Jumping to conclusions in delusional and non-delusional schizophrenic patients

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Objective. Several studies have provided evidence for the claim that a subgroup of (schizophrenic) patients with current delusions share a jumping to conclusions (JTC) bias. The primary aim of the present study was to investigate whether currently deluded and non-deluded schizophrenic patients perform differently on three tasks tapping probabilistic reasoning.

Method. Probabilistic reasoning was assessed in 31 schizophrenic patients, 28 psychiatric controls, and 17 healthy controls. In addition to the traditional draws to decision procedure, we employed two tasks for which participants had to judge, at each stage, the likelihood that beads come from either container (graded estimates procedure). Reaction times were recorded for the graded estimates procedure.

Results. A JTC bias was displayed by 42% of the schizophrenic patients in the draws to decision condition, while 7% of the psychiatric patients and none of the healthy controls reached a decision after only one bead. A similar pattern of results was observed for the graded estimates procedure. This bias was more pronounced in deluded schizophrenic patients, although currently non-deluded patients also showed evidence for earlier decisions. A bias to over-adjust when confronted with potentially disconfirmatory evidence was confined to deluded schizophrenic participants. There was also evidence for an increase in JTC in the deluded group over the course of the tasks. No substantial group differences occurred with respect to reaction time parameters indicating that results are not attributable to impulsivity.

Discussion. The findings provide further evidence for state and trait characteristics of abnormal reasoning in paranoid schizophrenia. Results are discussed in light of several competing explanations for JTC in schizophrenia.

In 1986, Hemsley and Garety put forward the hypothesis that deluded patients may share abnormalities in logical inference. Specifically, a jumping to conclusions (JTC)
bias has been assumed, that is, a tendency to make decisions extremely hastily, on the basis of little evidence (see Huq, Garety, & Hemsley, 1988; Garety, Hemsley, & Wessely, 1991; for a review see Garety & Freeman, 1999). This account may elegantly explain both the genesis and maintenance of a number of non-elaborated delusional beliefs where delusions emerge based on indirect or fallible evidence; for example, the belief that the secret service is spying on an individual because the telephone is making strange noises.

The strongest empirical support for the JTC account stems from investigations that have employed the probabilistic reasoning paradigm. In a typical task, the participant is presented two jars holding coloured beads in different proportions (e.g. container A: 85:15% green and red beads; container B: 85:15% red and green beads). The two containers are then removed from the participant's view. Subsequently, beads are drawn, one at a time, from one container only, and after each draw the participant is asked to consider from which container that bead was drawn.

Two versions of the task have been most frequently employed. In the draws to decision procedure, the participant is asked after each new bead whether a decision has been reached with respect to the source of the beads. Once the participant has reached a decision, the task is terminated. In the probability estimates procedure, the participant is required to provide probability estimates that beads are drawn from container A or B after every draw. Another variant of the paradigm (subsequently referred to as the graded estimates procedure) has been introduced by Young and Bentall (1997) and contains elements of both just described versions of the task. As for the probability estimates procedure, the number of beads drawn from the container is fixed. However, at each stage of the experiment the participant is asked whether a bead comes definitely, almost certainly, or probably from container A or B, or whether no preference has yet been formed. Using this procedure, the highest certainty rating corresponds closely to a decision response in the draws to decision procedure.

Support for the JTC account has been more consistent when the draws to decision procedure was used (see Fear & Healy, 1997; Garety et al., 1991). In line with the initial hypothesis, deluded schizophrenic patients reach a conclusion after fewer draws than healthy participants and psychiatric controls. An impressively homogeneous series of studies has demonstrated that 40% to 70% of patients with delusions make a decision after only one bead (Fear & Healy, 1997; Garety et al., 1991; Huq et al., 1988; Mortimer et al., 1996), whereas controls are often reluctant to draw inferences that early, especially patients with a diagnosis of obsessive-compulsive disorder (OCD; Fear & Healy, 1997; Volans, 1976). There is also evidence that deluded patients are quicker to dismiss the initial hypothesis (Fear & Healy, 1997; Garety et al., 1991; Young & Bentall, 1997).

In the present study we pursued four major aims. Our first aim was to compare delusional and non-delusional schizophrenic patients on the presence of a JTC bias. There is presently no solid evidence as to whether a JTC bias is confined to delusional (schizophrenic) patients or if a JTC response style is also displayed by schizophrenic patients in remission (i.e. patients with no current delusional features). Most previous studies have recruited a delusional experimental group and contrasted performance with healthy and non-schizophrenic psychiatric controls. One study (Mortimer et al., 1996), however, has investigated schizophrenic patients with an unreported proportion of deluded and non-deluded participants, and found no association between the severity of delusions and a JTC bias. Two recently published abstracts also indicate that JTC is rather a trait than a state effect of schizophrenia (Peters, Day, & Garety, 1999; Menon,
To address the impact of delusional symptomatology on JTC more directly, we recruited two schizophrenic subgroups with varying severity of current delusions, along with a healthy and psychiatric control group.

Our second aim was to contrast procedures. We administered both the draws to decision procedure and the graded estimates procedure. A direct contrast of both procedures within one experiment is essential to determine whether a jumping to conclusions bias can be demonstrated only with self-terminated procedures (draws to decision), or also with procedures where a fixed number of beads are shown (see Garety & Freeman, 1999, for a discussion).

Third, the probabilistic reasoning task is procedurally very complex, and there is evidence that patients with low IQ may display deviant performance (Garety et al., 1991), although some studies did not observe a correlation between performance and IQ (e.g. Mortimer et al., 1996). Thus, we wanted to quantify task comprehension (determined via clearly illogical responses, see methods section), in order to ensure that reasoning biases displayed by schizophrenic patients could not be attributed to problems with task comprehension. For example, presence of a strong over-adjustment bias (radical inversion of judgment in the face of conflicting evidence) may point to the possibility that participants misunderstood or forgot the basic principle that beads are drawn from one container throughout the entire task.

Finally, we examined the temporal characteristics of performance in the probabilistic reasoning task. Specifically, we were interested in whether patients not only respond hastily in the sense of fewer draws, but also need less time than controls when making definite judgments. For this purpose, we recorded individual reaction times for the graded estimates procedure.

Methods

Participants

Thirty-one schizophrenic inpatients participated in the study. Patients fulfilled DSM-IV criteria for schizophrenia as determined by an experienced psychiatrist at ward. Before testing, diagnoses were confirmed through a semi-structured interview. Schizophrenic psychopathology was assessed with the Brief Psychiatric Rating Scale (BPRS) by the doctor-in-charge. The BPRS items 11 (suspiciousness/paranoid ideas) and 8 (grandiosity) served as indices for delusional behaviour (patients were considered delusional if a BPRS score of at least 3 points (mild symptoms) was achieved). Seventeen schizophrenic patients displayed delusions at the time of testing. We recruited 28 mixed psychiatric inpatients as a control group who predominantly suffered from affective or anxiety disorders (OCD: N = 11; agoraphobia and/or panic disorder: N = 6; major depression: N = 5; PTSD: N = 3; personality disorder: N = 2; social phobia: N = 1). All patients were drawn from the University Hospital for Psychiatry and Psychotherapy in Hamburg. Exclusion criteria for the two psychiatric samples were severe substance abuse, any form of documented or suspected brain damage/disease and an additional axis I diagnosis other than depression. All schizophrenic patients were medicated with atypical neuroleptic medication at the time of testing. Six of the psychiatric control patients were medicated with antidepressant agents, three were receiving neuroleptics, and the rest were medication-free. Socio-demographic and psychopathological characteristics of the sample are displayed in Table 1. Seventeen participants served
### Table 1. Psychopathological and socio-demographic characteristics of the samples. Mean values are accompanied by standard deviations (in brackets)

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia (N = 31)</th>
<th>Psychiatric controls (N = 28)</th>
<th>Healthy controls (N = 17)</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male/female)</td>
<td>19/12</td>
<td>8/20</td>
<td>5/12</td>
<td>$\chi^2(2) = 7.91, p = .02$</td>
</tr>
<tr>
<td>Age</td>
<td>32.00 (9.87)</td>
<td>35.54 (13.02)</td>
<td>35.94 (10.04)</td>
<td>$F(2, 73) = 1.00, p &gt; .3$</td>
</tr>
<tr>
<td>Formal school education</td>
<td>12.18 (1.89)</td>
<td>12.08 (1.59)</td>
<td>12.08 (1.59)</td>
<td>$F(2, 69) = 0.15, p &gt; .8$</td>
</tr>
<tr>
<td>Previous hospitalizations</td>
<td>2.62 (1.74)</td>
<td>1.64 (1.93)</td>
<td>–</td>
<td>$t(52) = 1.96, p = .06$</td>
</tr>
<tr>
<td>Length of psychiatric illness</td>
<td>4.53 (5.96)</td>
<td>4.30 (5.93)</td>
<td>–</td>
<td>$t(55) = 0.15, p &gt; .8$</td>
</tr>
<tr>
<td>BPRS total score</td>
<td>42.42 (12.48)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>HDRS (17 items)</td>
<td>–</td>
<td>12.08 (7.92)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>HDRS anxiety (items 10, 11, 15)</td>
<td>–</td>
<td>3.30 (2.10)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
as the healthy control group. Controls were drawn from hospital staff and the general population via advertisement and word-of-mouth. Control participants were screened for absence of brain damage and mental illness via a semi-structured interview (M.I.N.I; Sheehan et al., 1998).

The mixed psychiatric group was assessed with the Hamilton Depression Rating Scale III (HDRS; Hamilton, 1960) and the OCD subsample with the Yale-Brown obsessive-compulsive scale (Y-BOCS; Goodman et al., 1989). The HDRS was administered as there is partial evidence that depression may also be associated with a hasty response style (Young & Bentall, 1997; however see Peters, Day, & Garety, 1997). As an index of anxiety we summed up three items from the HDRS tapping psychic and somatic anxiety (items 10 and 15) and hypochondriases (item 15).

**Experiment**

A computerized version of the probabilistic beads task was constructed using the Superlab software package. In total, three tasks were presented in a fixed order. The first two tasks followed the graded estimates approach of Young and Bentall (1997). Task 3 utilized a draws to decision procedure. In each task, participants were presented two containers holding different portions of beads (Task 1: 90%:10% red vs. green and vice versa; Task 2: 80%:20% yellow vs. blue and vice versa; Task 3: 90%:10% red vs. green and vice versa). Experimenters were allowed to answer questions in the course of Task 1. For the subsequent tasks, any further remarks were prohibited in order to prevent occurrence of a Rosenthal effect (specifically, intended or unintended manipulation of participant's task performance via suggestive remarks). Instructions were read by the experimenter from the screen display. Reaction times were recorded for individual responses in Tasks 1 and 2.

**Task 1 (graded estimates procedure)**

For Task 1, instructions were displayed next to a picture of two containers holding coloured beads (90%:10% red vs. green and vice versa). The experimenter explicitly stated the proportions of beads in each container. Further, it was explained that in the following session the computer would randomly draw beads from one container throughout the whole task. Beads would then be put back in the container. After each bead, the participant was asked to press a button (keys 1–7) according to his or her best estimate: 1 = beads are definitely from container A; 2 = beads are very likely from container A; 3 = beads are probably from container A; 4 = no estimate possible yet; 5 = beads are probably from container B; 6 = beads are very likely from container B; 7 = beads are definitely from container B. The experimenter was permitted to answer questions for Task 1, but only to familiarize participants with task instructions. Thus, the experimenter was permitted to either repeat or paraphrase the written instructions, but not to give any further information. For example, if participants erroneously believed that the computer randomly switches containers from bead to bead, the experimenter repeated the instructions that throughout each task the computer chooses from only one container. Subsequently, the first bead appeared, and the computer prompted participants to decide among the seven alternatives. There was also an explicit reminder about the proportion of beads in the two containers to minimize memory load. To further decrease memory load, each new bead was shown linked to the previous beads with a line segment, such that all drawn beads appeared connected on a string. The current bead was marked with an arrow. Along with every new bead an instruction set appeared stating that estimates/decisions should be carried
out while considering all beads. In total, 10 beads were ‘drawn’. If participants gave a definite rating for one container when confronted with only one bead, this was considered a JTC bias.

**Task 2 (graded estimates procedure)**
This task was designed to assess how subjects would react when confronted with potentially contradictory information. For this purpose, 20 beads were drawn which at first suggested that container A was the origin, then the likelihood slowly reversed (see ‘sequence of beads’). The instructions and design for Task 2 were identical to those from Task 1, except for information referring to the ratios of the beads and the colour of the beads (80%:20% blue and yellow and vice versa).

**Task 3 (draws to decision procedure)**
This task was designed to study participants’ performance in the draws to decision variant of the paradigm. With the exception of the instructions, the design in Task 3 was similar to that in Task 1. Participants were again familiarized with the general principle that the computer selects one container (90%:10% red vs. green and vice versa) and then draws beads from only this container. This time, however, participants were required to judge, at each stage, whether they were positive (i.e. have made their decision) that a bead came from container A or B, or whether they needed more beads to come to a decision. After a decision was made, the task was terminated. Responses (either ‘A’ [decision for container A], ‘B’ [decision for container B], or ‘X’ [no decision yet]) were typed in by the experimenter.

**Comprehension**
Indicators of non-comprehension were illogical decisions or estimates (e.g. judging higher probability for the container with predominantly green beads after only red beads were drawn). Any decision or estimate in favour of container B (ratings 5–7) within the first 10 beads of Task 1–3 was recorded as an illogical response (i.e. an error) by the experimenter.

**Sequence of beads**
The three tasks presented beads in the following order (R = red; G = green; Y = yellow; B = blue):

- Task 1: R-R-R-R-G-R-R-R-R-R
- Task 3: R-R-R-G-R-R-R-R-R

The sequence of beads in Task 2 at first clearly favoured container A until the 10th bead, the likelihood then reversed. By the end of the task, 10 yellow and 10 blue beads had been displayed, making both containers equally probable.

**Results**

**Sociodemographic parameters**
The groups did not significantly differ regarding age and educational level. However, the schizophrenic sample contained more males than both other groups. Although there is no evidence for a sex difference in probabilistic reasoning in the literature (see Garety & Steffen Moritz and Todd S. Woodward).
Freeman, 1999, p. 127), we determined for each parameter whether gender impacted task performance, which was not the case. The deluded and non-deluded group did not significantly differ on age, educational level or gender. The OCD subgroup of the mixed psychiatric group had a Y-BOCS total score of 24.00 points ($SD = 4.31$) which corresponds to most prior studies with acute OCD patients. Statistical tests for these and all other psychopathological indices are displayed in Table 1.

**Graded estimates procedure (Task 1 and 2)**

Schizophrenic patients needed significantly fewer beads than psychiatric controls to reach a decision in both Task 1 and Task 2, while the difference in comparison to healthy controls achieved trend level for both tasks. The schizophrenic subgroups did not differ significantly from each other on either task.

As can be seen in Table 2, in Task 2, the schizophrenic sample displayed an increased JTC bias (i.e. made a definite estimate when confronted with only one bead) relative to healthy and psychiatric controls, while for Task 1 the difference only achieved significance relative to healthy participants. Deluded and non-deluded schizophrenic participants did not differ regarding JTC in Tasks 1 and 2, although an early response style was more pronounced in non-deluded participants, especially in Task 1.

Finally, we calculated the percentage of patients who judged both containers as equally probable at the end of Task 2 (most reasonable judgment). Schizophrenic patients more often preferred one container at the end (81%) relative to healthy (65%) and psychiatric controls (54%). However, only the difference between schizophrenic and psychiatric patients was significant ($p = .05$). No significant differences occurred between deluded (82%) and non-deluded patients (79%). Further analyses revealed no differential preferences for either container A or B in the schizophrenic group(s).

**Draws to decision (Task 3)**

Schizophrenic patients decided after fewer beads relative to healthy controls and psychiatric patients, while the control groups performed similarly ($p > .6$). When the schizophrenic sample was split, comparable mean results emerged for deluded ($M = 2.71; SD = 2.69$) and non-deluded patients ($M = 3.07; SD = 2.53; p > .6$).

However, when we calculated the percentage of patients who decided after only one bead a different picture emerged. While 58% of the deluded patients decided after only one bead ($N = 10$), only 21% of the non-deluded patients ($N = 3$), 7% of the psychiatric inpatients ($N = 2$) and none of the healthy controls showed this response pattern (all comparisons with deluded patients $p < .005$). When groups were compared regarding decisions on the second bead, performance of deluded and non-deluded patients narrowed (65% vs. 43%; $p > .1$). Healthy controls (6%, $N = 1$) now differed from both schizophrenic subgroups (at least $p < .05$). Psychiatric patients (21%) could be differentiated from deluded patients ($p = .001$), the difference to non-deluded patients failed to reach significance ($p = .13$).

**Impulsivity (Task 1 vs. Task 2)**

We investigated whether participants were more reluctant in Task 2 relative to Task 1 to give high estimates for container A, as the ratio of the beads was closer in Task 2 (Task 1: 90:10; Task 2: 80:20) and participants may thus have adopted a more cautious strategy. Paired $t$ tests revealed that all (sub)groups except for deluded schizophrenic patients needed significantly more draws (at least $p < .05$) to make a definite rating relative to Task 1 (to make both tasks comparable we assigned a value of 11 when no definite rating
Table 2. Comparisons of sample and sub-samples regarding decisions in Tasks 1–3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Schizophrenia (S)</th>
<th>Psychiatric controls (P)</th>
<th>Healthy controls (H)</th>
<th>F statistics</th>
<th>Post hocs</th>
<th>Deluded (D)</th>
<th>F statistics</th>
<th>Post hocs</th>
<th>Non-deluded (ND)</th>
<th>F statistics</th>
<th>Post hocs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1, beads until definite rating</td>
<td>4.58 (3.75)</td>
<td>6.82 (4.02)</td>
<td>5.88 (3.96)</td>
<td>F(2, 73) = 2.98, p = .06</td>
<td>S &lt; H, P (p = .07; p = .03)</td>
<td>5.17</td>
<td>3.86</td>
<td>F(3, 72) = 2.28; p = .09</td>
<td>ND &lt; H, P (p = .04; p = .02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 1, JTC</td>
<td>25.8%</td>
<td>14.3%</td>
<td>0%</td>
<td>F(2, 73) = 2.88, p = .06</td>
<td>S &gt; H (p = .02)</td>
<td>23.5%</td>
<td>28.6%</td>
<td>F(3, 72) = 1.95, p = .12</td>
<td>ND, D &gt; H (p = .03; p = .06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 2, beads until definite rating</td>
<td>9.71 (9.28)</td>
<td>15.00 (7.72)</td>
<td>14.53 (7.19)</td>
<td>F(2, 73) = 3.49, p = .03</td>
<td>S &lt; H, P (p = .06; p = .02)</td>
<td>10.06</td>
<td>9.28</td>
<td>F(3, 72) = 2.32, p = .08</td>
<td>ND, D &lt; P (p = .04; p = .06); ND &lt; H (p = .09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 2, JTC</td>
<td>32.3%</td>
<td>3.6%</td>
<td>0%</td>
<td>F(2, 73) = 7.87, p = .001</td>
<td>S &gt; P, H (p = .02; p = .001)</td>
<td>35.3%</td>
<td>28.6%</td>
<td>F(3, 72) = 5.30, p = .002</td>
<td>D &gt; P, H (both p = .002; ND &gt; P, H (both p = .02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 3, beads until decision</td>
<td>2.87 (2.50)</td>
<td>4.89 (2.82)</td>
<td>4.59 (1.84)</td>
<td>F(2, 73) = 5.27, p = .007</td>
<td>S &lt; H, P (p = .03; p = .003)</td>
<td>2.71</td>
<td>3.07</td>
<td>F(3, 72) = 3.53, p = .02</td>
<td>D &lt; H, P (p = .03; p = .007); ND &lt; H, P (p = .1; p = .03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 3, JTC</td>
<td>41.9%</td>
<td>7.1%</td>
<td>0%</td>
<td>F(2, 73) = 10.22, p &lt; .001</td>
<td>S &gt; P, H (both p &lt; .001)</td>
<td>58.1%</td>
<td>21.4%</td>
<td>F(3, 72) = 10.68, p &lt; .001</td>
<td>D &gt; H, P, ND (p = .001; p = .001; p = .003; ND &gt; H (p = .08)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. Similar to Young and Bentall (1997) a value of 11 was assigned to participants who did not decide in Task 1 and 3 and a value of 21 in Task 2. JTC = jumping to conclusions, percentage of participants who gave a definite rating after only one bead. Post-hoc tests were calculated by means of Fisher’s LSD.
was made in Task 2 instead of a value of 21 as used in Table 2 for Task 2). Deluded patients needed a comparable number of draws in both tasks ($M = 5.2$ vs. $5.9; p > .4$). The deluded subgroup was the only group where the percentage of JTC increased from Task 1 to Task 2 (24% to 35%).

**Over-adjustment**

For Task 1, analyses of variance (ANOVA) performed for the entire schizophrenic sample revealed no evidence for significant over-correction in face of potentially disconfirmatory evidence and the subsequent confirmatory bead (difference bead 4 to bead 5 and bead 5 to bead 6; all $ps > .1$), although schizophrenic patients showed a somewhat greater tendency to over-adjust (see Fig. 1). For clarity, beads providing disconfirmatory evidence are marked with a (D) in Figs. 1, 2. When the schizophrenic sample was split into patients with and without delusions, the deluded group showed over-adjustment in comparison to all three groups (bead 4–5: at least $p < .05$; bead 5–6: at least $p < .01$), whereas non-deluded patients were indistinguishable from controls for all comparisons.

In Task 2, schizophrenic patients showed greater adjustment from bead 3–4 ($p = .04$) and back from 4 to 5 ($p = .04$) and from 9 to 10 ($p = .05$) relative to healthy controls. Group comparisons yielded significant differences between schizophrenic participants and psychiatric controls for the following switches: bead 8–9 ($p = .05$), 9–10 ($p = .02$), bead 10–11 ($p = .05$), bead 13–14 ($p = .03$) and bead 18–19 ($p = .003$). Deluded schizophrenic participants adjusted more than both control groups for bead 8–9 and bead 13–14 (at least $p < .05$) and relative to psychiatric patients for bead 9–10 ($p = .03$), bead 14–15 ($p = .05$), bead 18–19 ($p = .006$) and bead 19–20 ($p = .05$). For all comparisons in Task 2, deluded and non-deluded schizophrenic patients performed similarly ($p > .2$). None of the comparisons between non-deluded participants and controls achieved significance.

**Task performance over the course of the three tasks**

The pattern of JTC performance over the course of the three tasks (see Table 2) indicated that deluded patients decided in favour of one container increasingly often when confronted with only one bead. A repeated measures ANOVA yielded a significant
effect of time for deluded patients, \( F(2, 32) = 3.58, p = .04 \). In contrast, non-deluded patients showed a non-significant decline to Task 3 after plateau performance in Tasks 1 and 2. The interaction of conditions (percentage of JTC in Tasks 1, 2 and 3) $\times$ group (deluded, non-deluded) achieved significance \( (F(2, 58) = 3.11; p = .05) \).

**Temporal characteristics**

Healthy controls displayed longer reaction times when confronted with potentially disconfirmatory evidence in Task 1 (bead 4; \( p < .001 \) for comparisons with schizophrenic patients and psychiatric controls). One bead later, reaction times remained slowed relative to schizophrenic participants \( (p = .04) \). No other differences achieved significance for Task 1.

Marked slowing in Task 2 relative to both patient groups was revealed for healthy participants for bead 2 (confirmatory information); healthy participants were almost doubly slow compared with psychiatric controls \( (p = .05) \) and schizophrenic participants \( (p = .06) \). For bead 6 (confirmatory information), healthy participants again were markedly slowed relative to schizophrenic patients \( (p = .04) \). For bead 16, psychiatric patients were slowed relative to schizophrenic patients. Except for bead 13 in Task 2, where non-deluded patients were slower relative to deluded patients \( (p = .04) \), both subgroups were indistinguishable for all temporal parameters. No differences occurred between any of the groups and subgroups when reaction times were compared in decision trials \( (p > .1) \).

**Task comprehension, moderators of task performance**

Thirty-eight percent of all participants made at least one illogical response during the three tasks (schizophrenic patients: 52%, psychiatric patients: 32%, healthy controls: 23%; \( \chi^2(2) = 4.35; p = .11 \)). The subgroups of schizophrenic patients performed similarly (deluded: 53%; non-deluded: 50%). We further analysed to what extent patients with a JTC bias (at least one highest confidence rating at bead 1 in Tasks 1 or 2 or decision in Task 3) differed from participants with no such bias. There was evidence that patients demonstrating a JTC bias made more logical errors than participants with no JTC style, \( t(74) = 2.14, p = .04 \), pointing to the possibility that these participants did not understand the task. However, when participants with illogical responses were removed from the sample, differences between schizophrenic patients (especially the deluded subgroup) with the control groups remained significant for Task 3. There was no effect of gender, age, education (all participants), and length of illness (patients only). Numbers of
admissions were higher in participants with a JTC bias, $t(52) = 2.22; p = .03$. The BPRS total score was also significantly higher in schizophrenic patients, $t(25) = 2.44, p = .02$, displaying a JTC style with no single item yielding significant differences. However, when both delusional items of the BPRS where combined to a delusional sub-score a significant difference emerged ($p = .04$). Incorporation of hallucinations and unusual thought content into that index still yielded significant differences relative to schizophrenic participants with no JTC style ($p = .05$). The negative (BPRS items emotional withdrawal, motor retardation, blunted affect) and disorganized syndrome scores (BPRS-items conceptual disorganization, mannerisms and posturing, disorientation) did not differentiate the schizophrenic groups.

**Exploratory analysis with OCD participants, correlation between depression and task performance**

Analyses performed for the 11 OCD patients did not reveal any indication for delayed conclusions. When we correlated both YBOCS sub-scores according to the conventional algorithm proposed by Goodman et al. (1989) no single correlation with any of the variables from the experiment achieved significance. Moreover, the HDRS total score and the anxiety sub-score from the HDRS (items 10, 11 and 15) did not correlate with any of the parameters.

**Discussion**

The present results both confirm and extend our understanding of performance deviations in the probabilistic reasoning task displayed by patients diagnosed with schizophrenia. In accordance with prior studies, schizophrenic patients were more hasty in their decisions than both healthy and psychiatric controls. A JTC bias, assessed with the draws to decisions procedure (Task 3), was displayed by 42% of the schizophrenic patients but only 7% of the mixed psychiatric group. None of the normal controls showed this response style. Deluded schizophrenic patients showed the strongest JTC bias (58%) and significantly differed from all groups including non-deluded patients. Correlational analyses suggest that a hasty response style may represent a risk factor for relapse, as the number of admissions were associated with the JTC bias.

The extent of JTC for the entire schizophrenic sample in Task 3 is strikingly similar to data collected by Mortimer et al. (1996; 41.86%). However, the similarity of JTC in these two studies was not fully expected, as the draws to decisions procedure in our study immediately followed a task in which a prior expectancy was violated, and may have served to caution participants to delay decision-making. While the first 10 beads of Task 2 clearly suggested container A, the second 10 suggested container B (Mortimer et al., 1996, utilized a draws to decision procedure without increasing amounts of disconfirmatory evidence). In line with this argument, psychiatric controls and non-deluded patients performed somewhat more cautiously in Task 3 relative to Task 1 despite identical ratios. In contrast, there was a clear trend in deluded participants to perform more hastily in Task 3 relative to both preceding tasks (the repeated-measures ANOVA and the comparison with non-deluded participants yielded a significant effect).

While results from the draws to decision procedure seem to suggest that the jumping to conclusions bias is a state effect of delusional schizophrenia, results from the preceding (graded estimates) tasks, and also a further inspection of performance in Task 3, preclude a straight-forward inference. A hasty response style was also present in participants with no or low current delusional symptomatology in Tasks 1 and 2.
In fact, in Task 1, even more non-deluded schizophrenic patients gave the highest confidence rating after the first bead, and the schizophrenic subgroups performed almost identically on Task 2. In addition, when a more lax criterion was used for computing JTC in Task 3 (frequency of decisions after bead 2) the schizophrenia subgroups were indistinguishable, and non-deluded patients decided significantly earlier than healthy participants. Another result of note was that OCD patients did not differ from controls in their decision behaviour, in contrast to Fear and Healy (1997) and Volans (1976), who found that OCD patients were over-cautious.

In line with several prior reports (e.g. Garety et al., 1991), deluded schizophrenic patients showed a clear bias to over-adjust when confronted with potentially disconfirmatory evidence. This tendency was especially pronounced in Task 1. This over-adjustment displayed by deluded patients in view of disconfirmatory evidence in Tasks 1 and 2 may be interpreted as an enhanced decision flexibility. As such, it contrasts markedly with the increase of the JTC bias of the trials in deluded patients, with the latter providing evidence for incorrigibility. Consistent with the former is the observation that many deluded schizophrenic patients dramatically switch their attitude towards the persecutor or persons embedded in the paranoid belief depending on the situational context. For example, a patient may at one time judge his physician as the devil and some time later – while still being psychotic – approach him or her and ask for a psychotherapeutic appointment. Consistent with the latter is our demonstration of a bias against disconfirmatory evidence (BADE) in deluded patients, such that deluded patients were less able to revise incorrect interpretations in light of new disconfirming evidence (Woodward, Moritz, Cuttler & Whitman, in press). Further investigation of the circumstances under which patients elicit drastic shifts in decision behaviour and abnormal performance maintenance is warranted.

To summarize, the complex pattern of results indicates that JTC is more pronounced for, but not confined to, acute symptomatic schizophrenic patients with delusions. This finding is in accordance with data collected by Colbert and Peters (2002) in healthy subjects screened for delusional symptoms, who found that high scorers in the Peters Delusion Inventory also displayed a JTC bias (see also Menon et al., 2002; Peters et al., 1999, for compatible findings). Over-adjustment in view of potentially disconfirmatory evidence, however, was displayed in deluded patients alone for the present study. Although we used a procedure similar to Young and Bentall (1997), who did not find a specific JTC bias in deluded patients, our results confirm that a JTC style can be detected whether or not the task is self-terminated.

Inspection of the temporal response characteristics revealed no substantial group differences. Patients displayed speeded responding on some beads, but typically no differences occurred, especially with regard to the first beads of Tasks 1 and 2. There was evidence that healthy participants were more strongly slowed compared with all other groups when faced with the initial disconfirmatory evidence in Task 1, but this effect did not re-appear on Task 2 and 3, possibly due to practice. These results correspond to the findings of Fear and Healy (1997), who did not find reaction time differences in decisions between healthy controls and deluded patients.

The reaction time results are in accordance with the finding of Dudley, John, Young, and Over (1997), who concluded that schizophrenic patients do not perform more impulsively in the probabilistic reasoning task. However, unlike Dudley we did not find that all schizophrenic patients adapted their probability decisions to the ratios of the beads; this was the case only for non-deluded patients. Deluded patients required approximately as many beads to make a decision in Task 2 as they did in Task 1, and they
were the only group in which the percentage of patients with an extremely early decision was increased (24%–35%). The discrepancy between our findings and those obtained by Dudley et al. (1997) may also reflect procedural differences, as Dudley and co-workers used a counterbalanced design, whereas we used a fixed order.

Despite consistent findings with only a few exceptions (e.g. Brankovic & Paunovic, 1999; Young & Bentall, 1997), the exact mechanism underlying abnormal reasoning in schizophrenia is still not entirely understood, and is subject to ongoing debate. Several explanations have been formulated that may account for the data. The conventional interpretation of task results implicit in prior research is that schizophrenic patients are biased towards the most dominant option (forward strategy). Alternatively, patients may be quicker to dismiss weak options, and may at a second step opt for the remaining option (backward strategy). Both provide elegant explanations as to why patients decide quickly, but share weaknesses to explain the tendency of deluded patients to over-adjust when confronted with potentially conflicting evidence as shown in several prior studies including the present. At least, additional assumptions need to be incorporated to account for the latter finding. Both the forward and backward strategy would predict that participants persist with their initial choice when confronted with disconfirmatory evidence, or would at least not correct their decisions to a greater degree than controls, as the first option is still the strongest. Other mechanisms such as greater impulsivity are also insufficient to account for the data, as patients did not generally respond more quickly (see above).

Although the introduction of memory aids/reminders in our study minimized the impact of memory problems on task performance, in line with Hemsley (1996), there are two clear indications that patients with delusions make insufficient use of prior events/experience in this task. First, as just noted, patients with delusions changed their estimates dramatically when confronted with contradicting evidence. Moreover, while controls behaved extremely cautiously on Task 3 (which followed a task where participants were ‘led up the garden path’), deluded patients displayed a JTC bias similar to prior investigations. This finding is in agreement with the view that deluded patients weigh current information more heavily than past information, which cannot be explained by simple memory problems. While such an immediacy bias can, in our view, satisfactorily explain the present pattern of results, we would also like to propose a different account which may deserve further consideration in future investigations.

In a recent study (Moritz & Woodward, 2004), we employed a new paradigm that challenged various accounts of the beads task performance using a paradigm with pictures from the Thematic Apperception Test (TAT). Participants were asked to judge the plausibility of multiple interpretations of each picture. From a strict JTC (forward strategy) point of view, it was expected that patients with delusions would lock onto the most dominant interpretation while rejecting others. Contrary to this account, patients did not converge on one particular interpretation, but rather pursued multiple alternatives as expressed by more excellent and good ratings per trial. Patients gave higher plausibility ratings, particularly for pictures judged as poor or unlikely by controls. Healthy participants more often ruled out interpretations while patients responded more liberally. From these results we have inferred an extended version of the JTC hypothesis to account for data collected with the TAT and the probabilistic reasoning task. Deluded and non-deluded schizophrenic patients are thought to quickly accept (but not necessarily decide) among response options, whereas healthy participants are more cautious in doing so, and effectively narrow down the set of possible alternatives. In situations where only two (mutually exclusive) options are
provided such as in the probabilistic reasoning task, a liberal acceptance bias leads to an early decision in Task 3. With multiple alternatives surpassing this threshold, however, a decision is delayed and greater ambivalence is created. Put differently, we propose that a primary disturbance underlying (schizophrenic) delusions is that more explanations are entertained as plausible, whereas healthy participants are more selective and rule out certain hypothesis earlier. When absurd hypotheses are not ruled out quickly, and initially receive as much consideration as more valid hypotheses, there is an enhanced probability that under circumstances in which the subject is less corrigible, as found in deluded patients (Woodward et al., in press), and in situations where the correct interpretation is difficult to prove, the absurd hypotheses might prevail, resulting in the formation of a delusion. Initial over-interpretation (in a quantitative sense) may thus lead to delusions when further checks of a given situation favour the absurd or the improbable. Controls are more guarded against this, because very unlikely scenarios are excluded early in the problem-solving process. In addition, healthy controls are more able to revise their opinions in light of subsequent disconfirmatory evidence (Woodward et al., in press).

The tendency to over-adjust estimates in face of contradictory evidence displayed by deluded patients is in agreement with the liberal acceptance account. Competing hypotheses only appear to have been abandoned by schizophrenic patients, but are in fact still potent background alternatives which, particularly in deluded schizophrenic patients, can easily be triggered via new information. Moreover, the BADE account suggests that the potency of these competing hypotheses may not be diminished when disconfirmatory evidence is encountered. We would like to stress that the above interpretation is speculative, as the TAT and BADE tasks differ in many ways from the beads task.

For each of the three tasks, we recorded whether participants understood the task or not. The results suggest that the beads task may not be the optimal paradigm to test the jumping to conclusions construct as many participants – including healthy and psychiatric controls – had difficulty comprehending the task. Interpretation of the results is therefore limited. Patients committing clearly illogical responses (greater probability for container B in the first 10 beads of Tasks 1 and 2; decision for container B in Task 3) more often displayed a JTC style. This suggests that at least some of the differences between the groups can be explained by difficulties comprehending the task. However, when those participants who committed logical errors were dropped from analysis, the JTC style in deluded schizophrenia in Task 3 persisted. It may be instructive for future studies to directly ask participants about the motives for their decisions, and to require them to reproduce the task rationale after task completion to ensure that the basic principle was understood.

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