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Bonn 2008/48**

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December 2008

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A Fine-grained Analysis of the Jumping to Conclusions Bias in Schizophrenia: Data-Gathering, Response Confidence, and Information Integration

Andreas Glöckner* / Steffen Moritz‡

Abstract

Impaired decision behavior of schizophrenia patients has been repeatedly observed. We investigated the aspects of the jumping to conclusions bias (JTC): biases in information-gathering, information weighting and integration, and overconfidence, using the process tracing paradigm Mouselab, which allows for an in-depth exploration of various decision-making processes in a structured information environment. Although showing less focused and systematic information search, patients practically considered all pieces of information and showed no JTC in the sense of collecting less pieces of evidence. Choices of patients and controls both approximated a rational solution quite well, but patients showed more extreme and, in view of the ambiguous nature of the task, unjustified confidence. Both groups mainly used weighted additive decision strategies for information integration and only a small proportion relied on simple heuristics. Under high stress, induced by high affective valence plus time pressure, however, schizophrenia patients showed a less appropriate weighting of information and switched to equal weighting strategies. Patients that scored higher on the schizophrenia scale PANSS showed less information search and tended to rely more often on simple heuristics.

Keywords: Decision Making, Schizophrenia, Jump to conclusion, Heuristics

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Hasty decision-making is a hallmark feature of presently deluded schizophrenia patients. A look of a stranger, sounds in the telephone line and certain initials on number plates are mistaken as proof of a conspiracy or surveillance. Cognitive studies have asserted that this so-called jumping to conclusions bias (JTC) is not confined to idiosyncratic and delusions-related scenarios but extends to neutral situations (Garety, Hemsley, & Wessely, 1991; Huq, Garety, & Hemsley, 1988; Moritz & Woodward, 2005; Moritz, Woodward, & Lambert, 2007) and is also present in many non-acute patients (Moritz, Woodward, & Hausmann, 2006). A number of researchers therefore ascribe JTC a fundamental role in the pathogenesis of delusions, that is, fixed false beliefs (for reviews see Bell, Halligan, & Ellis, 2006; van der Gaag, 2006). Traditionally, JTC has been investigated with the beads or probabilistic reasoning task: The participant is consecutively presented a sequence of beads drawn either from a jar that predominantly contains beads, for example in green, or a jar that predominantly contains beads in red (Huq et al., 1988). The chain of events usually strongly favours one of the jars. Compared to both healthy and psychiatric controls, schizophrenia patients make early, premature and incautious decisions in 40-70% of the cases (i.e., they decide after only one bead has been drawn).

Our group has confirmed this bias, ruling out deficits in memory and poor motivation as confounding factors (Moritz & Woodward, 2005). Others have found that this bias is not a result of impulsivity (Dudley, John, Young, & Over, 1997). Using an experimental variant of the "Who wants to be a millionaire" quiz, patients with schizophrenia, irrespective of current delusional ideation, displayed a lowered decision-threshold, that is, they over-interpreted the available amount of evidence (Moritz et al., 2006). The precise nature of JTC is not entirely understood and under some circumstances (enhanced ambiguity and multiple response options) the bias may even be diminished or abolished (Moritz, Woodward, & Lambert, 2007). JTC can be conceptualized in different ways. It can be understood as a data-gathering bias (less information is taken into account for decision-making relative to controls) and/or overconfidence (the same amount of information is over-interpreted relative to controls) and/or suboptimal information weighting and integration (the validity of cues is not considered appropriately or heuristics are more strongly preferred relative to controls). Our group has recently investigated the second aspect, and we have repeatedly found that patients with schizophrenia are overconfident in errors (for a review see Moritz & Woodward, 2006), which so far has been mainly investigated in the context of memory tasks (independent replications by Kircher, Koch, Stottmeister, & Durst, 2007; Laws & Bhatt, 2005). We have also found that patients tend to reach more incautious decisions when asked to deduce the correct title of classical paintings (Moritz et al., submitted).

For the present study, we used a task that assesses the data-gathering, confidence, and the information integration aspect of JTC in a single paradigm. We were especially interested to investigate cue selection in patients, since a striking feature of schizophrenia is patients' reliance on unreliable sources of information (e.g., internet fora for conspiracy theories). JTC may not be a problem if it is rested on the most valid pieces of information, and indeed cognitive research has found that a subgroup of healthy participants adopt a so-called *take the best* heuristic (Bröder, 2000; Bröder & Schiffer, 2003; Gigerenzer & Goldstein, 1999; Glöckner, 2007; Rieskamp &

Hoffrage, 1999) and that the application of this heuristic in some environments leads to good decisions (Czerlinski, Gigerenzer, & Goldstein, 1999). A final aim was to investigate the impact of stress exerted by time-pressure and emotionally framed scenarios. On the basis of the available literature we expected that patients with schizophrenia (SPs) collect less (H1) and particularly less valid (H2) information, show a less systematic information search inspecting less valid information first (H3), are over-confident in their judgments (H4), and that this bias might be more pronounced under conditions of stress induced by time-pressure or affective framing of the task (H5) compared to controls (CPs). Following an exploratory account, we investigated whether there are differences in choice accuracy, whether participants particularly rely on a take the best strategy and if there is a relation between schizophrenia severity measures (i.e., PANSS) and the different aspects of JTC biases.

Methodological Preliminaries

The aforementioned hypotheses for decision-making in schizophrenia were investigated using emotional and neutral probabilistic inference tasks which have been repeatedly investigated in recent research on heuristics, that is, simple short-cut decision strategies (Bröder & Gaissmaier, 2007; Bröder & Schiffer, 2006; Gigerenzer & Goldstein, 1996; Glöckner, 2006; Newell, Weston, & Shanks, 2003).[1] We thereby used the standard process tracing paradigm of behavioral decision research: Mouselab (Payne, Bettman, & Johnson, 1988). In Mouselab, different cues (i.e., predictors) and their varying validity (i.e., predictive accuracy) are presented in a two-dimensional matrix (Figure 1). Information is (usually) hidden behind information cards and can be investigated by mouse click. Besides choices, decision times and confidence ratings, Mouselab allows recording and analyzing the amount, distribution and order of information search to infer individuals' decision strategies (for a discussion of the limitations of Mouselab, see Glöckner & Betsch, in press).

Method

Participants

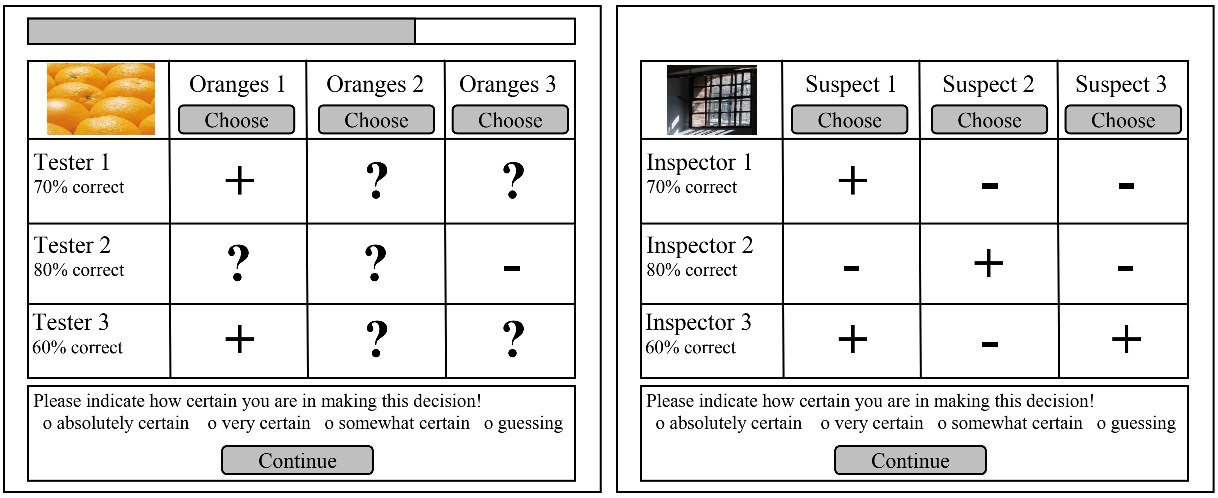
Overall, 67 participants took part in the experiment that belonged to a clinical condition of schizophrenic patients (SPs) or were control persons (CPs). The sample consisted of 37 SPs and 30 CPs. The groups were comparable in age (M_{SPs}= 31.8 vs. M_{CPs}= 32.0 years), IQ (both M=106) and duration of school education (M_{SPs}= 11.5 vs. M_{CPs}= 11.9 years). SPs were mainly male (28 male), whereas CPs were mainly female (20 female).[2]

1 In contrast to preference decisions (e.g., which car do you prefer), probabilistic inference tasks have an objectively correct solution.

2 To control for gender effects, we also ran the core analyses correcting for gender effects using gender as covariate. Although we observed some gender effects, the results concern-

Materials and Design

All participants completed a total of 108 probabilistic inference decisions between three options based on 3 cues which differed in validity (i.e., the percentage of correct predictions). The cues had a validity of .70, .80, and .60 (i.e., predictive validity of 70%, 80% and 60% accuracy). Participants were explicitly informed about the validity of the cues which was equal in all decision tasks. Half of the decisions used neutral materials (i.e., chose the better out of three brands of oranges; Figure 1, left), the other used more affective material (i.e., chose one out of three persons who more likely committed a crime; Figure 1, right) constituting the factor Affective Valence. This factor was fully crossed with the factor Presentation Format/Time Pressure. A third of the decisions were presented in the classic Mouselab with hidden information boxes and without time pressure, another third was presented in the same paradigm but with explicit time pressure induction using a time-bar (Figure 1, left). In the remaining decision tasks, information was instantly available and participants were instructed to decide as quickly as possible (Figure 1, right). Participants completed 18 decisions for the six combinations of conditions each, constituting the factor Decisions. Decision tasks were similar to the ones used in previous studies (Glöckner & Betsch, in press). Hence, we used a 2 (SPs vs. CPs) x 2 (Affective Valence) x 3 (Presentation format/Time Pressure) x 18 (Decisions) mixed model design with all factors except of the first one being manipulated within participants. Participants were assigned to one out of four balancing conditions in which order of the relevant conditions was varied (neutral vs. affective first; hidden vs. open information first).[3]



Caption. Decision screens for neutral orange decisions (left) and affective criminal case decisions (right). The left picture shows an example for a Mouselab with time-pressure condition, the right picture shows an example for open information presentation (cf. factor Presentation Format/Time Pressure).

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ing our hypotheses were similar to the results without covariate. In the following, only the simpler analyses without covariate are reported.

3 For pragmatic reasons, hidden information presentation under time pressure always followed after hidden information presentation without time pressure. Due to some error in the randomization procedure, participants were not exactly equally distributed over the counterbalancing conditions.

Procedure

Participants first completed a mouse-ability pre-test in which they opened the nine boxes of the information matrix by mouse-click as quickly as possible. This procedure was repeated five times to determine the average time for information search. Participants were introduced to the decision task using the neutral material (i.e., select the best orange based on testers). The three presentation formats of Presentation format/Time Pressure were introduced (i.e., hidden information Mouselab, hidden information Mouselab + time pressure, open information Mouselab) and participants completed a test decision for each of them. Complete instruction can be found in the appendix. Each decision trial started with the presentation of the information matrix with open or hidden information cards. In the two hidden information conditions, information cards could be opened with the mouse and remained open for the rest of the decision. Decision time was recorded from stimulus onset (open information), or from the inspection of the first information card (hidden information). In the explicit time pressure condition, only a limited time was available for information search. The time was individually determined from the average time for information search in the mouse-ability pre-test plus 2 seconds. Hence, there was just sufficient time for inspecting all information and applying a simple decision strategy. A down-counting time-bar was used to induce time pressure (see Figure 1, left). Options were selected by mouse-click. Afterwards individuals rated the confidence in their decision on the following 4-point scale: *absolutely certain* (1), *very certain* (2), *somewhat certain* (3), *guessing* (4). Finally, participants were informed that the next decision is about other oranges or other accused persons and the next trial was started by mouse-click. Decision tasks were presented using a block design of six blocks (2 Affective Valence x 3 Presentation Format/Time Pressure) with randomized order of decisions within each block. After each block a short break and a new instruction for the following block was included. Additionally, the premorbid intelligence of all participants was tested using the Multiple Choice Intelligence Task (MWT-B). Patients' symptoms were assessed using the Positive and Negative Syndrome Scale (PANSS). Neuroleptic dosage was converted in % maximal neuroleptic dosage following German prescription guidelines.

The aspects of JTC were tapped via the following variables:

A) Biased gathering of information
- Amount of inspected information.
- Validity of inspected information.
- Order of information search (information search in the first trials).

B) Overconfidence
- Mean confidence ratings.
- Number of confidence ratings "absolutely certain". Given that even the best cue had a validity of no more than 80%, any absolutely certain responses was deemed incautious.

C) Suboptimal weighting and information integration
- Percentage of normatively correct answers according to Bayes' theorem.

– Individuals' decision strategies. The percentage of participants that take into account all information and weight them by their validity (weighted additive strategy users), was compared with the proportion of participants that ignore less valid information (take the best users), and the ones that ignore cue weights (equal weight users).

Results

Reaction time in mouse handling pre-test. To analyze whether the SPs differ from CPs in their mouse-handling skills, a *t* - test was conducted using mean reaction time in the mouse pre-test as dependent variable. The test revealed a marginally significant difference, $t(61.7) = 1.70$, $p = .09$. Reaction time was higher for the SPs (M=7.1s) compared to the CPs (M=6.1s) indicating lower mouse-handling skills of the former.

Decision times. Decision times were log-transformed to base 10 before conducting the analysis to correct for deviations from normal distribution and to reduce the influence of outliers. A 2 (SPs vs. CPs) x 2 (Affective Valence) x 3 (Presentation Format/Time Pressure) x 18 (Decisions) mixed model analysis of variance (ANOVA) was computed to analyse log-transformed decision times. There was a highly significant main effect for Presentation Format/Time Pressure, F (1.4, 92.4) = 95.5, $p < .001$, $\eta^2 = .60$ (as in all following analyses Greenhouse-Geisser correction was used if the assumption of sphericity was violated). The log-mean decision times for the conditions hidden information Mouselab, hidden information Mouselab with time pressure, and open information Mouselab were 6.8s, 4.9s, and 3.6s. Thus, the time pressure manipulation worked, in that decision times decreased if a time limit was enforced in Mouselab. Note, however, that decision time in the open Mouselab paradigm was even way below the decision time in the time pressure Mouselab condition. The main effect for clinical condition and all interactions did not reach conventional significance levels (all *Fs* < 1.4). Thus, decision time did not differ between SPs and CPs. Hence, although SPs were slower in simple mouse-handling, they did not show longer decision times overall.

Information search. To analyze the hypotheses that SPs look up less information (H1) and concentrate more on less valid information (H2) than CPs, we calculated information inspection scores which indicate the percentage of opened information boxes per cue for each of the 2 (Affective Valence) x 2 (Presentation Format/Time Pressure: hidden information Mouselab with vs. without time pressure) blocks of decision tasks. A 2 (SPs vs. CPs) x 2 (Affective Valence) x 2 (Presentation format/Time Pressure: hidden information Mouselab with vs. without time pressure) x 3 (Cue) mixed model ANOVA was calculated using information inspection scores as dependent variable. There was no main effect of clinical condition, F (1, 65) = .57, $p = .45$, η^2 = .009. In the structured information environment Mouselab, SPs inspected 91% and CPs 88% of the information. Hence, there was no reduced information search of SPs and H1 was not supported by the data. There was a main effect for Cue, indicating that participants focused more on more valid cues, F (1.2, 77.9) = 23.2, $p < .001$, $\eta^2 = .26$. For cue 2 (80% validity), 97% of the information was inspected, whereas for the cues 1 (70% validity) and 3 (60% validity) only 89%

and 83% were investigated. SPs focused less strongly on this most valid cue and more on the less valid cues compared to CPs indicating a less systematic information search. The respective interaction effect, however, did not reach conventional significance levels, F (1.2, 77.9) = 1.86, p = .17, η^2 = .03. Hence, there is partial support for H2.

To analyze H3 that SPs use a less focused and more unsystematic information search, we analyzed the amount of information search that focused on the most important cue (i.e., cue 2) for the first three information acquisitions. In all three cases, CPs focused much more strongly on the most valid cue than SPs (total proportion of acquisitions on the most valid cue in 1st: 47% vs. 24%; 2nd: 65% vs. 40%; 3rd acquisition: 47% vs. 21%). All three differences were significant, as indicated by χ^2-tests (all $p < .001$). Hence, there is support for H3 that SPs show a less systematic information search in that they focus less strongly on the most important cues in the first information acquisitions.

Confidence ratings. A 2 (SPs vs. CPs) x 2 (Affective Valence) x 3 (Presentation Format/Time Pressure) x 18 (Decisions) mixed model ANOVA was computed to analyse confidence ratings. In line with H4, there was a tendency that SPs (M = 2.17) were more confident in their decisions than CPs (M = 2.40) (low scores indicate high confidence), which, however, did not reach conventional significance levels, F (1, 65) = 2.15, p = .15, η^2 = .03. There were main effects for affective valence, F (1, 65) = 8.3, p = .005, η^2 = .11 and Presentation Format/Time Pressure, F (2.0, 129.8) = 4.8, p = .01, η^2 = .07. Participants were more confident in the neutral (M = 2.22) as compared to the emotional (M = 2.34) decisions. There was, however, no interaction with the clinical condition. Participants under time pressure were less confident than in the two other conditions. It has been shown that overconfidence of SPs does not always result in a generally increased confidence level, but in more frequent extreme ratings (i.e., feelings of absolute confidence). Hence, to test H4 further, we investigated the frequency of the rating “absolutely certain”. In the probabilistic inference task used in the study, one could never be absolutely certain that a chosen outcome would be realized, because posterior probabilities were all below 1. Hence, “absolutely certain” ratings are an indicator for overconfidence. An extreme rating score (i.e., frequency of absolutely certain ratings) was analyzed using independent t - test. In line with earlier findings, we observed a significantly higher number of extreme ratings from SPs (M = 28.7) as compared to CPs (M = 9.3), t(52.2) = 2.8, p = .007, supporting the overconfidence H4. To investigate the effect further, we examined the number of extreme ratings separately for correct and wrong decisions according to Bayes’ Theorem. Interestingly, the effect was driven by more extreme ratings in the cases in which participants made correct decisions and the difference between CPs and SPs was not significant for the wrong decisions. Hence, in the structured environment Mouselab, SPs used more extreme ratings but mainly in cases in which they made normatively correct decisions. Thus, in line with the previous results, SPs seem to show more often extreme confidence ratings but often also in cases in which their decisions are normatively correct.

Quality of choices. To analyze the quality of choices we calculated the proportion of choices in line with the optimal solution according to Bayes' Theorem.[4] The resulting Bayes' Correct scores were analyzed using an independent sample *t* - test comparing SPs and CPs, which turned out to be far from significant, $t(65) = .40$, $p = .68$. In both conditions, a very high proportion of correct choices was observed. SPs showed 87% correct choices, CPs showed 88%. In a structured information environment which provided information about cue validities and allowed information search in a limited space, SPs decided with similar accuracy to CPs.

Decision strategy analysis. Individuals' decision strategies were analyzed by within-participants' comparisons of the distribution of choices using χ^2 - tests (for detailed description of the method see Glöckner & Betsch, in press).[5] The method allows to determine if individuals used a take the best heuristic (TTB, i.e., ignore less valid information and based their decision on the most important information only), an equal weight heuristic (EQW, i.e., ignore the validity of cues and chose the option which has more positive predictions), or a weighted additive strategy (WADD, i.e., choose the option with the higher weighted sum of cue values and cue validities) (Payne et al., 1988). The results indicate that there was no increased usage of TTB for SPs (Table 1).[6] In line with recent findings, SPs and CPs both mainly used a WADD strategy (cf. Bröder, 2003) that might be based on automatic processing (Glöckner & Betsch, in press). Interestingly, this is not the case for SPs which have to make (affective) criminal decisions under time pressure. We conducted a χ^2 - test of independence which compared the distribution of decisions strategies between the extreme stress conditions (i.e., criminal decisions under time pressure) and the remaining three conditions. For SPs the test turned out to be significant, $\chi^2(2, N = 137) = 18.8$, $p < .001$, whereas it was not significant for CPs, $\chi^2(2, N = 117) = 1.3$, $p = .51$. Hence, although under most conditions there is only little difference in information integration between SPs and CPs, SPs seem to weight information less appropriately (i.e., ignore cue weights) in high stress conditions in which time pressure and high affective valence coincide.

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4 The cue validities are defined as prior probabilities and, hence, under the assumption that the cues make independent predictions the Bayes' solution can be determined for instance using odd-ratios. The posterior probability for option A, *p*(A | cues, base-rate), according to Bayes' theorem can be determined by multiplying probability odds that are calculated by dividing each probability by its' complementary probability:

$$\frac{p(A|p_A, p_{C1}, p_{C2}, p_{C3})}{1-p(A|p_A, p_{C1}, p_{C2}, p_{C3})} = \frac{p_A}{1-p_A}\frac{p_{C1}}{1-p_{C1}}\frac{p_{C2}}{1-p_{C2}}\frac{p_{C3}}{1-p_{C3}}$$

with p_A as base-rate for option A (.33) and $p_{C1}, p_{C2}, and\ p_{C3}$ as a priori cue validities (.70, .80, .60). Note that the cue odds are inversed (i.e., numerator and denominator change position) if the respective cue predicts against option A. The option with the highest posterior probability should be chosen.

5 Per participant two tests χ^2 - tests were conducted which tested against the null hypotheses that individuals ignored less valid cues (i.e., used TTB) and that they did not take into account cue weights (i.e., used EQW). Only if both hypotheses could be rejected, individuals were classified as WADD users. In the case that the error rate for the classified strategy was above .50, individuals' decision strategy was not classified.

6 Because of a programming error, decision strategies could only be reliably determined for the Presentation Format/Time Pressure conditions hidden information Mouselab with time pressure and open information Mouselab.

Table 1

Clinical Condition	Decision Strategy Classification (in %)			
	TTB	EQW	WADD	not class.
	Time Pressure Mouselab Neutral (Oranges)			
SPs	.16	.16	.59	.08
CPs	.20	.20	.57	.03
	Open Mouselab Neutral (Oranges)			
SPs	.14	.00	.78	.08
CPs	.20	.13	.67	.00
	Time Pressure Mouselab Affective (Criminal Case)			
SPs	.19	.35	.38	.08
CPs	.17	.23	.57	.03
	Open Mouselab Affective (Criminal Case)			
SPs	.14	.08	.73	.05
CPs	.17	.10	.70	.03

Note. Proportion of participants using the respective decision strategy by condition. TTB (take the best) strategy indicates ignorance of less valid cues, EQW (equal weight) strategy indicates inappropriate equal weighting of cue information, WADD (weighted additive) strategy indicates an integration of cue information according to its validity. For the clinical condition, SPs stands for schizophrenia patients, CPs for controls.

Differential influence of time pressure and affective valence on SPs vs. CPs. As indicated by the previous analyses, there was a main effect of time pressure on decision time and a main effect of affective valence and time pressure on confidence. We, however, did not find significant interactions of these factors with clinical condition, indicating that there are no differential effects of stress induced by time pressure and affective valence on SPs as compared to CPs concerning decision time, confidence and information search. Nevertheless, we found a shift in decision strategies specifically for SPs under high stress induced by time pressure and affective valence. Under this condition, many SPs used EQW which means that they weighted cues less appropriately and seemed to ignore the validity of cues. Hence, H5 that biases of SPs should be more pronounced under stress was supported by the data for information integration strategies, but not for confidence and information search.

Correlations between schizophrenia measures and dependent variables. For SPs, the subscales of the PANSS (positive, negative, disorganization, delusions) were correlated with the total amount of information search, the Bayes' correct score, and the number of absolutely certain ratings (Table 2). The amount of information searches correlated significantly and negatively with PANSS positive and PANSS delusion, indicating that the amount of information search decreases with the severity of schizophrenia. We computed univariate ANOVAs to investigate the relation between strategy usage and PANSS positive scores. Specifically, we calculated contrasts comparing WADD users with users of the heuristics (TTB & EQW). There was a marginally significant difference for PANSS positive scores in the orange decisions within hidden information under time-pressure, F (1, 30) = 3.86, p = .059, η^2 = .11. The users of the simple heuristics TTB (M = 16.0, SE = 2.8) and EQW (M = 14.0, SE = 2.6) showed higher PANSS positive scores, compared to users of a WADD strategy (M = 10.4, SE = 1.4). Hence, users of the simple heuristics TTB and EQW had higher symptom scores than WADD users. Note, however, that the effect was not significant in the remaining Presentation Format/Time Pressure conditions and should be interpreted cautiously. Maximal neuroleptic dosage following German prescription guidelines (in percent) did not differ between users of different strategies and did not correlate significantly with information search, Bayes' correct scores and confidence. The average dosage was *M* = 61% (*SD* = 44%).

Table 2

Schizophrenia Measures	Info Search	Bayes' Correct	Amount Absolute Certain
PANSS positive	-.38*	.03	-.05
PANSS negative	-.27	.23	.03
PANSS desorg	-.01	-.05	-.17
PANSS delusion	-.40*	-.02	-.10

Note. Relationship between schizophrenia measures and decision parameters (amount of information search, proportion of correct choices according to Bayes' theorem, amount of absolute certain ratings for confidence).

Discussion

In the current study, we investigated different aspects of jumping to conclusions (JTC) in schizophrenia versus healthy participants: information gathering, overconfidence and information integration in probabilistic inference decisions based on information provided in an information matrix using Mouselab. We found that SPs show a less systematic information search compared to CPs. In line with the clinical observation that patients give undue weight to less relevant and sometimes random aspects, schizophrenia participants focused more strongly on less valid information and started the information search with less valid information. In a structured information environment, however, they do not inspect less pieces of information than CPs. This finding reflects recent evidence that JTC in the sense of a data-gathering bias is not found with all paradigms (Ziegler, Rief, Werner, Mehl, & Lincoln, 2008) and may under some conditions also be abolished in the beads task (Moritz, Woodward, & Lambert, 2007). We furthermore observed that SPs tend to be overconfident, in that they use the extreme and inappropriate rating "absolutely certain" more often than controls which accords to findings using memory paradigms (Moritz et al., 2006, for a review; Moritz, Woodward, Jelinek, & Klinge, 2008). SPs and CPs mainly used complex WADD strategies to make decisions (i.e., they took into account all pieces of information according to their importance / validity). Under most conditions, there was no tendency that SPs relied stronger on simple heuristics such as Take the Best (TTB) or Equal

Weighting (EQW). Only under high stress induced by affective valence and time pressure SPs relied stronger on EQW strategies which implies a less appropriate weighting of information (i.e., all pieces of information are weighted equally although they differ in validity). Interestingly, in spite of these differences concerning aspects of decision making, we did not observe an overall difference in the quality of the choices compared with the normative standard provided by Bayes' theorem between SPs and CPs. In the structured information environment Mouselab, the effects of JTC biases on decision quality seems to be low. Hence, structured information presentation in a matrix format including information on cue validities might be a promising account to enhance decision quality of SPs.

For SPs, we observed a correlation between schizophrenia measures (PANSS positive, PANSS delusion) and the amount of information search. Participants that scored higher on these measures gathered less pieces of information. Furthermore, in the neutral condition under time pressure we observed that the patients who used simple heuristics (i.e., TTB & EQW) scored higher on symptom measures. The effect was however not found in the other conditions and should hence be replicated in further studies before solid inferences can be drawn.

In sum, our results qualify findings concerning JTC biases in structured information environments. Although we found JTC biases for specific aspects of information search (i.e., less focused, less ordered), confidence ratings (i.e., more extreme ratings) and information integration (i.e., inappropriate cue weighting under stress) other aspects (i.e., amount of information search, average confidence rating, integration strategy without stress, quality of decisions) were not influenced. This more differentiated view was made possible by a paradigm tapping different aspects of JTC in a single paradigm which could stimulate further research. Cognitive treatment programs such as the Metacognitive Training for Schizophrenia patients (Moritz & Woodward, 2007; Moritz, Woodward, & Group, 2007) have began to train patients to search both for more and especially valid pieces of information and to tone down confidence in case of inconsistent evidence or ambiguity.

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Appendix: Instructions

Welcome to the experiment! In the course of this experiment, you will make a number of decisions. In different situations and on the basis of given information, you will decide which of the several types of oranges is of the best quality, and which of several suspects is the most likely to have committed a crime. Please do your utmost to reach an optimal decision. In some cases, your decision time will be limited. You should by all means adhere to this time frame. Should you have any questions, please do not hesitate to ask the experimenter.

Neutral Orange Selection Decisions

In the following, you should decide which of three types of orange is of the best quality. In order to do this, you will receive information from three people who have tested the oranges. These testers have assessed the quality of the oranges as good (+) or bad (-). [Example omitted] Testers are allowed to give several positive and negative evaluations. The testers' conclusions vary in reliability. From many years of experience, the following is known:

Tester 1: 70% of evaluations are correct (7 out of 10).

Tester 2: 80% of evaluations are correct (8 out of 10).

Tester 3: 60% of evaluations are correct (6 out of 10).

Please note that none of the testers produces completely reliable evaluations. Thus, even three positive evaluations can still mean there is an orange type of poor quality. Should you have any questions, please contact the experimenter now. If this is not the case, please click on "Continue" to start the decision phase!

Additional instruction for hidden information presentation and no time pressure

You are asked to choose the type of orange that is of the best quality. The information provided by the testers is initially hidden by question marks ("?"), but it can be revealed by using the mouse. You are under no time constraints when reaching your decision. Please try to decide as correctly as possible and in as short a space of time as possible.

Instruction after each decision

A new day at the market – new kinds of orange! Please make another decision! Please choose from three kinds of orange. Please try to decide as correctly as possible and in as short a space of time as possible.

Affective Decisions Concerning a Criminal Case

In the following, you should decide which of three suspects is most likely to have committed a crime. In order to do this, you will receive information from members of the criminal investigation department. Three chief inspectors have assessed whether a particular suspect is guilty (+) or not guilty (-). [Example omitted] Chief inspectors are allowed to consider several suspects guilty or not guilty. The inspectors' conclusions vary in reliability. From many years of experience, the following is known:

Inspector 1: 70% of evaluations are correct (7 out of 10).

Inspector 2: 80% of evaluations are correct (8 out of 10).

Inspector 3: 60% of evaluations are correct (6 out of 10).

Please note that none of the inspectors produces completely reliable evaluations. Thus, even three positive evaluations can still mean there is a suspect who is not guilty. Should you have any questions, please contact the experimenter now. If this is not the case, please click on "Continue" to start the decision phase!

Additional instruction for open information presentation

You should now decide which of the suspects is most likely to have committed a crime. The inspectors' information is unconcealed. You are not under time constraints when reaching your decision. Please try to decide as correctly as possible and in as short a space of time as possible.

Instruction after each decision

A new criminal case – new suspects! Please make another decision! Please choose between three suspects. Please try to decide as correctly as possible and in as short a space of time as possible.

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