**Analytic cognitive style, not delusional ideation, predicts data gathering in a large beads task study**

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**Abstract**

Introduction: It has been proposed that deluded and delusion-prone individuals gather less evidence before forming beliefs than those who are not deluded or delusion-prone. The primary source of evidence for this “jumping to conclusions” (JTC) bias is provided by research that utilizes the “beads task” data gathering paradigm. However, the cognitive mechanisms subserving data gathering in this task are poorly understood.

Methods: In the largest published beads task study to date (n = 558), we examined data gathering in the context of influential dual-process theories of reasoning.

Results: Analytic cognitive style (the willingness or disposition to critically evaluate outputs from intuitive processing and engage in effortful analytic processing) predicted data gathering in a non-clinical sample, but delusional ideation did not.

Conclusion: The relationship between data gathering and analytic cognitive style suggests that dual process theories of reasoning can contribute to our understanding of the beads task. Nevertheless, it is not clear why delusional ideation did not predict data gathering or show an association with analytic cognitive style in this study.

**Keywords**

beads task; cognitive style; delusion; dual-process theory; jumping to conclusions

**Introduction**

It has been proposed that reasoning impairments and biases can play a crucial role in the formation and maintenance of delusional beliefs (Coltheart, Langdon, & McKay, 2011; Connors & Halligan, 2015; Garety & Freeman, 1999, 2013). A seminal study in this literature is Huq, Garety, and Hemsley’s (1988) adaptation of the “beads task” data gathering paradigm (Phillips & Edwards, 1966) to examine the relationship between delusions and data gathering. They presented participants with two jars filled with colored beads of complementary ratios: a mostly pink jar (85 pink beads; 15 green beads) and a mostly green jar (85 green beads; 15 pink beads). After these jars had been hidden, participants were shown a sequence of beads that were ostensibly being drawn from one of these jars (the sequence was actually prespecified). After each bead was revealed, participants were asked whether they wanted to see another bead or make a decision about which jar the beads were being drawn from. Participants diagnosed with clinical delusions requested significantly fewer beads than psychiatric and healthy controls. Dozens of beads task studies have subsequently been published, many of which have replicated this result (Garety & Freeman, 1999, 2013). Furthermore, a recent meta-analysis found that limited data gathering in the beads task is associated with higher delusional ideation in non-clinical populations (Ross, McKay, Coltheart, & Langdon, 2015), which is consistent with theories that propose that clinical delusions lie on a continuum with normal belief (Linscott & van Os, 2013).

The beads task has been used to test the hypothesis that deluded and delusion-prone individuals have a “jumping to conclusions” (JTC) data gathering bias that results in them forming beliefs on the basis of less evidence than people who are not deluded or delusion-prone (Garety & Freeman, 1999, 2013). Nevertheless, there is considerable debate about how best to interpret the JTC bias literature (Dudley, Cavanagh, Daley, & Smith, 2015; S. Evans, Averbeck, & Furl, 2015). Notably, the most widely used versions of the task do not provide any objective basis for classifying responses as correct or incorrect (van der Leer, Hartig, Goldmanis, & McKay, 2015), meaning that performance on this task cannot be directly evaluated in terms of normative standards of reasoning. In fact, some scholars have claimed that evoking a JTC bias has no explanatory value at all: “portrayal of people with delusions as having a JTC bias is a redescription rather than an explanation” (Corlett & Fletcher, 2014, p. 399). Disagreement about the JTC bias suggests that a useful direction for research could be to examine data gathering in the beads task within the context of a well-developed cognitive model of normal reasoning.

A substantial body of evidence supports the existence of two distinct reasoning processes (J. S. B. T. Evans, 2010; J. S. B. T. Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2011): Type 1 or “intuitive” processing which does not require working memory, and is typically fast, high capacity, automatic, and independent of cognitive ability; and Type 2 or “analytic” processing which requires working memory, and is typically slow, low capacity, deliberative, and dependent on cognitive ability. It has been argued that these processes interact in a “default-interventionist” manner, with Type 1 processes providing a fast intuitive response that guides behavior unless slower Type 2 monitoring processes intervene and offer an alternative response (J. S. B. T. Evans, 2007).

Dual process theories of reasoning have been developed and refined using a variety of reasoning tasks. Among the most celebrated is 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?” Most people respond with the first answer that comes to mind: 10 cents. However, thinking more carefully reveals that this intuitively appealing answer is incorrect. If the ball costs 10 cents then the bat must cost $1.10, which means that the total cost is $1.20, not $1.10. The correct answer is 5 cents. Performance on this problem and related problems provide evidence that there is substantial variation in the general population in “analytic cognitive style”—the *willingness* or *disposition* to critically evaluate outputs from Type 1 processing and engage in effortful Type 2 processing. Analytic cognitive style is a core component of rationality (Stanovich, 2011; Stanovich & West, 2008) that is dissociable from cognitive ability (Toplak, West, & Stanovich, 2011, 2013) and has important consequences for diverse domains of psychological functioning (Pennycook, Fugelsang, & Koehler, 2015).

There exist striking parallels between dual process theories of normal reasoning and theories of delusions that implicate a JTC bias. According to dual process theories, Type 1 processing acts as a “machine for jumping to conclusions” (Kahneman, 2011, p. 79) that is “radically insensitive to both the quality and the quantity of the information that gives rise to impressions and intuitions” (p. 86). Similarly, contemporary theories of delusions posit that a JTC bias plays an important role in delusion formation because “anomalous or ambiguous information is rapidly appraised and a delusion is formed on the basis of limited evidence” (Garety & Freeman, 2013, p. 327).

It has recently been proposed that the cognitive style of people with delusions might be characterised by an over-reliance on Type 1 processing, or an under-utilization of Type 2 processing, or both (Aimola Davies & Davies, 2009; Freeman, Evans, & Lister, 2012; Freeman, Lister, & Evans, 2014; Gold & Gold, 2014; Speechley & Ngan, 2008)[[1]](#footnote-2),[[2]](#footnote-3). Such proposals are consistent with recent meta-analyses that have found that reduced data gathering is associated with increased self-reported delusional ideation (Ross et al., 2015) and psychotic diagnoses (Dudley, Taylor, Wickham, & Hutton, 2015). In addition, studies have reported that data gathering in the beads task is associated with performance in an analytic reasoning task (Brosnan, Hollinworth, Antoniadou, & Lewton, 2014) and self-reported “systemizing” (Brosnan, Ashwin, & Gamble, 2013).

In the present study we investigated whether analytic cognitive style and delusional ideation predict data gathering in the beads task *independently* of each other. In addition, we controlled for a variety of potential confounds to isolate unique variance predicted by these two variables—in particular, we controlled for cognitive ability, traditional religiosity, and paranormal belief since they have been found to be associated with analytic cognitive style, or data gathering in the beads task, or both (Irwin, Drinkwater, & Dagnall, 2014; Pennycook et al., 2015).

**Methods**

*Participants*

Participants were recruited using *Mechanical Turk*,an online marketplace where people can sign up for paid tasks, including psychological studies (Buhrmester, Kwang, & Gosling, 2011). Only people with a strong track record of completing tasks satisfactorily (a “HIT approval rating” of greater or equal to 95%) and a USA-based *Mechanical Turk*user account were eligible to respond to the advertisement. Participation was voluntary and participants received $US2.20 as remuneration. Sessions lasted approximately 45 minutes.

We included two instructional manipulation checks to ensure that participants were paying attention to the tasks. Following the advice of Oppenheimer, Meyvis, and Davidenko (2009), we did not exclude participants who failed these checks on their first attempt. Rather, these participants were told that they had made an error and were asked to attempt the instructional manipulation check again. If a participant passed on their second attempt, we took this as evidence that their attention had been refocused, and their data were retained for further analysis. If a participant failed on their second attempt, we took this as evidence that they were not motivated to follow simple instructions, and their data were excluded from the analysis.

Surveys that were incomplete were excluded from analysis. Complete surveys were subjected to the following sequential screening criteria (the number of participants failing a given criterion are shown in parentheses): they had a USA IP address (22); they had an IP address that did not match that of any other participant (24); they indicated that they are a fluent speaker of English (5); they indicated that they had not answered questions randomly and/or provided answers that did not reflect their true beliefs (13); they indicated that they had not consulted the Internet or other people to get answers to reasoning problems (20); they passed both Instructional Manipulation checks on their first or second attempt (46); they indicated that they were 18 years old or older (1; the minimum age for being eligible to open a *Mechanical Turk* account is 18 years old); they requested fewer than 50 beads during the beads task (12; the maximum number possible in our study is 50—see justification below). After screening, 558 participants (out of the 701 who completed the survey) were retained for analysis.

*Materials*

*Beads task*

Participants were shown an image of two jars of beads and task instructions based on those of Garety *et al.* (2005). One jar was labelled as being a “mainly red jar” and was described and depicted as having 60 red beads and 40 blue beads, and the other jar was labelled as being a “mainly blue jar” and was described and depicted as having 40 red beads and 60 blue beads. After the images of the jars had been removed, participants were shown a sequence of beads apparently being drawn from one of the jars with replacement. In reality, the sequence of beads was prespecified and identical for all participants (b = blue; r = red): b r r b b r b b b r b b b b r r b r r b b r b b r b b b r r b r r b b b b r b b r r r r b b r b b b. The first 20 beads followed a widely used sequence from Garety *et al*. (2005) that stopped at 20 beads. We added an additional 30 beads to the sequence (maintaining roughly the same ratio of blue to red beads throughout the sequence) to provide participants with the opportunity to see a substantial number of beads. After each draw, participants were asked if they would like to decide which jar the beads were being drawn from or if they would like to see another bead. As per standard procedure, data gathering was operationalized as the number of beads a participant asked to see before making a decision—i.e. “draws to decision”. Requesting an unusually vast number of beads suggests that a participant either was not paying close attention to the sequence of beads or had interpreted the task instructions differently to other participants. Consequently, prior to analysis we removed participants who asked to see all 50 beads. In total, only 12 participants (i.e. 2.1% of otherwise eligible participants) were removed on this basis.

*Analytic cognitive style measures*

*The 3-item Cognitive Reflection Test (CRT3; Frederick, 2005).*

The CRT3 consists of simple mathematical problems, including the bat and ball problem, that generate intuitively appealing but misleading conclusions. Correct responses were summed to create a CRT3 score.

*The 4-item Cognitive Reflection Test (CRT4; Toplak et al., 2013).*

Like the CRT3, the CRT4 consists of simple mathematical problems that generate intuitively appealing but misleading conclusions. However, the CRT4 has an important advantage: the CRT3 is very difficult, with students at elite universities frequently providing incorrect responses (Frederick, 2005), which suggests that a floor effect might be evident in many populations. The CRT4 is considerably easier (Toplak et al., 2013). Correct responses were summed to create a CRT4 score.

*The 15-item “heuristics and biases” battery (Toplak et al., 2011).*

This battery was designed to explore important aspects of rational thought. For example, “When playing slot machines, people win approximately 1 in every 10 times. Julie, however, has just won on her first three plays. What are her chances (out of 10) of winning the next time she plays?” Correct responses were summed to create a heuristics and biases score.

*The 8-item syllogistic reasoning test (De Neys & Franssens, 2009).*

Four items are “conflict syllogisms” that have conclusions in which deductive logic was in conflict with believability (two items had unbelievable-valid conclusions, and two items had believable-invalid concussions); and four items are “non-conflict syllogisms” that have conclusions in which deductive logic was consistent with believability (two problems had unbelievable-invalid conclusions, and two problems had believable-valid conclusions). For example, “Premise 1: All vehicles have wheels. Premise 2: A boat is a vehicle. Conclusion: Therefore, a boat has wheels. Assume that the two premises are true. Does the conclusion follow logically from the two premises?” This is a conflict syllogism because the syllogism is logically valid but has an unbelievable conclusion (typical boats do not have wheels). Correct responses to the conflict problems were summed to create a conflict syllogism score.

An analytic cognitive style score was calculated by summing scores from the CRT3, the CRT4, the heuristics and biases battery, and the conflict syllogisms from the syllogistic reasoning test (minimum possible score 0; maximum possible score 26).

*Cognitive ability measures*

Solving any reasoning task requires both cognitive ability and analytic cognitive style. Nevertheless, different tasks pose different cognitive challenges (Stanovich, 2011; Stanovich & West, 2008; Toplak et al., 2011, 2013). To solve the bat and ball problem, for example, requires not only basic numeracy (i.e. cognitive ability), but also a high level of analytic processing to inhibit and override an intuitive incorrect response. For this reason, we follow earlier research in referring to the bat and ball problem and related problems as “analytic cognitive style” tasks. By contrast, basic numeracy problems do not present an incorrect intuitive lure, so basic numeracy alone is sufficient to solve these problems (Pennycook & Ross, 2016). Consequently, basic numeracy and basic literacy problems are referred to as “cognitive ability” tasks. Following earlier research, we examine whether additional variation in a measure of interest (in this case, data gathering in the beads task) is explained by performance in analytic cognitive style tasks after controlling for performance in cognitive ability tasks (Pennycook et al., 2015; Toplak et al., 2011, 2013).

*The Wordsum test (Huang & Hauser, 1998).*

This verbal intelligence test comprises of 10 multiple choice vocabulary questions in which participants are asked to identify which of five words comes closest in meaning to a target word. For example, one of the target words is *animosity* and the five options are *hatred, animation, disobedience, diversity*, and *friendship*. The Wordsum test correlates well with full-scale measures of intelligence such as the WAIS-R (Huang & Hauser, 1998), and has been used in 16 General Social Surveys (Davies & Smith, 1994) and numerous psychological, sociological, and political science studies (Malhotra, Krosnick, & Haertel, 2007).

*The 3-item basic numeracy test (Schwartz, Woloshin, Black, & Welch, 1997).*

This test is comprised of simple mathematical problems. 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 opted for the shorter version to minimize the length of the study.

A cognitive ability score was calculated by summing scores from the Wordsum test and the numeracy test (minimum possible score 0; maximum possible score 13).

*Delusional ideation*

The 21-item Peters et al. Delusions Inventory (PDI; Peters, Joseph, Day, & Garety, 2004; Peters, Joseph, & Garety, 1999) was used to measure delusional ideation. Participants are asked if they have ever had any of 21 delusion-like experiences. 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 the associated distress, preoccupation, and conviction. The PDI has been used in numerous studies, including at least 22 beads task studies (Ross et al., 2015). We found that the scale had acceptable internal consistency: Cronbach’s α = 0.75.

*Religious belief and participation*

A 9-item religious belief scale (Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012) was used to measure conventional religious beliefs, and a 5-item religious participation scale (Pennycook et al., 2012) was used to assess the frequency of participation in conventional religious activities. We found that the scales had good internal consistency: Cronbach’s α = 0.95 and α = 0.89 for religious belief and religious participation respectively.

*Paranormal belief*

The 26-item Revised Paranormal Belief Scale (Tobacyk, 2004; Tobacyk & Milford, 1983) was used to measure paranormal belief. Three religious items were removed because they were made redundant by the religious belief scale. We found that the scale had good internal consistency: Cronbach’s α = 0.95.

*Demographic variables*

Participants were asked to report their gender (Male 63.9%, Female 36.1%); age in years (Mean = 30.2); highest level of education [1 = None (0%), 2 = some high school (1.3%), 3 = high school (9.8%), 4 = technical trade or vocational training (5.7%), 5 = some college, no degree (41.7%), 6 = Bachelor’s degree (29.2%), 7 = Master’s degree (10.0%), 8 = Professional degree (0.9%), 9 = Doctoral degree (1.4%)]; and an estimate of total family income level from all sources before taxes for 2013 [1 = less than $10,000 (7.7%), 2 = $10,000 to under $20,000 (13.1%), 3 = $20,000 to under $30,000 (14.7%), 4 = $30,000 to under $40,000 (11.8%), 5 = $40,000 to under $50,000 (11.1%), 6 = $50,000 to under $75,000 (15%), 7 = $75,000 to under $100,000 (11.8%), 8 = $100,000 to under $150,000 (10.6%), 9 = $150,000 to under $250,000 (2.7%), 10 = $250,000 or more (1.6%)].

*Procedure*

The study was conducted using *Qualtrics* (Provo, UT, USA). The order of presentation of tasks was the same for all participants and was as follows:

1. A declaration of informed consent.

2. The first manipulation check.

3. The beads task.

4. The PDI (order of presentation of items randomized).

5. The CRT4.

6. The CRT3.

7. The second manipulation check.

8. The heuristics and biases battery.

9. The syllogistic reasoning test.

10. The Wordsum test.

11. The numeracy test.

12. The religious belief and religious participation scales (order of presentation of items randomized).

13. The paranormal belief scale (order of presentation of items randomized).

14. Pilot questionnaires that are not relevant to the present study.

15. Demographic questions.

16. Questions about honesty and accuracy of responses.

17. Debrief.

**Results**

Descriptive statistics are reported in Table 1 (see supplementary materials Table 1 for individual-level data used in the analyses). The mean number of draws to decision was 9.17 beads (see supplementary materials Figure 1 for a plot showing the distribution of scores), which is very close to the mean of 8.71 that was reported in one of the first beads task studies that focused on a general population sample (Colbert & Peters, 2002). And the mean PDI score was 58.11 (see supplementary materials Figure 2 for a plot showing the distribution of scores), which is almost identical to the mean of 58.9 that was reported for the general population sample in the study that introduced the 21-item PDI (Peters et al., 2004).

A mixture of categorical, ordinal, and continuous variables were analysed; and some of the ordinal and continuous variables were not normally distributed. For these reasons we used Spearman’s rank-order correlations (*rs*), which are reported in Table 2. All four analytic cognitive style measures (CRT4, CRT3, heuristics and biases battery, and conflict syllogisms) were positively associated with each other (all *p*-values < .01); and the two cognitive ability measures (Wordsum test and numeracy test) were positively associated with each other (*p* < .01).

--- Insert Table 1 about here ---

**Table 1.** Descriptive statistics. Gender (Male = 0; Female = 1). S.E. of Skew = 0.10; S.E. of Kurtosis = 0.21. N = 558.

We summed scores from individual tests to create composite measures of analytic cognitive style and cognitive ability, as has been done in earlier research (Pennycook et al., 2012; Toplak et al., 2011, 2013). With respect to the hypotheses being tested, the most important associations are between draws to decision and analytic cognitive style, and draws to decision and the PDI. Draws to decision was positively correlated with analytic cognitive style (*rs*= .26, p < .01), but no statistically significant association was found between draws to decision and the PDI (*rs*= -.02, p = .70). Another point of interest is that no statistically significant association was found between analytic cognitive style and the PDI (*rs*= -.07, p = .08).

--- Insert Table 2 about here ---

**Table 2.** Spearman’s rank-order correlations. Note: DTD = Draws To Decision; PDI = Peters et al. Delusions Inventory; CRT4 = Four Item Cognitive Reflection Test; CRT3 = Three Item Cognitive Reflection Test; H&B = Heuristics and Biases; CS = Conflict Syllogisms; ACS = Analytic Cognitive Style; Word = WordSum; Numb = Numeracy Test; CA = Cognative Ability; RB = Religious Belief; RP = Religious Participation; PB = Paranormal Belief; Gen = Gender (Male = 0; Female = 1); Edu = Education; Inco = Income. \**p* < .05 and \*\**p* < .01, two-tailed tests. N = 558.

The extent to which draws to decision can be predicted by analytic cognitive style and the PDI independently of each other (and other factors) was explored using hierarchical multiple regression. We entered variables into the regression in the following order: first step—demographic variables (age, gender, education and income); second step—the PDI; third step— paranormal belief; fourth step—religious belief and religious engagement; fifth step—cognitive ability; and sixth step—analytic cognitive style. We entered analytic cognitive style last because our primary objective was to determine whether analytic cognitive style explained additional variation after controlling for potential confounds. Visual inspection of a plot of predicted values of draws to decision against residuals indicated that the linear model’s assumption of normality of the error distribution was violated. 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 this assumption of the linear model, we followed the advice of Field (2013) and re-ran the analysis using the bootstrap resampling method implemented in SPSS version 21 (Armonkm, NY, USA: IBM Corp.), which is reported in Table 3. This analysis indicated that at the sixth step of the regression analytic cognitive style predicted draws to decision (B = 0.24, 95% CI [.14, .35], p < .01), but the PDI did not (B < 0.01, 95% CI [-0.1, 0.1], p = .76).

To test the robustness of this result we also examined whether the four separate measures of analytic cognitive style (i.e. CRT4, CRT3, the heuristics and biases battery, and the conflict syllogisms from the syllogistic reasoning test) each predicted draws to decision when entered into the final step of the regression instead of the overall analytic cognitive style score. We found that each of these measures predicted draws to decision (all p-values < .01; see supplementary materials Tables 2-5), which provided evidence that analytic cognitive style is a robust predictor of data gathering in the beads task.

--- Insert Table 3 about here ---

**Table 3.** Hierarchical multiple regression analyses predicting draws to decision. Note: Gender (Male = 0; Female = 1) and PDI = Peters et al. Delusions Inventory (PDI). 95% bias corrected and accelerated confidence intervals and standard errors are based on 1000 bootstrap resamples. Note. *R2* = .03 for Step 1 (p < .01); *ΔR2* = .00 (*p* = .39) for Step 2; *ΔR2* = .01 (*p* = .05) for Step 3; *ΔR2* = .00 (*p* = .92) for Step 4; *ΔR2* = .01 (p = .04) for Step 5; *ΔR2* = .04 (*p* < .01) for Step 6. N = 558.

**Discussion**

The present study provided evidence that analytic cognitive style predicts data gathering in the beads task independently of the other variables considered in this study. That is to say, draws to decision was predicted by performance in tests that index analytic cognitive style, even when controlling for general cognitive ability, delusional ideation, paranormal belief, religious belief, religious participation, and various demographic variables. That we controlled for cognitive ability is important because all tasks that have been designed to index analytic cognitive style also depend on cognitive ability (Pennycook et al., 2015; Pennycook & Ross, 2016; Stanovich, 2011; Stanovich & West, 2008; Toplak et al., 2011, 2013).

The present study did not provide evidence that delusional ideation predicts data gathering. By contrast, a recent meta-analysis found that delusional ideation was negatively associated with data gathering (Ross et al., 2015). Nevertheless, the effect size reported in the meta-analysis was very small, which suggests that if there exists a true association, a sample of 558 participants might be too small to reliably reject a false null hypothesis of no association. Alternatively, the putative association reported in this meta-analysis might be the result of publication bias, which is a problem in the social sciences (Ferguson & Heene, 2012; Franco, Malhotra, & Simonovits, 2014).

The present study did not find evidence for an association between delusional ideation and analytic cognitive style, so does not provide support for suggestions that the cognitive underpinning of delusions can be interpreted using dual process theories of reasoning. Nevertheless, the present study did find evidence that analytic cognitive style is negatively associated with both religious belief and paranormal belief, which is consistent with earlier research (Pennycook et al., 2015; Pennycook, Ross, Koehler, & Fugelsang, 2016). These contrasting results leave us with a question: why is there an association with religious belief and paranormal belief, but not delusional ideation? An obvious possibility is that delusion-like belief differs from religious belief and paranormal belief in that it is not in fact associated with analytic cognitive style. However, we suggest that an alternative explanation is worth considering. A noteworthy difference between the PDI and the religious belief and paranormal belief scales used in the present study is that the PDI does not probe belief directly. Most items in the PDI start with the qualification “Do you ever feel as if…” (e.g., “Do you ever feel as if people are reading your mind?”). And it asks follow up questions about distress, preoccupation, and conviction for items that participants answer with a “yes”. Consequently, it is possible that the PDI is not well suited to examining associations between analytic cognitive style and *belief*, which might explain the lack of association in the present study.

We have three suggestions for how future research could examine relationships among data gathering, analytic cognitive style, and delusions. First, use measures of delusion-like belief that tap more directly into participants’ *beliefs* than the PDI. One possibility could be to use measures that tease apart anomalous experiences and paranormal/delusion-like attributions for those experiences (e.g., Irwin, Dagnall, & Drinkwater, 2013). Second, use clinical populations, perhaps comparing schizophrenia patients with and without delusions using performance-based measure of analytic cognitive style. Third, use data gathering paradigms that afford the possibility of comparing performance to normative standards for data gathering (e.g., van der Leer et al., 2015).

Finally, we should highlight an important limitation of the present study: it is correlational, not experimental. Consequently, despite our attempts to control for confounding factors, we cannot make causal inferences. Future research could use experimental paradigms that examine whether manipulating analytic cognitive style influences data gathering in the beads task and delusions (and delusion-like beliefs). Such manipulations could take the form of explicit or implicit primes that have been used to influence religious belief (Gervais & Norenzayan, 2012; Shenhav, Rand, & Greene, 2012).

**Conclusion**

In the largest published beads task study to date, we examined whether analytic cognitive style and delusional ideation predict data gathering independently of each other. We found that increased analytic cognitive style predicted greater data gathering, even when controlling for delusional ideation, cognitive ability, paranormal belief, religiosity, and demographic variables. Conversely, we did not find any evidence that delusional ideation predicted data gathering or was associated with analytic cognitive style. Overall, our results suggest that data gathering in the beads task can be interpreted within the framework of dual process theories of reasoning, but more work is needed to determine whether reasoning impairments and biases associated with delusions and delusion-like beliefs can be interpreted in terms of this framework too.

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**Disclosure Statement**

None

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1. Some of these authors refer to “System 1” and “System 2”, or “Stream 1” and “Stream 2”. However, “Type 1” and “Type 2” are now recommended as the most appropriate technical terms; see J. S. B. T. Evans and Stanovich (2013). [↑](#footnote-ref-2)
2. For a rather different approach to explaining delusions using dual process theories of reasoning see Frankish, 2009). [↑](#footnote-ref-3)