordinal, and continuous variables were analyzed; and responses to some of the ordinal and continuous variables were not normally distributed. Consequently, we used Spearman’s rank-order corrections (*rs*).



**Table 1.** Spearman’s rank-order correlations. Note: PE = Paranormal Explanation; PDI = Peters et al. Delusions Inventory; CRT = Cognitive Reflection Test; CRT-2 = Cognitive Reflection Test Two; Num = Numeracy Test; Gender (Male = 0; Female = 1); \**p* < .05 and \*\**p* < .01, two-tailed tests; N = 234.

We found that the CRT and the CRT-2 were positively correlated (*rs* = .474, *p* < .01), with the strength of the correlation being comparable to the correlation found in the study that introduced the CRT-2 (*rs* = .511, *p* < .01; Thomson & Oppenheimer, 2016). Nevertheless, 120 participants (52% of participants) reported that they had previously been exposed to at least one item from the CRT, and 44 participants (19% of participants) reported that they had previously been provided with solutions to at least one item from the CRT. Because prior exposure to the CRT has an effect on responses to the CRT (Chandler et al., 2013; Chandler et al., 2015), we use the CRT-2 alone as our measure of analytic cognitive style in our primary analyses. Nevertheless, to examine the robustness of our results we undertook a secondary analysis in which we removed all participants who reported having been exposed to at least one item from the CRT and used the sum of the CRT and the CRT-2 as our measure of analytic cognitive style (secondary analyses are reported in supplementary materials Tables 3-5).

The CRT-2 was negatively correlated with paranormal explanations for anomalous experiences (*rs* = -.221, *p* < .01) and the PDI (*rs* = -.140, *p* < .05), but no significant association was found between the CRT-2 and anomalous experiences (*rs* = -.033, *p* = .62). We used Zou’s (2007) method for comparing correlation coefficients, as implemented in the R package Cocor (Diedenhofen & Musch, 2015). This analysis confirmed that the CRT-2 was significantly more strongly correlated with paranormal explanations for anomalous experiences than with anomalous experiences themselves (95% C.I. for difference in *rs* [-.448, -.160]) and with the PDI (95% C.I. for difference in *rs* [-.273, -.002]).

We used three separate hierarchical multiple regression analyses to explore whether analytic cognitive style predicted 1) paranormal explanations, 2) anomalous experiences, and 3) PDI scores. Our primary hypothesis was that analytic cognitive style would predict paranormal explanations for anomalous experiences after controlling for other variables. At step 1 we entered demographic factors (age and gender) as independent variables; at step 2 we added a measure of cognitive ability (i.e. the numeracy test); and at step 3 we added a measure of analytic cognitive style (i.e. the CRT-2). Visual inspection of a plot of predicted values of paranormal explanations against residuals indicated that the linear model’s assumption of normality of the error distribution was violated. Consequently, to calculate beta coefficients, beta standard errors, bias corrected confidence intervals, and p-values for each of the predictors that are robust to this departure from the assumption of the linear model, we followed the advice of (Field, 2013) and re-ran the analyses using the bias corrected bootstrap resampling method. This was implemented in SPSS version 21 (Corp., 2012) using 3000 re-samples. Results are reported in Table 2. These results reveal that higher levels of analytic cognitive style, as indexed using the CRT-2, predicted lower levels of paranormal explanation independently of age, gender, and cognitive ability. To test the robustness of this result we ran the same hierarchical regression using the CRT total score (i.e. CRT correct plus CRT-2 correct) after removing all participants who had reported seeing any of the CRT items previously. These results are broadly consistent, in particular the CRT total score predicted paranormal explanations at Step 3 (see supplementary materials Table 3).



**Table 2.** Hierarchical multiple regression analysis predicting paranormal explanations for anomalous experiences. Note: CRT-2 = Cognitive Reflection Test Two; Gender (Male = 0; Female = 1); *R2* = .017 for Step 1 (p = .138); *ΔR2* = .020 (*p* = .030) for Step 2; *ΔR2* = .048 (*p* = .001) for Step 3; N = 234.

We were also interested in whether analytic cognitive style would predict anomalous experience after controlling for other variables. Independent variables were entered into the regression equation in the same steps as when testing our first hypothesis. Results are reported in Table 3. These results reveal that analytic cognitive style, as indexed using the CRT-2, did not predict anomalous experience independently of age, gender, and numeracy. To test the robustness of this result we ran the same hierarchical regression using the CRT total score after removing all participants who had reported seeing any of the CRT items previously. These results are broadly consistent, in particular the CRT total score did not predict paranormal experiences at Step 3 (see supplementary materials Table 4).



**Table 3.** Hierarchical multiple regression analysis predicting anomalous experiences. Note: CRT-2 = Cognitive Reflection Test Two; Gender (Male = 0; Female = 1); *R2* = .005 for Step 1 (p = .564); *ΔR2* = .000 (*p* = .902) for Step 2; *ΔR2* = .001 (*p* = .685) for Step 3; N = 234.

We were also interested in whether analytic cognitive style predicts PDI scores after controlling for other variables. Independent variables were entered into the regression equation in the same steps as when testing our first and second hypotheses. Results are reported in Table 4. These results reveal that analytic cognitive style, as indexed using the CRT-2, did not predict PDI scores independently of age, gender, and numeracy. To test the robustness of this result we ran the same hierarchical regression using the CRT total score after removing all participants who had reported seeing any of the CRT items previously. These results are broadly consistent, in particular the CRT total score did not predict PDI scores at Step 3 (see supplementary materials Table 5).



**Table 4.** Hierarchical multiple regression analysis predicting delusional ideation. Note: CRT-2 = Cognitive Reflection Test Two; Gender (Male = 0; Female = 1); *R2* = .011 for Step 1 (p = .270); *ΔR2* = .043 (*p* = .001) for Step 2; *ΔR2* = .007 (*p* = .199) for Step 3; N = 234.

**4. Discussion**

We found that analytic cognitive style (i.e. the willingness or disposition to critically evaluate outputs from intuitive processing and engage in effortful analytic processing) predicted paranormal explanations for anomalous experiences. In other words, participants who tend to reject intuitive responses for reasoning problems and identify correct responses were more likely to reject paranormal explanations for their anomalous experiences, even when controlling for cognitive ability, age, and gender. By contrast, we did not find evidence that analytic cognitive style predicted anomalous experiences. These results are consistent with cognitive theories of delusions that posit that delusions are caused by two factors—anomalous experiences and reasoning deficits that result in individuals failing to reject implausible candidate explanations for their anomalous experiences (Coltheart et al., 2011).

These results conceptually replicate evidence that analytic cognitive style predicts low levels of paranormal explanation for anomalous experiences induced in a laboratory study (Bouvet & Bonnefon, 2015). In addition, our results extend this research because we examined explanations for long-standing beliefs about paranormal experiences. It is more challenging to harmonize our results with a study that found that self-reported intuitive-experiential cognitive style (roughly, a propensity to rely on Type 1 processing) predicted both anomalous experiences and paranormal explanations for these experiences, whereas a self-reported rational cognitive style (roughly, a propensity to use Type 2 processing) predicted neither (Irwin & Wilson, 2013). Nevertheless, we suggest that our results provide a more direct examination of the relationship between analytic cognitive style, anomalous experiences, and paranormal explanations because we used performance-based measures of cognitive style, rather than a self-report measure.

PDI scores were not found to predict anomalous experiences or paranormal explanations after controlling for age, gender, and cognitive ability. Although null results are difficult to interpret, we suggest PDI scores might not robustly predict paranormal explanations because the PDI does not tease apart anomalous experiences and explanations for those experiences. Indeed, we found that the correlation between analytic cognitive style and paranormal explanations was significantly stronger than the correlation between analytic cognitive style and PDI scores.

Our study has a number of limitations that ought to be highlighted. First, the relationship between delusion-like beliefs and paranormal beliefs is uncertain. While measures of delusion-like belief, such as the PDI, have been examined in clinical populations diagnosed with delusions (Peters et al., 2004; Peters et al., 1999), the SAE has not. Consequently, research in clinical populations is needed to examine the validity of this measure. Second, we only used a basic numeracy test to measure cognitive ability. The CRT measures both analytic cognitive style and cognitive ability (Pennycook & Ross, 2016), and we cannot be certain that we have adequately controlled for cognitive ability (Westfall & Yarkoni, 2016). Consequently, it could be that cognitive ability, rather than analytic cognitive style, is the true cause of the association between paranormal explanations and CRT-2 scores. Earlier studies that explored analytic cognitive style controlled for cognitive ability more rigorously, either by including a short vocabulary test (e.g., Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012) or an intelligence test (e.g., Toplak et al., 2011). Third, our sample comprises almost exclusively of university students, which renders the generalizability of our results to other populations uncertain (Henrich, Heine, & Norenzayan, 2010).

**Conclusion**

In the present study we used paranormal interpretations of anomalous experiences to model delusion-like belief. Consistent with theories of delusions that highlight the importance of reasoning deficits, we found that lower levels of analytic cognitive style predict endorsement of paranormal explanations for anomalous experiences, but not the anomalous experiences themselves. These results suggest that analytic cognitive style might play a role in the formation and maintenance of delusions.

**Conflict of interest**

The authors of this manuscript have no conflict of interest.

**References**

Aimola Davies, A. M., & Davies, M. (2009). Explaining pathologies of belief. In M. R. Broome & L. Bortolotti (Eds.), *Psychiatry as cognitive neuroscience: philosophical perspectives* (pp. 285-323).

Bell, V., Halligan, P. W., & Ellis, H. D. (2006). The Cardiff Anomalous Perceptions Scale (CAPS): A new validated measure of anomalous perceptual experience. *Schizophrenia Bulletin, 32*(2), 366-377. doi:10.1093/schbul/sbj014

Bell, V., Halligan, P. W., & Ellis, H. D. (2008). Are Anomalous Perceptual Experiences Necessary For Delusions? *The Journal of Nervous and Mental Disease, 196*(1), 3-8. doi:10.1097/NMD.0b013e31815f6619

Bell, V., Halligan, P. W., Pugh, K., & Freeman, D. (2011). Correlates of perceptual distortions in clinical and non-clinical populations using the Cardiff Anomalous Perceptions Scale (CAPS): Associations with anxiety and depression and a re-validation using a representative population sample. *Psychiatry Research, 189*, 451-457. doi:10.1016/j.psychres.2011.05.025

Bouvet, R., & Bonnefon, J. F. (2015). Non-reflective thinkers are predisposed to attribute supernatural causation to uncanny experiences. *Personality and Social Psychology Bulletin, 41*(7), 955-961. doi:10.1177/0146167215585728

Cella, M., Vellante, M., & Preti, A. (2012). How psychotic-like are paranormal beliefs? *Journal of Behavior Therapy and Experimental Psychiatry, 43*(3), 897-900. doi:10.1016/j.jbtep.2012.01.003

Chandler, J., Mueller, P. A., & Paolacci, G. (2013). Nonnaïveté among Amazon Mechanical Turk workers: Consequences and solutions for behavioral researchers. *Behavior Research Methods, 46*, 112-130. doi:10.3758/s13428-013-0365-7

Chandler, J., Paolacci, G., Peer, E., Mueller, P., & Ratliff, K. A. (2015). Using nonnaive participants can reduce effect sizes. *Psychological Science, 26*(7), 1131-1139. doi:10.1177/0956797615585115

Coltheart, M., Langdon, R., & McKay, R. (2011). Delusional belief. *Annual Review of Psychology, 62*(5), 271-298. doi:10.1146/annurev.psych.121208.131622

Coltheart, M., Menzies, P., & Sutton, J. (2010). Abductive inference and delusional belief. *Cognitive Neuropsychiatry, 15*(1), 261-287. doi:10.1080/13546800903439120

Corp., I. (2012). IBM SPSS Statistics for Macintosh, Version 21.0. Retrieved from

David, A. S. (2010). Why we need more debate on whether psychotic symptoms lie on a continuum with normality. *Psychological Medicine, 40*(12), 1935-1942. doi:10.1017/S0033291710000188

Davies, M., & Egan, A. (2013). Delusion: cognitive approaches--Bayesian inference and compartmentalization. In K. W. M. Fulford, M. Davies, R. G. T. Gipps, G. Graham, J. Z. Sadler, G. Stanghellini, & T. Thornton (Eds.), *The Oxford Handbook of Philosophy and Psychiatry* (pp. 689-727). Oxford, UK: Oxford University Press.

Diedenhofen, B., & Musch, J. (2015). Cocor: A comprehensive solution for the statistical comparison of correlations. *PLOS ONE, 10*(3), e0121945. doi:10.1371/journal.pone.0121945

Dudley, R., Taylor, P., Wickham, S., & Hutton, P. (2016). Psychosis, delusions and the "jumping to conclusions" reasoning bias: A systematic review and meta-analysis. *Schizophrenia Bulletin, 42*(3), 652-665. doi:10.1093/schbul/sbv150

Evans, J. S. B. T. (2007). On the resolution of conflict in dual process theories of reasoning. *Thinking & Reasoning, 13*(4), 321-339. doi:10.1080/13546780601008825

Evans, J. S. B. T. (2010). *Thinking twice: Two minds in one brain*. Oxford, UK: Oxford University Press.

Evans, J. S. B. T., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8*(3), 223-241. doi:10.1177/1745691612460685

Field, A. P. (2013). *Discovering statistics using IBM SPSS Statistics: And sex and drugs and rock 'n' roll* (4 ed.). Ca, USA: Sage.

Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics, 10*(2), 171-178. doi:10.1007/s10683-006-9159-4

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives, 19*(4), 25-42. doi:10.1257/089533005775196732

Freeman, D., Evans, N., & Lister, R. (2012). Gut feelings, deliberative thought, and paranoid ideation: A study of experiential and rational reasoning. *Psychiatry Research, 197*(1-2), 119-122. doi:10.1016/j.psychres.2011.12.031

Freeman, D., Lister, R., & Evans, N. (2014). The use of intuitive and analytic reasoning styles by patients with persecutory delusions. *Journal of Behavioral Therapy and Experimental Psychiatry, 45*(4), 454-458. doi:10.1016/j.jbtep.2014.06.005

Garety, P. A., & Freeman, D. (2013). The past and future of delusions research: From the inexplicable to the treatable. *British Journal of Psychiatry, 203*(5), 327-333. doi:10.1192/bjp.bp.113.126953

Gold, J., & Gold, I. (2014). *Suspicious minds: How culture shapes madness*. New York, NY: Free Press.

Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with ORSEE. *Journal of the Economic Science Association, 1*(1), 114-125. doi:10.1007/s40881-015-0004-4

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2-3), 61-135. doi:10.1017/S0140525X0999152X

Heriot-Maitland, C., & Peters, E. (2015). Dimensional approaches to delusional beliefs. In O. Mason & G. Claridge (Eds.), *Schizotypy: New Dimensions* (pp. 165-179). East Sussex: Routledge.

Hodgkinson, G. P., & Sadler-Smith, E. (2014). Self-report assessment of individual differences in performance for analytic and intuitive processing: a critical review. In M. Sinclair (Ed.), *Handbook of Research Methods on Intuition* (pp. 101-115). Cheltenham, UK: Edward Elgar.

Irwin, H. J., Dagnall, N., & Drinkwater, K. (2012a). Paranormal belief and biases in reasoning underlying the formation of delusions. *Australian Journal of Parapsychology, 12*(1), 7-21.

Irwin, H. J., Dagnall, N., & Drinkwater, K. (2012b). Paranormal belief and cognitive processes underlying the formation of delusions. *Australian Journal of Parapsychology, 12*(2), 107-126.

Irwin, H. J., Dagnall, N., & Drinkwater, K. (2013). Parapsychology experience as anomalous experience plus paranormal attribution: A questionnaire based on a new approach to measurement. *Journal of Parapsychology, 77*, 39-53.

Irwin, H. J., Drinkwater, K., & Dagnall, N. (2014). Are believers in the paranormal inclined to jump to conclusions? *Australian Journal of Parapsychology, 14*(1), 69-82.

Irwin, H. J., & Wilson, K. (2013). Anomalous experiences and the intuitive-experiential style of thinking. *The Journal of the American Society for Psychical Research, 72*, 65-71.

Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.

Larøi, F., Raballo, A., & Bell, A. V. (2015). Psychosis-like experiences in non-clinical population. In F. Waters & M. Stephane (Eds.), *The Assessment of Psychosis* (pp. 92-101). New York, NY: Routledge.

Lawrence, E., & Peters, E. R. (2004). Reasoning in believers in the paranormal. *The Journal of Nervous and Mental Disease, 192*(11), 727-733. doi:10.1097/01.nmd.0000144691.22135.d0

Linscott, R. J., & van Os, J. (2013). An updated and conservative systematic review and meta-analysis of epidemiological evidence on psychotic experiences in children and adults: On the pathway from proneness to persistence to dimensional expression across mental disorders. *Psychological Medicine, 43*(6), 1133-1149. doi:10.1017/S0033291712001626

Lipkus, I. M., Samsa, G., & Rimer, B. K. (2001). General performance on a numeracy scale among highly educated samples. *Medical Decision Making, 21*(1), 37-44. doi:10.1177/0272989x0102100105

Maher, B. A. (1974). Delusional thinking and perceptual disorder. *Journal of Individual Psychology, 30*, 98-113.

Maher, B. A. (1988). Anomalous experience and delusional thinking: the logic of explanations. In T. F. Oltmann & B. A. Maher (Eds.), *Delusional Beliefs* (pp. 15-33). Chichester, UK: John Wiley and Sons.

Maher, B. A. (1999). Anomalous experience in everyday life: Its significance for psychopathology. *The Monist, 82*(4), 547-570.

McKay, R. (2012). Delusional inference. *Mind & Language, 27*(3), 330-355.

McLean, B. F., Mattiske, J. K., & Balzan, R. P. (2016). Association of the jumping to conclusions and evidence integration biases with delusions in psychosis: A detailed meta-analysis. *Schizophrenia Bulletin, Advance online publication*. doi:10.1093/schbul/sbw056

Pacini, R., & Epstein, S. (1999). The relation of rational and experiential information processing styles to personality, basic beliefs, and the ratio-bias phenomenon. *Personality Processes and Individual Differences, 76*(6), 972-987.

Pechey, R., & Halligan, P. (2011). The prevalence of delusion-like beliefs relative to sociocultural beliefs in the general population. *Psychopathology, 44*(2), 106-115. doi:10.1159/000319788

Pennycook, G., Cheyne, J. A., Seli, P., Koehler, D. J., & Fugelsang, J. A. (2012). Analytic cognitive style predicts religious and paranormal belief. *Cognition, 123*(3), 335-346. doi:10.1016/j.cognition.2012.03.003

Pennycook, G., Fugelsang, J. A., & Koehler, D. J. (2015a). Everyday consequences of analytic thinking. *Current Directions in Psychological Science, 24*(6), 425-432. doi:10.1177/0963721415604610

Pennycook, G., Fugelsang, J. A., & Koehler, D. J. (2015b). What makes us think? A three-stage dual-process model of analytic engagement. *Cognitive Psychology, 80*, 34-72. doi:10.1016/j.cogpsych.2015.05.001

Pennycook, G., & Ross, R. M. (2016). Commentary: Cognitive reflection vs. calculation in decision making. *Frontiers in Psychology, 7*, 1-4. doi:10.3389/fpsyg.2016.00009

Pennycook, G., Ross, R. M., Koehler, D. J., & Fugelsang, J. A. (2016). Atheists and agnostics are more reflective than religious believers: Four empirical studies and a meta-analysis. *PLOS ONE, 11*(4), e0153039. doi:10.1371/journal.pone.0153039

Peters, E. R., Joseph, S. A., Day, S., & Garety, P. A. (2004). Measuring delusional ideation: The 21-Item Peters et al. Delusions Inventory (PDI) *Schizophrenia Bulletin, 30*(4), 1005-1022. doi:10.1093/oxfordjournals.schbul.a007116

Peters, E. R., Joseph, S. A., & Garety, P. A. (1999). Measurement of delusional ideation in the normal population: Introducing the PDI (Peters et al. Delusions Inventory). *Schizophrenia Bulletin, 25*(3), 553-576. doi:10.1093/oxfordjournals.schbul.a033401

Ross, R. M., McKay, R., Coltheart, M., & Langdon, R. (2015). Jumping to conclusions about the beads task? A meta-analysis of delusional ideation and data-gathering. *Schizophrenia Bulletin, 41*(5), 1183-1191. doi:10.1093/schbul/sbu187

Ross, R. M., Pennycook, G., Mckay, R., Gervais, W. M., Langdon, R., & Coltheart, M. (in press). Analytic cognitive style, not delusional ideation, predicts data gathering in a large beads task study. *Cognitive Neuropsychiatry*.

Schwartz, L. M., Woloshin, S., Black, W., & Welch, H. G. (1997). The role of numeracy in understanding the benefit of screening mammography. *Annuals of Internal Medicine, 127*(11), 966-972.

So, S. H.-W., Siu, N. Y.-F., Wong, H.-l., Chan, W., & Garety, P. A. (2016). ‘Jumping to conclusions’ data-gathering bias in psychosis and other psychiatric disorders — Two meta-analyses of comparisons between patients and healthy individuals. *Clinical Psychology Review, 46*, 151-167. doi:10.1016/j.cpr.2016.05.001

Speechley, W. J., & Ngan, E. T. C. (2008). Dual-stream modulation failure: A novel hypothesis for the formation and maintenance of delusions in schizophrenia. *Medical Hypotheses, 70*(6), 1210-1214. doi:10.1016/j.mehy.2007.11.017

Stanovich, K. E. (2011). *Rationality and the reflective mind*. Oxford, UK: Oxford University Press.

Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology, 94*(4), 672-695. doi:10.1037/0022-3514.94.4.672

Stone, T., & Young, A. W. (1997). Delusions and brain injury: The philosophy and psychology of belief. *Mind & Language, 12*(3/4), 327-364.

Thomson, K. S., & Oppenheimer, D. M. (2016). Investigating an alternative form of the Cognitive Reflection Test. *Judgment and Decision Making, 11*(1), 99-113.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2011). The Cognitive Reflection Test as a predictor of performance on heuristics-and-biases tasks. *Memory & Cognition, 39*(7), 1275-1289. doi:10.3758/s13421-011-0104-1

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Assessing miserly information processing: An expansion of the Cognitive Reflection Test. *Thinking & Reasoning, 20*(2), 147-168. doi:10.1080/13546783.2013.844729

Westfall, J., & Yarkoni, T. (2016). Statistically controlling for confounding constructs is harder than you think. *PLOS ONE, 11*(3), e0152719. doi:10.1371/journal.pone.0152719

Zou, G. Y. (2007). Towards using confidence intervals to compare correlations. *Psychological Methods, 12*(4), 399-413. doi:10.1037/1082-989x.12.4.399.supp

1. The cognitive style questionnaire used in this study is based on Cognitive-Experiential Self-Theory (Pacini & Epstein, 1999), which is somewhat different to the dual process theories that we focus on here. [↑](#footnote-ref-1)