A Randomized Experimental Investigation of Reasoning Training for People With Delusions

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The present study aimed to investigate whether a brief reasoning training module changes the “jumping to conclusions” data gathering bias in people with delusions. A secondary aim was to examine whether improvements in reasoning would lead to greater flexibility in thinking about delusions. It was found that people with delusions and a diagnosis of schizophrenia (n = 34) requested less information on a reasoning task compared with a nonclinical control group (n = 34). The clinical group was then randomly allocated to a session of reasoning training or to an attention control condition. Following training, participants showed a significant increase in data gathering, and a small number reported more flexibility and less conviction in their delusions, although this finding was not significant. The presence at baseline of an extreme reasoning bias moderated the effect of training. The study provides further confirmation of the jumping to conclusions bias and shows that data gathering can be improved, though the severest form of the bias is resistant to change. It is recommended that lengthier, delusion-related reasoning packages be developed and evaluated.

Key words: jumping to conclusions/schizophrenia

Introduction

Delusions are a key symptom of schizophrenia, occurring in approximately three-quarters of cases.1 They are frequently distressing and disabling, and existing treatments are only partially effective. Many patients with schizophrenia show a relatively poor response to antipsychotic medication, with approximately 50% of patients demonstrating persistent delusions even after the first acute psychotic episode has abated.2 Recent research indicates that the effects of antipsychotic medication on delusional conviction, in particular, are less marked than on other aspects of delusions, such as associated distress and behavioral response.5 Cognitive behavioral therapy (CBT) for psychosis was initially developed to improve the treatment of persistent distressing delusions and hallucinations, and meta-analyses consistently indicate that this new intervention does show efficacy but that the effects are small to moderate.6–8 Although antipsychotic medication and CBT, therefore, both have benefits, the goal of delivering sustained improvement in delusions remains. Better treatments are needed, based on a sound understanding of cause and maintenance.

Over the last 10 years, delusions have become a focus of cognitive theories and empirical research and are considered to result from a number of interacting biological, psychological, and social factors.9–14 One factor highlighted has been reasoning biases.15–18 Delusions have been shown with particular consistency to be associated with reduced data gathering and belief inflexibility (see reviews19–21). In this article, we report the first experimental study to focus on an attempt to reverse these biases and inspect the impact on delusional thinking.

Reduced Data Gathering and Belief Inflexibility

Reduced data gathering in individuals with delusions has been repeatedly demonstrated using probabilistic reasoning tasks based on a Bayesian model of probabilistic inference.22–28 On a typical probabilistic reasoning task (the beads task), participants are asked to request as many pieces of evidence (colored beads) as they would like before making a decision (from which of 2 hidden jars the beads are drawn). The participants are shown that the jars have beads of 2 different colors and are informed of the proportions of each colored bead in the jars. In the original version of the task, one jar has 85 black beads and 15 yellow beads and the other jar has the opposite ratio of black and yellow beads. In a more difficult version, the beads are in the ratio 60:40. The key variable employed is the number of items requested before making a decision. Individuals with delusions request fewer beads before making their decision...
than psychiatric or nonclinical controls. The extreme form of the bias—"jumping to conclusions" (JTC)—has been operationalized as when a decision is made after 2 or fewer beads. Approximately 40% of people with delusions jump to conclusions even when the beads are in the difficult ratio of 60:40.16

The JTC bias has been replicated widely, using various modifications of the basic paradigm, not only in people with delusions but also in people who have recovered from delusions, people at risk of delusions, and people with delusion proneness in the general population (see recent reviews17,20,21). That the bias is present in at-risk populations and in remitted groups, although in an attenuated form, suggests it is a trait representing liability to delusions but that it may in addition be exacerbated in acute delusional states.16,24,26,29 Taken together, this research indicates that this bias is a trait that may contribute to both delusion formation and persistence. The evidence also shows that this is a data gathering bias rather than a deficit in probabilistic reasoning.19 The reasoning bias is specifically associated with level of delusional conviction.16,25,30 In a novel line of research, it has recently been shown to moderate the response to antipsychotic treatments in a drug-naive group of patients with a first episode of psychosis, such that those with an extreme JTC bias showed a poorer treatment response.27

The mechanism for this bias, however, is not yet clear, and various proposals have been made: eg, Moritz et al11 have proposed that it represents a reduced threshold for acceptance of a hypothesis (a liberal acceptance bias), and Broome et al29 have suggested that it might be related to impaired working memory and intolerance of uncertainty, although consistent evidence has not yet been found to support any of these hypotheses. The relationship of JTC to the well-attested cognitive impairments of schizophrenia (such as attention, memory, and executive function deficits) has yet to be examined systematically. It should be noted that JTC differs from these cognitive impairments in schizophrenia in that, unlike them, it has been shown to be specifically related to delusional symptoms.

A related empirical literature shows that many individuals with delusions produce few alternative explanations for the evidence cited for their beliefs,32 do not think that they could be mistaken in their belief,33 and report that they would not change their belief in a hypothetical contradiction task.34 These findings have recently been incorporated into the concept of belief flexibility. Belief flexibility refers to "a meta-cognitive process about thinking about one's own delusional beliefs, changing them in the light of reflection and evidence and generating and considering alternatives" (Garety et al).16(p374)

There have been indications that belief flexibility predicts a positive response to both antipsychotic medication35 and CBT.33,36,37 We recently found evidence that belief inflexibility mediates the effect of JTC on delusional conviction.16 It is proposed that JTC limits belief flexibility thereby maintaining and escalating levels of delusional conviction. Therefore, it is possible that reducing JTC may have a more immediate effect on belief flexibility than on delusional conviction.

The clinical implications of this research for psychological therapy for psychosis are apparent, as we previously argued: "we believe that reducing the conviction ... with which delusions are held, and protecting against future relapse should be assisted by targeting the meta-cognitive processes of reflection on delusions, thus eliciting ways of opening up new possibilities in thinking. This will involve attention to all-or-nothing thinking, data gathering and the careful consideration and generation of alternative explanations” (Garety et al).16(p382)

Clinically, therefore, we propose that if a data gathering bias and belief inflexibility lead to high levels of delusional belief conviction and greater delusional persistence, then methods of changing the biases will be of therapeutic benefit. Theoretically, if changing reasoning style alters delusional ideation, this will support the claims of cognitive models that hypothesize that reasoning has a causal role in delusions.

The Study

The aim of the study was to investigate whether a newly developed reasoning training module induces changes in data gathering in people with a diagnosis of schizophrenia-spectrum disorder and current delusions. A secondary aim was to explore whether improvements in reasoning would lead to improvements in flexibility in thinking about delusions. It was hypothesized that

1. Individuals with delusions will request less information than individuals without delusions on probabilistic reasoning tasks (ie, will "JTC").

2. Individuals with delusions who receive brief reasoning training will show improvement on general reasoning as measured by the probabilistic reasoning task (data gathering) compared with individuals with delusions who receive no reasoning training.

3. Reasoning training will lead to greater belief flexibility associated with the delusion as assessed by asking about the possibility of being mistaken, the response to hypothetical contradiction, and the production of alternative explanations.

It was also planned to examine whether training reduced delusional conviction. However, because delusional beliefs are strong and persistently held, it was considered unlikely that one training session would lead to significant and immediate reductions in delusional conviction.

Methods

Participants

Individuals with current delusions and a schizophrenia-spectrum disorder were recruited from mental health
services within an UK National Health Service Trust serving a population of approximately one million inhabitants, the South London and Maudsley NHS Foundation Trust. Inclusion criteria were a case note diagnosis of schizophrenia or schizoaffective or delusional disorder, a current delusional belief held with at least 75% self-rated conviction, aged 18–65 years, and fluent in English. Individuals were excluded if they had primary diagnosis of alcohol or substance dependence, organic syndrome or learning disability, or a profound visual impairment. Thirty-nine individuals meeting the criteria were referred for the study. Four individuals declined to take part, and one individual was excluded because of clinical concerns. Nonclinical participants were matched on age, ethnicity, and occupation with the clinical group. They were recruited from a locally developed database containing the names of people from the general population who were willing to take part in research. In addition, participants were recruited from temporary staff working in the South London and Maudsley NHS Foundation Trust and by “snowball” sampling. Individuals were excluded from the nonclinical group if they had a primary diagnosis of organic syndrome, learning disability, profound visual impairment, or nonfluent English if they reported any history of severe mental illness.

Design
The study was in 2 stages: first, we employed an independent 2-group comparison, comparing the clinical and the nonclinical groups’ performance on the probabilistic reasoning task; then we conducted a randomized experiment, with only the clinical participants, who were randomized either to the reasoning training intervention or to an attention control activity, to compare changes in reasoning, belief flexibility, and delusions before and after intervention. All participants (clinical and nonclinical) first completed assessments of intellectual functioning, anxiety, depression, and data gathering. The clinical participants also completed assessments of belief flexibility, detailed assessments of the main delusion, and general psychopathology. The clinical participants were then randomized to receive a 45-minute reasoning intervention or to an attention control condition consisting of a neuropsychological assessment of comparable duration. The same experimenter (K.R.) administered both the training and the control conditions. After the administration of the experimental training or the control activity, the data gathering, belief flexibility, and delusion assessments were repeated.

Randomization Procedure
The randomization schedule was generated using www.randomisation.com and kept independently of the experimenter. The experimenter was only informed of the randomization allocation once the participant had provided informed consent and an appointment had been arranged for the testing.

Measures
Prerandomization. Wechsler Abbreviated Scale of Intelligence General intellectual ability was assessed using the 2-subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI) (vocabulary and matrix reasoning).38 The 2-subtest version of the WASI takes approximately 15 minutes to administer and provides an estimation of full-scale IQ.

Positive and Negative Symptom Scale. The Positive and Negative Symptom Scale is a 30-item semistructured interview designed to assess positive, negative, and general psychopathology associated with schizophrenia.39 Respondents are asked to report the occurrence of symptoms over the last 7 days. These are then rated according to severity on a 7-point scale (1–7, “absent–extreme”). Higher scores indicate a greater presence of symptoms. The positive and negative subscales are each calculated by summing 7 items, while the general subscale is calculated on the basis of 16 items.

Depression Anxiety Stress Scale. The Depression Anxiety Stress Scale is a 42-item instrument with 3 subscales measuring current symptoms of depression, anxiety, and stress.40 Each of the subscales consists of 14 items with a 0–3 scale (0 = did not apply to me at all, 3 = applied to me very much). Higher scores indicate higher levels of emotional distress.

Pre- and Postintervention Tests and Measures (Clinical Group Only). Probabilistic Reasoning Task The probabilistic reasoning task (also known as the “Beads Task”) is a standard task used to assess data gathering.16 Two computerized versions of the task were used. In version 1 (the 60:40 task), one jar had 60 red beads and 40 blue beads and the other jar had 40 red beads and 60 blue beads. In version 2 (the 85:15 task), one jar had 85 red beads and 15 blue beads and the other jar had 15 red beads and 85 blue beads. In both versions of the task, participants were shown pictures of the 2 jars and told that one of the jars would be selected at random by the computer and that beads would be drawn from the selected jar. After each bead was drawn, participants were asked if they would like to see more beads (ie, if they would like more information) or if they could say, with certainty, from which of the jars the beads were being drawn. Once a bead had been drawn, it remained at the bottom of the screen thereby providing a memory aid. The key variable was the number of beads requested by the participant before making a decision. JTC was classified as requesting 2 or fewer beads. Both versions of the task (60:40 and 85:15) were administered before and after completion of the training or control tasks, but the color of the beads used in each version were changed from pre to post administration.

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Belief Flexibility. Three assessments were made of belief flexibility: possibility of being mistaken, reaction to hypothetical contradiction, and alternative explanations. Two assessments were from the Maudsley Assessment of Delusions Scale, as reported in Garety et al. The scale has good interrater reliability (mean kappa = 0.82). The clinical participants were asked whether or not it was possible that they may be mistaken about their beliefs (possibility of being mistaken, PM). A positive response indicates belief flexibility. They were also assessed with a hypothetical but plausible scenario which if true would contradict the delusion (“reaction to hypothetical contradiction,” RTHC) and asked how this would affect their belief. There are 4 response options: to dismiss the belief; to decrease level of conviction; to accommodate the hypothetical scenario into the belief, leaving it unchanged; and to ignore or reject the relevance of the scenario. The first 2 options are taken to indicate belief flexibility. A third assessment of belief flexibility was the reporting of alternative explanations using the procedure described by Freeman et al. The evidence for the delusion was elicited, and then, in a structured assessment, participants are asked whether there are any alternative explanations. One or more alternative explanations represent belief flexibility.

Delusional Conviction. Delusional conviction was assessed by asking participants to rate how strongly they held the belief from 0% to 100%, where 0% was “do not believe” and 100% was “absolutely certain.”

Reasoning Training Intervention
The training used engaging material of a neutral content and aimed to convey the overall idea that it is preferable not to reach a decision too quickly. Participants were presented with 3 training tasks, each lasting 15 minutes, which aimed to illustrate reasoning biases and ways of correcting them. It targeted data gathering, generation and consideration of alternative ideas, and the use of confirmatory and disconfirmatory evidence. Two of the tasks (object identification and picture interpretation) were adapted from previously devised modules of the meta-cognitive training (MCT) package, designed for group administration by Moritz et al. described also in Moritz and Woodward. The third task, visual illusions, was designed specifically for this study. The whole training was presented using Microsoft PowerPoint during a single session lasting approximately 45 minutes. At no time was the content of training discussed in relation to the participants’ delusions or any aspect of the assessment. Each task had 3 phases: presentation of stimuli and free response, review of initial responses and instruction in reasoning, and further practice with additional stimuli.

Object Identification. In this task, participants are shown pictures of 10 objects (e.g., a rocking chair, a flower, a fish), but each object is revealed piece by piece over a series of 8 slides (one piece per slide). After each piece is revealed, the participant is asked whether they would like to see another piece of the picture (i.e., whether they wanted more information) or whether they could say with certainty what the object was from 6 response options provided on screen. As more pieces are revealed, particular response options become less plausible. The aim of the task is to encourage the participant to seek more data before reaching a decision. Pictures of 5 objects were shown first. Once the participant had identified what they thought the object was, the first piece of the next picture was presented. In the next phase, 2 of the first pictures were reviewed with the participant and all the pieces revealed. In some cases, this illustrated that making decisions before they had all the available pieces of the picture (i.e., JTC) could lead to a wrong decision. Following this training, participants were shown 5 more pictures and asked to request as many pieces as they wished in order to say what the object was from 6 alternatives.

Picture Interpretation. During this task, participants are shown pictures of 9 paintings and asked to identify the correct title of each painting from 4 alternatives. The aim of this task is to encourage participants to consider the likelihood of each alternative title being correct based on the content of the picture. In this way, participants are discouraged from making hasty decisions based on insufficient evidence and to consider alternative hypotheses, weighing up supporting and disconfirming evidence. Four of the paintings were shown first and responses recorded without any indication as to whether or not they were correct. During the training phase, the baseline pictures were reviewed. Participants were encouraged to identify and discuss evidence contained in each painting that would support or refute each of the corresponding 4 titles being correct. The correct title was identified as the one with the most evidence to support it and the least amount of evidence to refute it. Following the final phase, participants were presented with a further 5 pictures. Again, participants were asked to say which of 4 possible titles they thought was correct based on the evidence contained in the picture.

Illusions. In the illusions task, participants are shown 11 classic images that can be perceived in 2 ways (e.g., an old or young woman). The aim of this task is to illustrate to participants that there is often more than one way of seeing things, that first impressions can sometimes reveal only half the truth, and therefore, that it is better to delay a decision. Participants were initially shown 5 pictures. On presentation of each picture, participants were asked to say what they could see. Responses were recorded, and the next picture presented. During the next phase, the initial pictures were reviewed and both the images in each
revealed. Following this training, participants were shown a further 6 pictures and asked what they could see.

**Attention Control Condition: Neuropsychological Tasks**

Participants in the control condition were asked to complete a series of neuropsychological tests and tasks, in total lasting for 45 minutes. The tests were intended to be as engaging and cognitively demanding as the training condition but to lack any reasoning training component. The neuropsychological tests were the Hayling Sentence Completion task,\(^43\) the Brixton Spatial Anticipation Test,\(^43\) the Trail Making Test A and B,\(^44\) the Cognitive Estimates Test,\(^45\) and the Wechsler Memory Scale Third Edition—spatial span subtest.\(^46\) Because they do not relate to the hypotheses of this study, results of these tests are not reported.

**Analysis and Sample Size Determination**

Data were managed and analysed using SPSS for Windows\(^47\) and Stata Version 9.\(^48\) Group differences were examined using t tests or linear regressions for dimensional variables and chi square or Fisher tests for dichotomous variables. For the principal test of the effects of training, we looked at proportional changes in the number of beads needed to come to a conclusion in the JTC tasks. To implement this analysis, we investigated arithmetic differences on a logarithmic scale. For the JTC 60:40 task, we created the contrast, C1, equal to \(\ln(\text{JTC60Post}) - \ln(\text{JTC60Pre})\) — a logarithm of a ratio—where “ln” means natural logarithm and JTC60Post and JTC60Pre are the number of beads drawn in the JTC task postrandomization and prerandomization (ie, at baseline), respectively. Similarly, for the JTC 85:15 task, we created the contrast \(C2 = \ln(\text{JTC85Post}) - \ln(\text{JTC85Pre})\). Finally, we assumed that the effect of the experimental intervention would be the same for C1 and C2, and a linear random-effects model was fitted using Stata’s xtreg command to estimate this common effect (in terms of the difference between the logarithms of ratios for the 2 experimental groups). Finally, taking exponents (antilogarithms) of the estimate and its corresponding 95% confidence intervals produces an estimate and 95% confidence limits for a ratio (the number of beads drawn in the experimental condition divided by the number of beads drawn by the controls, adjusting for chance differences between the groups at baseline). Two-tailed tests and confidence intervals are reported throughout.

The sample size had been determined in the study protocol on the basis of a power calculation using nQueryAdvisor.\(^49\) The calculation concerned an estimate of a group difference between the reasoning training and the attention control clinical groups on the probabilistic reasoning task following the intervention. Drawing upon the data reported in Freeman et al.,\(^32\) it was expected that there would be a group difference between allocation conditions of 3 beads on the 85:15 task. This expected group difference was divided by 3, the baseline SD reported in previous beads studies, giving an effect size of one. Therefore, it was calculated that 17 people in each condition would be needed to detect such an effect with 80% power using a 2-tailed t test (significance level = 0.05).

| Table 1. Demographic Data in Clinical (Delusional) and Nonclinical Groups |
|---------------------------------|-----------------|-----------------|
|                                | Clinical (Delusion) | Nonclinical |
|                                | Group (n = 34)     | Group (n = 34)  |
| Mean age, y (SD)               | 39.0 (10.2)        | 36.4 (12.2)     |
| Gender                         |                   |                 |
| Male                           | 25 (73.5%)        | 24 (70.6%)      |
| Female                         | 9 (26.5%)         | 10 (29.4%)      |
| Ethnic group                   |                   |                 |
| White                          | 17 (50%)          | 19 (55.9%)      |
| Black Caribbean                | 13 (38.2%)        | 10 (29.4%)      |
| Black African                  | 1 (2.9%)          | 1 (2.9%)        |
| Asian                          | 0                | 2 (5.9%)        |
| Other                          | 3 (8.8%)          | 2 (5.9%)        |
| Mean full-scale IQ (SD)        | 98.2 (14.2)       | 109.7 (12.7)    |

**Results**

**Demographic and Clinical Data**

Key demographic variables relating to the clinical and nonclinical groups are presented in Table 1. Participants were matched on age and gender, but the nonclinical participants had a higher IQ score than the clinical group, \(t(66) = -3.52, P = .001\). All the clinical participants had a case note diagnosis of schizophrenia. Further information on the clinical participants, reported by randomization condition, is shown in Table 2.

**Hypothesis 1: Data Gathering in the Clinical and Nonclinical Groups**

The individuals with delusions requested significantly fewer beads on both the 60:40, \(t(66) = -3.41, P = .001\), and 85:15, \(t(66) = -2.70, P = .008\), versions of the beads task than the nonclinical participants (see Table 3). These significant group differences on the beads tasks remained after controlling for intellectual functioning. In a linear regression with number of beads drawn on the 60:40 task as the dependent variable, group (delusion, nonclinical) was a significant predictor, \(\beta = .295, SE = 1.152, P = .018\), but not intellectual functioning, \(\beta = .232, SE = 0.040, P = .060\). In a linear regression with number of beads drawn on the 85:15 task as the dependent variable, group (delusion, nonclinical) was a significant predictor, \(\beta = .295, SE = 0.682, P = .024\), but not intellectual functioning, \(\beta = .063, SE = 0.024\),
P = .624. Consistent with these tests, the numbers of clinical participants JTC (ie, requesting 2 beads or fewer) on the 60:40, $\chi^2 (df = 1) = 6.07, P = .014$, and 85:15, $\chi^2 (df = 1) = 8.74, P = .003$, versions of the beads task were significantly higher than the numbers of nonclinical participants. JTC on the 60:40 task was highly associated with JTC on the 85:15 task, $\chi^2 (df = 1) = 32.98, P < .001$.

Table 3 also provides data on the mean scores, within the clinical and nonclinical groups, of the subgroups who jump to conclusion and those who do not. It will be seen that the clinical group’s mean scores are all numerically lower than the nonclinical group’s, including in the subgroup of those who do not JTC, indicating a tendency to gather less data than controls in this subgroup also.

Hypothesis 2: Data Gathering After Reasoning Training

The number of beads drawn in the beads tasks before and after randomization conditions are displayed in Table 4. There is an increase in beads drawn following training but not following the attention control condition. Table 5 gives results on the number of people jumping to conclusions, and here, it is notable that for both versions of the beads task there is little change in the number of people who jump to conclusions after training (ie, who show the extreme reasoning style). This implies that the increases in the number of beads drawn (ie, data gathering) displayed in Table 4 were mostly due to the people who did not jump to conclusions before randomization. In the training group, those who jumped to conclusions on the first administration of the 60:40 task have a mean improvement in beads score of 0.44 (SD = 2.13), whereas those who did not jump to conclusions on the first administration of the task have a mean improvement in beads score of 4.00 (SD = 4.04). Similarly, on the 85:15 task, the mean improvement for people with JTC was 0.72 (SD = 2.41), but the improvement was 1.67 (SD = 4.13) for those people who did not show JTC. On average, all participants in the intervention group improved, compared with the controls, but the amount of improvement was dependent on their baseline measurement. Resulting from this preliminary descriptive analysis, we decided to evaluate the effect of the experimental intervention by estimating the proportional increase in beads drawn (expressed as a ratio of beads drawn in the experimental condition over the number of beads drawn by the controls), assuming that

### Table 2. Clinical Data by Randomization Condition

|                      | Training Condition ($n = 17$) | Control Condition ($n = 17$) |
|----------------------|-------------------------------|-------------------------------|
| Mean length of illness (SD) | 16.2 (9.0)                   | 10.8 (10.2)                  |
| Status               |                               |                               |
| Inpatient            | 1 (5.8%)                      | 8 (47.1%)                    |
| Outpatient           | 15 (88.2%)                    | 9 (52.9%)                    |
| Mean PANSS score (SD) |                               |                               |
| Positive scale       | 20.76 (3.63)                  | 19.06 (3.78)                 |
| Negative scale       | 11.29 (3.19)                  | 11.06 (4.41)                 |
| General scale        | 31.47 (6.38)                  | 28.59 (4.73)                 |
| Delusion type        |                               |                               |
| Persecutory          | 11                            | 9                             |
| Grandiose            | 6                             | 8                             |
| Mean % conviction in the delusion (SD) | 95.3 (9.3) | 97.0 (6.8) |
| DASS anxiety         | 13.3 (12.1)                   | 14.5 (10.9)                  |
| DASS depression      | 14.4 (12.5)                   | 14.8 (14.0)                  |
| DASS stress          | 15.9 (11.2)                   | 17.3 (13.5)                  |
| Mean full-scale IQ (SD) | 95.8 (15.4)                  | 100.7 (12.8)                 |

Note: PANSS, Positive and Negative Symptom Scale; DASS, Depression Anxiety Stress Scale.

### Table 3. Beads Task Data for the Clinical and Nonclinical Groups

| Probabilistic Reasoning Task | Clinical Participants ($n = 34$) | Nonclinical Participants ($n = 34$) |
|-----------------------------|----------------------------------|-------------------------------------|
| 60:40 task                  |                                  |                                     |
| Mean (SD)                   | 3.8 (3.9)                       | 7.4 (4.9)                           |
| Median                      | 2                               | 8                                   |
| Number JTC/non JTC          | 19/15                           | 9/25                                |
| JTC subgroup mean (SD)      | 1.2 (0.4)                       | 1.4 (0.5)                           |
| Non JTC subgroup mean (SD)  | 7.1 (3.9)                       | 9.6 (3.8)                           |
| 85:15 task                  |                                  |                                     |
| Mean (SD)                   | 2.7 (2.3)                       | 4.4 (2.8)                           |
| Median                      | 2                               | 4                                   |
| Number JTC/non JTC          | 20/14                           | 8/26                                |
| JTC subgroup mean (SD)      | 1.2 (0.4)                       | 1.5 (0.5)                           |
| Non JTC subgroup mean (SD)  | 4.9 (2.1)                       | 5.4 (2.6)                           |

Note: JTC, jumping to conclusions.
the ratio is common to both JTC tasks (see under “Analysis” in the “Methods” section, above). We estimate that the intervention increased the number of beads drawn by about 50% (compared with the controls)—the point estimate of the ratio being 1.49 with 95% confidence interval (1.09, 2.03) ($P = .012$).

**Hypothesis 3: Belief Flexibility After Training**

Five of the individuals with delusions showed improved belief flexibility at the postassessment indicated by a positive change of response on any of the 3 items (table 6). Four of these participants were in the training condition, and 1 participant was in the control condition, which is not a significant difference, Fisher’s Exact test $P = .335$. One participant in the training condition showed less belief flexibility as assessed by the hypothetical contradiction question (ignores or rejects relevance).

| Belief Flexibility | Training Condition (n = 17) | Control Condition (n = 17) |
|-------------------|-----------------------------|---------------------------|
| Response to hypothetical contradiction | | |
| Dismisses belief | 0 (0%) | 1 (5.9%) | 0 (0%) | 0 (0%) |
| Changes conviction | 7 (41.2%) | 7 (41.2%) | 3 (17.6%) | 3 (17.6%) |
| Accommodates | 4 (23.5%) | 2 (11.7%) | 2 (11.8%) | 1 (5.9%) |
| Ignores or rejects | 6 (35.3%) | 7 (41.2%) | 7 (70.6%) | 13 (76.5%) |
| Possibility mistaken | | | |
| Yes | 5 (29.4%) | 7 (41.2%) | 4 (23.5%) | 4 (23.5%) |
| No | 12 (70.6%) | 10 (58.8%) | 13 (76.5%) | 13 (76.5%) |
| Alternative explanations | | | |
| None | 14 | 13 | 15 | 14 |
| One | 3 | 4 | 2 | 3 |

**Effects of Training on Delusional Belief Conviction**

For the training group, the mean level of delusional conviction changed from 95.3 (SD = 9.3) to 90.0 (SD = 20.0). For the control group, the mean level of conviction was unchanged before and after condition at 97.0 (SD = 6.84). Three participants reported less conviction in their delusional belief following training. In these cases, conviction reduced from 100% to 30%, 100% to 90%, and from 75% to 50%. One participant increased their conviction following training from 75% to 90%. There were no changes in the control group.

**Discussion**

The current study replicates the well-established data gathering bias among people with delusions and a clinical diagnosis of schizophrenia. The participants with delusions, a group with long-term illnesses and persistent symptoms, were selected to have high levels of delusional conviction. They requested less information than the nonclinical participants without delusions before making a decision on both versions of the beads task. Over 50% of the clinical sample jumped to conclusions compared with a quarter of the nonclinical sample. However, this study was an attempt to move beyond demonstrating an association of delusions and reasoning by investigating whether the data gathering bias can be modified and assessing the consequent effect on thinking about delusions.

A brief, single session training intervention had an effect on data gathering, reflected in a significant increase immediately after training in the number of beads requested on both versions of the beads task. The study therefore demonstrates that it is possible to change the data gathering of people with delusions, in the short term. The change was greater on the 60:40 version of the beads task. Why was there a difference in training effects on the 2 tasks? It could be that the training was only weakly effective, or it might be explained by the level of difficulty of the 2 tasks. The 85:15 task is much easier.
than the 60:40 version and can be successfully solved after a small number of draws. There is less objective benefit in delaying a decision on the 85:15 task because it is clear at a very early stage which jar has been chosen, and delaying the decision is unlikely to increase accuracy. The 60:40 task is more difficult because the ratio of the beads in the 2 jars is very similar, and delaying a decision is more beneficial in reaching a correct solution. The central theme of the training that gathering information is helpful has more relevance to the more difficult version of the beads task.

An interesting finding adds a note of caution to interpreting the training effects. Although there was an overall group mean increase of about 50% in the number of beads requested on the beads task from pre- to posttraining, the numbers of participants showing the extreme JTC bias remained consistent. On average, all participants in the intervention group improved, compared with the controls, but the amount of improvement was dependent on their baseline measurement. The effect was much smaller in those with the extreme bias. As noted in the introduction, a prior JTC bias has recently been found to moderate change in response to antipsychotic medication; in this study, a prior JTC bias moderated the effects of reasoning training. It was clear that training improved data gathering more among those individuals with delusions who did not show the JTC bias at the outset. This leads to the conclusion that JTC in people with delusions is a strong bias that is somewhat unresponsive to only a brief training intervention.

We were also interested in the effects of reasoning training on thinking about delusions and on delusional conviction. This is of theoretical importance because if a reasoning bias contributes to delusion formation and maintenance, as hypothesized, reversing this bias should have an impact on delusional thinking. It also provides a test of a general effect of the training in addition to training participants in gathering data. Our delusion group at baseline had little belief flexibility and very high levels of conviction in their beliefs. It should be noted that the training content at no point considered delusion-relevant material nor were the individual’s delusions ever discussed. We were specifically interested in examining whether a focus on general reasoning strategies might generalize to affect thinking about delusions, thereby providing some further evidence for a causal role of reasoning in delusions. After training, 24% (\(n = 4\)) showed greater belief flexibility and 18% (\(n = 3\)) some reduction in delusional conviction. In contrast, only one patient in the control group showed a change in belief flexibility, and none changed at all in conviction. Although only preliminary, this is an indication both of a causal role and of the potential benefits for delusions of reasoning training, suggesting that change in data gathering and reasoning strategies might indeed mediate change in delusional thinking. A larger study, powered for this, could be designed to examine this mediation hypothesis. We therefore conclude that this approach, if further developed, has promise for intervening with delusions.

The study had a number of limitations. First, it was underpowered to determine whether changes in belief flexibility or delusional conviction are statistically significant or to undertake formal statistical tests of mediation. These data indicate that sample sizes of approximately 50 people in each condition would be needed to have sufficient power to detect whether the benefits of this brief training on delusional conviction are significant. Larger sample sizes would also make it less likely that there are chance differences in the participants randomized to the conditions (although the groups did appear to be reasonably similar on clinical and demographic variables in the present study, with the exception of in- or outpatient status).

Secondly, the results indicate that the effects of this particular brief training are limited. As noted, we used neutral training materials that did not feature the beads task or the content of delusions in order to investigate the effects of changing a general reasoning strategy. There may be better methods to encourage more data gathering and to develop reasoning strategies that will impact on delusional thinking. It is possible that a lengthier training package, with a focus on generalizing to delusional thinking, which proceeds from the engaging materials used in the current study to stimuli related to interpersonal judgments and then to materials more directly relevant to the content of delusions, such as interpersonal threat, may have a greater impact on the more extreme JTC reasoning bias and on belief flexibility and delusional conviction. This sort of intervention could be carried out over a short course and the longer term effects to evaluate durability of change assessed. Consistent with this, a pilot study of the MCT package from which this intervention was partially derived, delivered over 8 sessions, and has reported some encouraging preliminary data of significant changes in positive symptoms. Thirdly, outcomes in this study were not examined by a rater blind to condition. Finally, in the current study, we did not investigate any specific hypotheses about the mechanisms underlying JTC. It is, for example, possible that cognitive deficits, such as executive function or working memory, might contribute to this bias. Future studies might examine both the relationship of JTC to cognitive impairment and also address whether reasoning training has effects on improvements in cognitive function, such as attention or other aspects of cognition, which might contribute to improvements in reasoning. Furthermore, the relationship of JTC with IQ is not clear, although most studies have not found that it is strongly associated. This study used a common but limited abbreviated measure of IQ and thus does not provide a thorough examination of this question. Studies that aim to increase the understanding of the mechanisms are also likely to help.
in developing an effective reasoning training package for treating delusions.

In conclusion, research in recent years has shown that a number of psychological processes are associated with delusions; the challenge now is to develop more effective psychological interventions based on this new knowledge. The findings of this study point to one promising new approach.

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