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Delusions and Delusional Reasoning

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In 2 studies, delusional participants assigned higher probabilities to narratives of actual delusions than participants with no history of delusions; previously delusional participants did not differ significantly from delusional participants or participants with no history of delusions. In Study 2, the authors found that this reasoning bias was specific to delusions and did not generalize to "neutral" text. Familiarity with the content of the delusion narratives played a mediating role in the estimation of their probability, but delusional status also had a significant, independent effect. These findings are consistent with the Bayesian model of delusion formation proposed by D. R. Hemsley and P. A. Garety (1986), and with R. P. Bentall, P. Kinderman, and S. Kaney's (1994) concept of "emotional saliency." A productive area of future research might be to further determine the elements of "emotional saliency" and their impact on the individual steps of the Bayesian model.

Of the relatively small number of theories dealing with the formation and maintenance of delusional beliefs, we believe those based on a Bayesian model of hypothesis evaluation offer the best opportunities for productive research. This type of model was first adapted to explain the process through which persons acquire and maintain "normal" beliefs (Fischhoff & Beyth-Marom, 1983). The steps for hypothesis evaluation in a Bayesian model of normal belief formation consist of (a) identifying sources of information most useful for discriminating among competing hypotheses, (b) assessing implications of an observed bit of information for competing hypotheses, (c) compiling information and forming an overall impression of the probability of competing hypotheses, and (d) selecting a course of action.

Hemsley and Garety (1986) adapted a Bayesian model of hypothesis evaluation to explain the formation and maintenance of delusional beliefs. In their model, delusions arise when persons make errors in one or more stages of hypothesis evaluation. The areas of evaluation that appeared most flawed to Hemsley and Garety were those involving hypothesis formation and probability estimation. According to Hemsley and Garety, delusional persons generate unlikely hypotheses about the world, and then overestimate the probability that these hypotheses are true.

Most of the research supporting a Bayesian model of delusion formation has focused on the amount of information requested by delusional persons to make probability-based decisions in various types of tasks. For example, Garety, Hemsley, and Wessely (1991) found that delusional participants requested fewer draws of colored beads from one of two jars before reaching a decision about the source of the beads. (Each jar contained an equal number of beads of two colors but with opposite proportions: e.g., 85 black and 15 yellow in one jar; 15 black and 85 yellow in the other.) Participants with delusions were also much more likely to be "extreme responders"—participants who made their decision about the jar source after only one draw. Garety et al. claimed that their findings indicate that delusional persons formulate probability estimates faster, and with less information, than nondelusional persons. Subsequent studies replicated these findings and also found that the reasoning bias of persons with delusions was not simply a matter of "quick judgment" (Fear & Healy, 1997) and was not due to impulsiveness or memory deficits (Dudley, John, Young, & Over, 1997b).

There are preliminary indications that emotionally relevant information may exaggerate the reasoning bias found in delusional persons. These indications come from two studies that used "emotionally salient" stimuli in reasoning tasks modeled after the bead-draws task used in Garety et al. (1991). In these two studies, ratios of positive and negative comments about an unknown person's personality characteristics were used in place of Garety et al.'s bead ratios. The personality comments were presumed to be emotionally salient based on Bentall et al.'s (1994) theory that persons with persecutory delusions have an attentional and memory bias for information consistent with the theme of their delusion or self-concept. In both Dudley, John, Young, and Over (1997a) and Young and Bentall (1997), delusional participants requested significantly fewer draws of the emotionally salient stimuli before

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deciding their source, or reached higher levels of certainty about their source more quickly than nonpsychiatric control groups. This was also true of the neutral stimuli, but to a lesser extent. The Group × Type-of-Stimulus (emotional or neutral) interaction just missed statistical significance. These two studies suggested that emotional saliency plays some role in the reasoning bias of delusional persons during hypothesis evaluation, with the caution that the findings did not meet the stricter criterion of a statistically significant Group × Type-of-Stimulus interaction.

According to a review by Garety and Freeman (1999), the reasoning bias found in delusional persons during hypothesis evaluation seems to be a bias in "data gathering" rather than a deficit in probability reasoning; in other words, delusional persons formulate probability estimates faster than nondelusional persons after gathering less information. Evidence that delusional persons, in fact, can consider data they are given and reason without bias comes from a modification of the data-gathering procedure used in the studies just reviewed. In this modification, researchers controlled data gathering by showing the same number of bead draws to all participants who then were asked the probability that the beads came from a particular source. Under these conditions, unlike the request for bead draws procedure, there were no group differences in probability estimates (Dudley, John, Young, & Over, 1997b; Fear & Healy, 1997; Garety et al., 1991).

A fundamental tenet of the Bayesian model of delusion formation is that delusional persons assign higher probabilities to unlikely hypotheses. Although we recognize the potential contribution of the studies we have reviewed, we believe a more content-valid and "naturalistic" test of the Bayesian model would be to directly examine the probabilities assigned by delusional persons to delusional beliefs. Following a procedure used by Junginger, Barker, and Coe (1992), we asked participants to estimate the probability that various narratives of actual delusions were true.

In some ways, our procedure addressed two different theories of the formation and maintenance of delusional beliefs. If the probability estimates of delusional persons are flawed, as proposed by Hemsley and Garety (1986), then delusional participants might be expected to assign higher probabilities to the delusions than nondelusional participants. However, because all participants reviewed the same amount of information (i.e., we controlled data gathering), perhaps this reasoning bias will not be evident (cf. Garety & Freeman, 1999). On the other hand, an extension of Bentall et al.'s (1994) model beyond its emphasis on persecutory delusions and threat-related information could indicate that other types of information may be self-referent or emotionally salient for delusional persons, and such persons may have a bias for information related to any of their delusions, not just persecutory types. To the extent narratives of actual delusions are emotionally salient for delusional persons, any role played by emotional saliency in the evaluation of hypotheses by delusional participants may be invoked by our experimental task (cf. Bentall et al., 1994).

One aspect of our study may help clarify some of these issues. In Study 2, we took a preliminary look at one potential source of information on which delusional participants might be basing their probability estimate—familiarity, a potential source of information during data gathering and a likely component of emotional saliency.

Study 1

Method

Participants. Participants were 30 delusional, 15 previously delusional, and 30 nondelusional adult psychiatric inpatients at a short-term psychiatric hospital in southern Louisiana. These participants represented approximately 80% of the inpatients who were asked to participate in the study. Psychology undergraduate students who were given extra credit in their undergraduate psychology courses for their assistance recruited 38 adults with no psychiatric history. The nonpsychiatric participants consisted of relatives, friends, and neighbors of the students.

Psychiatric diagnoses were obtained from hospital records. In addition, psychiatric participants were questioned about current and past delusional beliefs in a semistructured interview based on the Structured Clinical Interview for DSM-III-R (SCID; Spitzer, Williams, Gibbon, & First, 1990). Delusional participants were those who reported current delusions. Previously delusional participants reported no current delusions, but confirmed past delusional beliefs. Nondelusional participants reported no history of delusions, and none were indicated in their hospital records.

A summary of participant characteristics is presented in Table 1. There was a significantly greater percentage of Black participants in the psychi-

Table 1
Participant Characteristics for Study 1

Characteristic	Delusional (n = 30)	Previously delusional (n = 15)	Nondelusional (n = 30)	Nonpsychiatric (n = 38)
Age				
$M \pm SD$	36.6 ± 9.9	35.1 ± 8.1	35.9 ± 11.9	36.6 ± 14.6
Gender				
% Male	56.7	66.7	60.0	42.1
Race**				
% Black	60.0	40.0	36.7	21.0
Years of education				
$M \pm SD$	11.4 ± 3.7	11.4 ± 2.3	10.8 ± 2.9	10.9 ± 2.9
Diagnosis***				
% Schizophrenia	43.3	60.0	10.0	
% Schizoaffective	10.0	0.0	10.0	
% Mood	13.3	26.7	36.7	
% Other	33.3	13.3	43.3	

** $p < .01$. *** $p < .001$.

atric groups (47%) than in the nonpsychiatric group (21%), $\chi^2(1, N = 113) = 7.02$, $p = .008$. Within the psychiatric groups, there was a significantly greater percentage of schizophrenic disorders (including schizoaffective disorder) in the delusional and previously delusional groups (56%) than in the nondelusional group (20%), $\chi^2(1, N = 75) = 13.61$, $p < .001$. No other significant differences in participant characteristics were found.

Procedure. Following the delusion-history interview, participants were read two sample narratives of delusions similar to those in the experimental task. These narratives were written in the third person and included a brief demographic sketch of the person expressing the belief—for example, "Single-white-male, 25, believed he was being 'monitored' by several governmental agencies. . ." Participants were asked to estimate the probability that the belief was true on a 7-point Likert-type scale. The scale ranged from 0 (*impossible*) to 6 (*highly likely*), with 3 (*50/50*) marking the midpoint of the continuum.

In the experimental task, the interviewer read narratives of 25 actual delusions selected from a larger group of delusions described in Junginger et al. (1992). The narratives varied in length, mostly due to the complexity of the delusion being described, but generally were 100–130 words. There were five examples each of the five most common, classic types of delusions described in Junginger et al.: grandiose, persecutory, reference, bizarre (non-Schneiderian), and Schneiderian (control, thought broadcasting, insertion, and withdrawal). On a scale identical to the one used with the two sample narratives, participants were asked to estimate the probability that each delusion narrative was true as described and with the meaning given (as opposed to the probability that such situations and events could take place in the abstract).

Results

We planned three separate, main analyses of the data in Study 1. To control for the possibility of Type I error, we used the Bonferroni correction to set the corrected alpha level at 0.0167 (nominal alpha of 0.05/3 main analyses). Scheffé post hoc tests with alpha set at .05 were used to examine relevant pairwise group differences following significant main and interaction effects.

Our first interest was whether the experimental groups estimated different probabilities for the delusion narratives. We calculated a mean probability estimate for the 25 delusion narratives for each group; these means are shown in Figure 1. We then calculated a two-way analysis of variance (ANOVA) specifying group as an independent variable along with race to control for the disproportionate number of Black participants in the psychiatric groups. The analysis found a significant main effect for group, $F(3, 105) = 8.65$, $p < .001$, and race, $F(1, 105) = 6.81$, $p = .010$. Black participants assigned higher probability estimates to the delusions ($M = 3.44$, $SD = 1.27$) than did White participants ($M = 2.54$, $SD = 1.02$). The Group × Race interaction was not significant, $F(3, 105) = 1.03$, $p = .382$. Eta-squared (η^2), a measure of effect size (Cohen, 1977), was .200 for the group main effect, .061 for the race main effect, and .029 for the nonsignificant Group × Race interaction. Scheffé post hoc, pairwise comparisons of the four experimental groups found that the delusional group had significantly higher probability estimates than the nondelusional ($p < .001$) and nonpsychiatric ($p < .001$) groups. None of the other pairwise comparisons were significant.

Recall that there was a disproportionate number of participants with schizophrenic disorders in the delusional and previously delusional groups. Because of this it may be unclear whether the higher probability estimates for delusion narratives assigned by delusional participants should be attributed to their delusional status or to schizophrenia. To help resolve this issue, we excluded 31 participants with a diagnosis of schizophrenia or schizoaffective disorder in a follow-up, two-way ANOVA. In spite of the significant decrease in sample size and statistical power, the analysis again found a significant main effect for group, $F(3, 74) = 4.02$, $p = .010$, $\eta^2 = .140$. The race main effect, however, was no longer significant, $F(1, 74) = 3.50$, $p = .067$, $\eta^2 = .045$, nor was the Group × Race interaction, $F(3, 74) = .77$, $p = .511$, $\eta^2 = .031$. Scheffé post hoc, pairwise comparisons of the four experimental groups found that the probability estimates of the delusional group were significantly greater than those of the previously delusional ($p = .022$), nondelusional ($p = .001$), and nonpsychiatric ($p = .004$) groups. None of the other pairwise comparisons were significant. Together, these findings indicated that the higher probability estimates for delusion narratives assigned by delusional participants were best attributed to delusional status and not to schizophrenia.

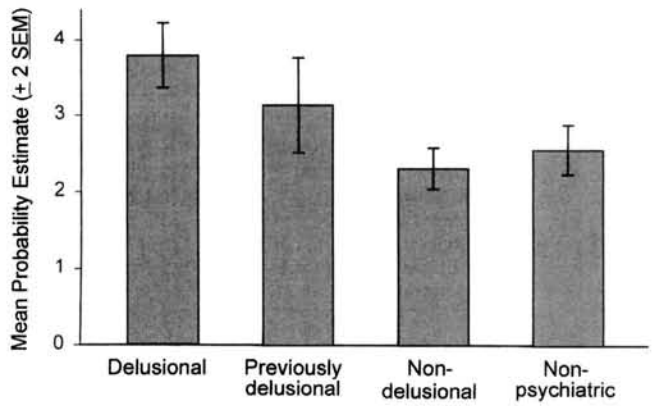

Figure 1. Mean probability estimates ± 2 standard error of the mean (*SEM*) error bars of the four experimental groups for the 25 delusion narratives. The mean probability estimate of delusional participants was 3.79 (*SEM* = 0.22); of previously delusional participants, 3.12 (*SEM* = 0.32); of nondelusional participants, 2.30 (*SEM* = 0.14); and of nonpsychiatric participants, 2.53 (*SEM* = 0.14).

We next addressed the issue of whether the experimental and racial groups perceived the probabilities of the five classic types of delusions differently. We calculated a two-way multivariate analysis of variance (MANOVA) to control for possible relationships among dependent variables (i.e., the five types of delusions), followed by a post hoc, discriminant function analysis to determine the unique contribution of each type of delusion to differences in probability estimates among the groups (cf. Huberty & Morris, 1989).

Table 2 shows the mean probability estimates of the four experimental groups for each of the five classic types of delusions. The two-way MANOVA found a significant main effect for group ($\Lambda = .73$), $F(15, 279) = 2.21$, $p = .006$, $\eta^2 = .098$, and race ($\Lambda = .87$), $F(5, 101) = 2.96$, $p = .015$, $\eta^2 = .128$. Again, the Group × Race interaction was not significant ($\Lambda = .81$), $F(15, 279) = 1.49$, $p = .108$, $\eta^2 = .068$.

Post hoc discriminant function analysis of the experimental groups found one significant function ($\Lambda = .71$), $\chi^2(15, N = 113) = 37.13$, $p = .001$, with a canonical correlation of .51. The standardized canonical discriminant function coefficients of the

Table 2
Mean Probability Estimates and Standard Deviations for the Five Classic Delusion Types in Study 1

Delusion type	Delusional (n = 30)	Previously delusional (n = 15)	Nondelusional (n = 30)	Nonpsychiatric (n = 38)
Grandiose	3.84 ± 1.60	3.25 ± 1.75	2.28 ± 1.21	2.52 ± 1.30
Persecutory	3.93 ± 1.26	3.57 ± 1.78	2.74 ± 1.28	2.74 ± 1.05
Reference	3.95 ± 1.54	3.23 ± 1.57	2.28 ± 0.90	2.67 ± 1.21
Bizarre (non-Schneiderian)	2.89 ± 1.62	2.16 ± 1.12	1.58 ± 0.56	1.79 ± 0.90
Schneiderian	4.33 ± 1.37	3.40 ± 1.23	2.60 ± 1.25	2.96 ± 1.34

five types of delusions indicate the unique contribution of each type of delusion to group separation based on the probability estimates (StatSoft, Inc., 1999). Schneiderian delusions, with a discriminant function coefficient of .50, contributed most to experimental group separation, followed by bizarre (.39) and reference (.34). Grandiose (−.04) and persecutory (−.002) delusions contributed little to group separation. The post hoc discriminant function analysis of the racial groups found one significant function (Λ = .82), $\chi^2(5, N = 113) = 21.40, p = .001$, with a canonical correlation of .42. Persecutory (.75) and grandiose delusions (.63) contributed most to racial group separation; bizarre (−.21), reference (−.17), and Schneiderian delusions (−.01) contributed little to group separation.

Discussion

The results of Study 1 support a reasoning bias in delusional persons when estimating the probability of delusional beliefs, just as characterized in the Bayesian model. Delusional participants assigned higher probabilities to delusion narratives than nondelusional participants, a bias that is most likely not due to a diagnosis of schizophrenia. This finding seems related to a previous finding that patients with persecutory delusions (along with depressed patients) assigned higher frequencies to negative social interactions than nonpsychiatric controls (Kaney, Bowen-Jones, Dewey, & Bentall, 1997). However, the elevated probability estimates of our delusional participants were best explained by a bias for Scheiderian, bizarre, and reference delusions. This suggests that a broad range of stimuli is emotionally salient for delusional persons in addition to the threat-related information that appears to be emotionally salient for paranoid persons (Bentall et al., 1994; Kaney et al., 1997).

The finding that different types of delusions best separated the experimental and racial groups in Study 1 may indicate that a "false consensus effect" (Ross, Green, & House, 1977)—a general tendency to assume that others have beliefs, attitudes, and experiences similar to oneself—was operating in our experimental task. One of the mechanisms believed to be responsible for the false consensus effect is the tendency for persons to associate with similar others and, as a consequence, become exposed to selective information about the world (Ross, Green, & House, 1977). The elevated probability estimates for persecutory and grandiose delusion narratives assigned by Black participants, and the elevated estimates for Schneiderian, bizarre, and reference narratives assigned by delusional participants, might be explained by the selective exposure of these groups to the beliefs of their peers.

A caution in the interpretation of the findings in Study 1 is that psychiatric persons may display a response bias that is a function of the assessment method used rather than some specific reasoning bias (cf. Chapman, Chapman, & Daut, 1974; Maher, 1974); in other words, a method bias by delusional participants, not flawed probability judgments, may have accounted for the differences among the experimental groups. This issue was addressed in Study 2 by the inclusion of neutral stimuli in the probability estimate task. Study 2 also examined the role played by familiarity with the content of the delusion narratives in the participants' estimates of their probability.

Study 2

Method

Participants. Participants were 30 delusional, 18 previously delusional, and 37 nondelusional adults from two psychiatric facilities in upstate New York, and 25 nonpsychiatric participants with no history of psychiatric hospitalization or psychosis from medical outpatient facilities in the same locale. All but 3 psychiatric participants were hospitalized at the time of their assessment. The participants represent approximately 60% of those asked to take part in the study. Psychiatric diagnoses and delusion histories were obtained, and the experimental groups were organized using procedures similar to those described in Study 1.

A summary of participant characteristics is presented in Table 3. The groups differed in age, $F(3, 106) = 3.36, p = .022$, and gender ratio, $\chi^2(3, N = 110) = 8.20, p = .042$, but neither of these characteristics was associated with participants' probability estimates for delusion narratives ($r = -.03, p = .753$; $r = .022, p = .816$, respectively). As in Study 1, there was a significantly greater percentage of schizophrenic disorders (including schizoaffective disorder) in the delusional and previously delusional groups (50%) than in the nondelusional group (8%), $\chi^2(1, N = 85) = 16.92, p < .001$. There were no other significant differences in participant characteristics.

Procedure. As in Study 1, delusion narratives were selected from a sample of 138 delusion narratives taken from Junginger et al. (1992). Before that was done, 87 psychology undergraduate students estimated the probability that each of the 138 delusion narratives was true on a scale that ranged from 0 to 100. (Students could use any whole number within that range.) Descriptors were placed on the scale to represent the following probability levels: 0 (*impossible*), 25 (*probably not*), 50 (*possibly*), 75 (*probably*), and 100 (*definitely*). The means and 95% confidence intervals (CIs) of the students' probability estimates then were used to select the delusion narratives for Study 2.

Two delusion narratives, one grandiose and one persecutory, were selected for each of four probability levels: 0–20, 20–40, 40–60, and 60–80. (An 80–100 probability level could not be included because the mean of the undergraduates' estimates did not exceed 80 for any delusion

Table 3
Participant Characteristics for Study 2

Characteristic	Delusional (n = 30)	Previously delusional (n = 18)	Nondelusional (n = 37)	Nonpsychiatric (n = 25)
Age*				
$M \pm SD$	40.0 ± 12.2	42.7 ± 10.0	34.6 ± 11.2	44.4 ± 17.4
Gender*				
% Male	30.0	61.1	62.2	44.0
Race				
% White	93.3	77.8	94.6	92.0
Years of education				
$M \pm SD$	11.8 ± 3.3	12.1 ± 2.4	11.6 ± 3.7	13.0 ± 2.8
Diagnosis***				
% Schizophrenia	30.0	11.1	2.7	
% Schizoaffective	30.0	22.2	5.4	
% Mood	16.7	44.4	62.2	
% Other	23.3	22.2	29.7	

* $p < .05$. *** $p < .001$.

narrative.) Our intention was to select delusion narratives across a range of probability levels so we could roughly match the narratives with neutral statements that had similar probabilities. Within each probability level, the two narratives selected had a similar mean and 95% CI; between probability levels, the 95% CIs did not overlap.

To assess whether delusional participants had a specific reasoning bias for delusion narratives, five nondelusional, "neutral content" statements were written that varied in the probability that a red or black ball could be picked blindly from a bag containing various proportions of red and black balls. The probability levels of the neutral statements were based on the proportion represented by the colored ball being picked. For example, the statement, "He had a bag with 100 balls, and only 100 balls. 25 balls were black. 75 balls were red. He said that without looking, he could pick out a black ball," represented the 25-probability level. Neutral statements were written for the 0, 25, 50, 75, and 100 probability levels. The neutral statements were very similar to the neutral content of the colored beads reasoning task developed by Garety, Hemsley, and Wessely (1991).

Before the experimental tasks, the probability scale used by the undergraduates was described to participants. Participants then used this scale to estimate the probability of a neutral practice statement that had a 50 probability of being true. If a participant's estimate was less than 40 or greater than 60, the rationale for an estimate of 50 was explained until the investigator was confident the participant understood how the scale was to be used.

In the experimental task, participants were given written versions of the eight delusion narratives, five neutral statements, and the probability rating scale. The interviewer then read the eight delusion narratives to the participant who was asked, as in Study 1, to estimate the probability that the narrative was true as described and with the meaning given. To address the issue of whether familiarity with the content of the narratives contributed to probability estimates, participants were asked about their direct experience with the situations described, "Has this ever happened to you?"; whether they personally knew someone else who had experienced the situations described, "Have you ever personally known someone that this happened to?"; and whether they had heard about the situations described, such as on television, "Have you ever heard of this happening?" Finally, participants estimated the probabilities of the neutral statements in the same manner as the delusion narratives.

Results

We planned five separate, main analyses of the data in Study 2. To control for the possibility of Type 1 error, we used the Bonferroni correction to set the correction alpha level at 0.01 (nominal alpha level 0.05/5 main analyses). Scheffé post hoc tests with alpha set at .05 again were used to examine relevant pairwise group differences following significant main and interaction effects.

Our first interest in Study 2 was whether the reasoning bias of delusional participants found in Study 1 was specific to delusion narratives or general to other types of content. To address that issue, we calculated mean probability estimates for the eight delusion narratives and the five neutral statements for each group. These means are shown in Figure 2. Note that there appears to be an interaction effect between group and type of statement (delusion or neutral), with differences among the groups limited to estimates for the delusion narratives.

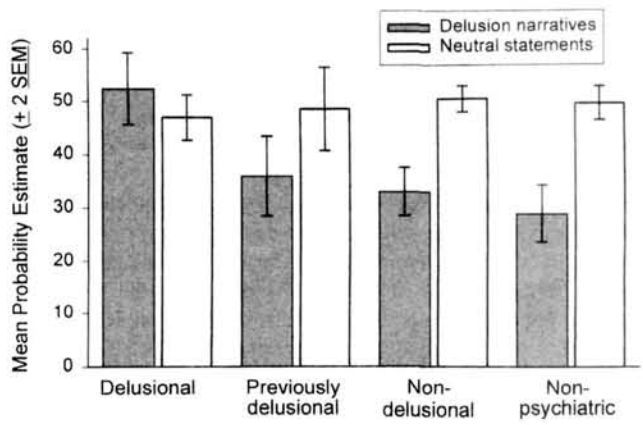

Figure 2. Mean probability estimates ± 2 standard error of the mean (*SEM*) error bars of the four experimental groups for the eight delusion narratives and five neutral statements. For delusion narratives, the mean probability estimate of delusional participants was 52.20 (*SEM* = 3.54); of previously delusional participants, 35.69 (*SEM* = 3.80); of nondelusional participants, 32.78 (*SEM* = 2.34); and of nonpsychiatric participants, 28.44 (*SEM* = 2.84). For neutral statements, the mean probability estimate of delusional participants was 46.93 (*SEM* = 2.16); of previously delusional participants, 48.57 (*SEM* = 3.94); of nondelusional participants, 50.38 (*SEM* = 1.24); and of nonpsychiatric participants, 49.49 (*SEM* = 1.59).

We calculated a repeated-measures Group × Statement Type ANOVA and found significant main effects for group, $F(3, 105) = 5.69$, $p = .001$, $\eta^2 = .140$, and statement type ($\Lambda = .73$), $F(1, 105) = 38.24$, $p < .001$, $\eta^2 = .267$, and a significant Group × Statement Type interaction ($\Lambda = .77$), $F(3, 105) = 10.37$, $p < .001$, $\eta^2 = .229$. Scheffé post hoc, pairwise comparisons of the four groups found that the delusional group had a significantly higher probability estimate for the delusion narratives, relative to the neutral statements, than the nondelusional group ($p = .022$) and the nonpsychiatric group ($p = .003$). None of the other pairwise comparisons were significant. In essence, these findings were identical to the initial findings in Study 1, with the added demonstration of a differential reasoning bias.[1]

As in Study 1, there were a disproportionate number of participants with schizophrenic disorders in the delusional and previously delusional groups. Therefore, we calculated a follow-up repeated-measures ANOVA after excluding 27 participants with a diagnosis of schizophrenia or schizoaffective disorder. In spite of the significant decrease in sample size and statistical power, this second analysis again found a significant Group × Statement Type interaction ($\Lambda = .76$), $F(3, 78) = 8.10$, $p < .001$, $\eta^2 = .238$. The main effect for statement type was also significant ($\Lambda = .77$), $F(1, 78) = 23.11$, $p < .001$, $\eta^2 = .229$, but the main effect for group failed to meet the significance level of the corrected alpha, $F(3, 78) = 2.97$, $p = .037$, $\eta^2 = .102$. Scheffé post hoc, pairwise comparisons of the four experimental groups found that the only significant difference in probability estimates was between the delusional and the nonpsychiatric groups ($p = .040$). As in Study 1, these analyses indicated that the higher probability estimates for delusion narratives assigned by delusional participants were best attributed to their delusional status and not to schizophrenia.

A review of the delusions reported by delusional participants in the delusion history interview found a few that were similar in content to one or two of the delusion narratives, but none that were identical. However, varying numbers of participants in each of the groups reported having experienced at least one of the situations described in the narratives. This could be interpreted to mean that the initial findings in Study 2 were simply the result of delusional and previously delusional participants overestimating the probability of their own delusions.

To control for that possibility, we calculated another repeated measures ANOVA in which we excluded for each participant probability estimates for narratives he or she claimed to have personally experienced. The analysis found that the interaction effect of the original repeated measures ANOVA on all the probability data was decreased somewhat, but still held, when estimates for personally experienced narratives were excluded ($\Lambda = .85$), $F(3, 104) = 6.27$, $p = .001$, $\eta^2 = .153$. The main effect for statement type was also significant ($\Lambda = .61$), $F(1, 104) = 67.98$, $p < .001$, $\eta^2 = .395$, but the main effect for group was not, $F(3, 104) = 2.15$, $p = .099$, $\eta^2 = .058$. Scheffé post hoc, pairwise comparisons of the four experimental groups found no significant differences. However, when we calculated less conservative, simple linear contrasts with alpha set at .05 and with each group in turn as the reference category (SPSS for Windows 10.0.7, 2000), we found a significant difference between the delusional and nonpsychiatric groups ($p = .016$). None of the other linear contrasts were significant. Thus, it did not appear that the interaction effect found in the original analysis on all the probability data could be entirely attributed to delusional participants simply overestimating the probability of their own delusions.

Our next interest was the role played by familiarity with the delusion narratives in the participants' estimates of their probability. Participants' answers to the three questions about their familiarity with the content of the eight delusion narratives were summed (yes = 1, no = 0) resulting in a "familiarity score" that could range from 0 to 24. The mean familiarity score for delusional participants was 8.87 ($SD = 4.75$); for previously delusional participants, 8.06 ($SD = 3.56$); for nondelusional participants, 4.90 ($SD = 2.95$); and for nonpsychiatric participants, 4.48 ($SD = 2.65$). We calculated an ANOVA and found a significant effect for group, $F(3, 106) = 10.67$, $p < .001$, $\eta^2 = .232$. Scheffé post hoc, pairwise comparisons of the four groups found that the delusional and previously delusional groups had significantly higher familiarity scores than the nondelusional group ($p < .001$ and $p = .027$, respectively) and the nonpsychiatric group ($p < .001$ and $p = .018$, respectively). None of the other pairwise comparisons were significant.

The familiarity score was highly correlated with the difference score of the mean probability estimate for delusion narratives minus the mean probability estimate for neutral statements ($r = .46$, $p < .001$).[2] Our next interest was the respective influence of familiarity and delusional status on the participants' probability estimates. We calculated another repeated-measures ANOVA (the second on all the data), but this time entered the familiarity score as a covariate. The analysis again found a significant effect for the Group × Statement Type interaction ($\Lambda = .87$), $F(3, 104) = 4.98$, $p = .003$, $\eta^2 = .126$, but also a significant Familiarity Score × Statement Type interaction ($\Lambda = .89$), $F(1, 104) = 12.68$, $p <$

[1] Bentall et al.'s (1994) model postulates an attentional and memory bias for information related to the delusions or self-concept of paranoid persons, which triggers awareness of personally threatening negative events and activates an externalizing attributional bias in an attempt to protect self-esteem. Although we did not test their model directly, we were able to assess the respective reasoning biases of paranoid and nonparanoid participants in Study 2 by identifying a subgroup of delusional participants who had primary persecutory delusions ($n = 16$) and comparing their probability estimates with those of delusional participants who did not have primary persecutory delusions ($n = 14$). The mean estimate of the persecutory group for persecutory narratives was 53.13 ($SD = 22.47$); for grandiose narratives, 46.96 ($SD = 22.17$). The mean estimate of the nonpersecutory group for persecutory narratives was 53.89 ($SD = 21.42$); for grandiose narratives, 55.43 ($SD = 20.43$). We calculated a Group × Statement Type (persecutory or grandiose) repeated-measures ANOVA and found nonsignificant effects for group, $F(1, 28) = .42$, $p = .53$, $\eta^2 = .015$; statement type, $F(1, 28) = .98$, $p = .50$, $\eta^2 = .016$; and the Group × Statement Type interaction ($\Lambda = .96$), $F(1, 28) = 1.29$, $p = .27$, $\eta^2 = .044$. We also found no significant differences between the probability estimates of persecutory participants for persecutory and nonpersecutory narratives, $t(15) = 1.22$, $p = .24$.

[2] Only when we included all three measures of familiarity did we find significant correlations between familiarity and the probability estimates for delusion narratives of three of the four experimental groups: delusional ($r = .51$, $p = .004$), previously delusional ($r = .48$, $p = .043$), and nondelusional ($r = .33$, $p = .044$). When personal familiarity was excluded from the computation of the familiarity score, familiarity was no longer significantly correlated with the probability estimates for delusion narra-

.001, $\eta^2 = .109$. The main effects for statement type ($\Lambda = .73$), $F(1, 104) = 39.29, p < .001, \eta^2 = .274$, and familiarity score, $F(1, 104) = 15.80, p < .001, \eta^2 = .132$, were also significant, whereas the group main effect was not, $F(3, 104) = 2.33, p = .079, \eta^2 = .063$. Scheffé tests can give inappropriate alpha levels for complex analyses such as analyses of covariance and so are not allowed in SPSS for Windows. Therefore, we calculated simple linear contrasts with alpha set at .05, and with each group in turn as the reference category (SPSS for Windows 10.0.7, 2000). We found significant differences between the delusional group and the nonpsychiatric ($p = .034$) and previously delusional ($p = .025$) groups on their probability estimates of the delusion narratives relative to the neutral statements. None of the other linear contrasts were significant.

When we compared the eta-squared values for the Group × Statement Type interactions in the first (.229) and second (.126) repeated measures ANOVAs on all the data, we found that the introduction of the familiarity score in the second analysis reduced the amount of variance of the relative mean probability estimates explained by delusional status by 45% (i.e., 1 − [.126/.229]). When considered with the other findings on familiarity, this was evidence that participants' familiarity with the delusion narratives partially mediated their estimates of the narratives' probabilities (see Baron & Kenny, 1986). It is important to note, however, that the analyses also clearly showed that delusional status had a significant effect on the relative mean probability estimates independent of the participants' familiarity with the narratives. In other words, there was more than one influence on the participants' estimates of the probabilities of the delusion narratives.

General Discussion

Two groups of geographically (and to a lesser extent, culturally) distinct, delusional participants assigned higher probabilities to delusion narratives than nondelusional participants. In Study 2, we found that this reasoning bias was specific to delusions and did not generalize to "neutral" text. Furthermore, analyses that excluded participants with schizophrenic disorders indicated that the higher probabilities assigned to delusion narratives by delusional participants were most likely due to their delusional status and not to schizophrenia. Considered together, these findings seem persuasive that delusional persons overestimate the probability of delusional beliefs.

Our findings are consistent with the Bayesian model of delusion formation proposed by Hemsley and Garety (1986). The third step in forming beliefs in the Bayesian model is to assign probability estimates to various competing hypotheses. Delusional participants assigned higher probabilities to beliefs that were viewed by nondelusional participants as being less likely.

The findings for previously delusional participants were less clear. In both studies, the initial analyses on all the data found that the probability estimates of previously delusional participants did not differ significantly from those of either delusional or nondelusional participants. These findings seem consistent with the implicit notion that the previously delusional group was midway along a continuum between delusional and nondelusional status.

It may seem surprising that differences were found between the delusional group and the other groups in their probability estimates for delusion narratives because all groups reviewed the same amount of information. As we described previously, the reasoning bias in delusional persons seems to disappear when researchers control data gathering. Thus, the absence of differences among the groups in probability estimates for neutral statements was not unexpected. One explanation for why there was a reasoning bias for delusion narratives is that they consisted of less structured descriptions of personal beliefs, characteristics, and behaviors, which had a range of probabilities as indicated by the estimates of undergraduate raters. Unlike the numerically framed neutral statements, the less structured delusion narratives may have led our delusional participants to reference other sources of information in forming their probability estimates.

It is likely that delusional participants referenced several sources of information in forming their probability estimates. A preferred source may be related to Bentall et al.'s (1994) idea that paranoid persons have an attentional and memory bias for emotionally salient and self-referent, threat-related information consistent with the theme of their delusion or self-concept (Bentall et al., 1994). In support of this idea, we found that an indicator of self-referent information—familiarity with the content of delusion narratives—was a partial mediator of delusional participants' estimates of the probability of the narratives.

However, when familiarity was statistically controlled, delusional participants still assigned higher probability estimates to the delusion narratives. This may suggest that emotional saliency extends beyond self-referent information. Furthermore, in Study 1, probability estimates for delusion narratives with nonpersecutory themes best discriminated the experimental groups, whereas narratives with persecutory themes were poor discriminators. In Study 2, as we described in Footnote 1, the mean probability estimates of "persecutory" participants were not significantly different from those of "nonpersecutory" participants, and the estimates of persecutory participants for persecutory narratives were not significantly different from those for grandiose narratives. These findings suggest that other types of information, in addition to threat-related information, play a role in the reasoning bias of delusional persons. What also seems apparent is that our findings cannot be attributed solely to paranoid participants overestimating the probability of narratives with self-referent, threat-related content (cf. Bentall et al., 1994).

Another possible source of information for delusional participants in forming their probability estimates is the assumption of the false consensus effect that others have beliefs, attitudes, and experiences similar to oneself (Ross et al., 1977). Kaney et al. (1997) provided some support for this possibility with their findings that patients with persecutory delusions rated the frequency of negative social interactions similarly for self and others (i.e., high consensus), whereas depressed and control groups did not. In our studies, it is conceivable that delusional participants overestimated the probability of delusion narratives not only because they were familiar with the content of particular narratives but also because they believed that unlikely things happen in the abstract—because unlikely things happen to them and others they know.

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tives of any of the experimental groups. Personal familiarity by itself was significantly correlated with the probability estimates for delusion narratives of only the delusional group ($r = .49, p = .006$).

There is a limitation in our methodology that could restrict the interpretation and generalizability of our findings. Our cross-sectional design cannot determine cause and effect relationships. Longitudinal studies are needed to determine the temporal relationship between reasoning biases and delusional beliefs, and whether changes in reasoning bias occur over the course of illness.

What we found in Studies 1 and 2 raises a number of interesting questions and suggests several productive areas for further research into the mechanisms of delusion formation and maintenance. Our findings support a Bayesian explanation of delusion formation, especially where it addresses biases in assigning probabilities to hypotheses. Familiarity with hypotheses seems to be an important mediator of their perceived probability and can be made to fit into the Bayesian model as a preferred source of information for discriminating among competing hypotheses. However, the fact that familiarity did not account for all, or even most, of the reasoning bias found in our delusional participants indicates that other factors were operating.

We believe that a much broader range of stimuli is emotionally salient for delusional persons than the self-referent, threat-related stimuli proposed by Bentall et al. (1994) for paranoid persons. We suspect that the emotional saliency of our delusion narratives contributed to our delusional participants' overestimating their probability. We also suspect that our familiarity measure represented only a small component of this saliency factor. In addition, we cannot rule out the possibility that a false consensus effect was operating in our experimental task and may have further enhanced the probability estimates of delusional participants.

A productive area of future research might be to focus on the individual steps of the Bayesian model after first determining some of the parameters of emotional saliency. We would suggest examining the influence of emotional saliency on the alternative hypotheses generated by delusional persons; on the steps taken to generate these hypotheses; on the information gathered to evaluate them; and, as we did here, on the probability estimates assigned to them. That strategy would seem to get at the heart of the type of reasoning bias exhibited by the delusional participants in our study. It could also help tease out the relative strengths of the Bayesian and Bentall models of delusion formation and identify potential interactions. Models that incorporate the various sources of information a person uses to generate hypotheses about the world, and assign probabilities to them, should provide insights into the mechanisms of delusion formation and maintenance.

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