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Articles

Investigating the Specificity of Dual-Processing Deficits to Delusions

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Abstract

Objective: Delusions, a defining characteristic of schizophrenia, are considered a consequence of aberrant reasoning. However, it is unclear whether aberrant reasoning reflects a more general deficit in schizophrenia. This study aimed to investigate differences in intuitive reasoning (System 1) and analytical reasoning (System 2) between individuals with schizophrenia, with and without delusions, and controls. We hypothesized that individuals with schizophrenia would exhibit impaired performance on System 2 tasks compared with controls, deluded patients would show greater impairments on System 1 tasks, and deluded patients would differ from non-deluded patients and controls in response modifications across task trials.

Method: Participants included 14 patients with schizophrenia with delusions, 12 patients without delusions, and 22 controls. Cognitive reasoning was assessed using the verbal Odd One Out subtest, a Kahneman Reasoning Test designed to evaluate heuristic-based reasoning, and a non-Kahneman Reasoning Test. The study also examined participants' abilities to modify responses across trials following feedback.

Results: Findings supported only the first hypothesis (Odd One Out Test, p = .006; non-Kahneman Reasoning Test, p = .03), confirming a deficit in analytical reasoning. However, performance on the Kahneman Reasoning Test was comparable across groups, with no detectable group differences in heuristic reasoning. Deluded patients did not differ from non-deluded patients or controls in heuristic or analytical reasoning.

Conclusions: Findings suggest that schizophrenia is associated with selective deficits in analytical reasoning while no impairment in heuristic reasoning was detected. These findings challenge prior assumptions about delusion-related cognitive dysfunction and highlight the need for future research to explore the mechanisms underlying apparently preserved heuristic reasoning in schizophrenia.

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1. Introduction

Alongside hallucinations, delusions are considered a defining feature of schizophrenia (American Psychiatric Association, 2022). There are various types of delusions (e.g., persecutory, grandiose, referential, etc.), though they can all be defined as "fixed beliefs that are not amenable to change in light of conflicting evidence" (American Psychiatric Association, 2022). Fifty-three theoretical models of delusions have been proposed (for a review see Denecke et al., 2024). Amongst them, cognitive models of delusions have attempted to explain the formation and maintenance of such beliefs as a consequence of aberrant reasoning (Ward & Garety, 2019). However, given that people with schizophrenia tend to perform worse than individuals without schizophrenia across a range of cognitive tasks (Gebreegziabhere et al., 2022; McCutcheon et al., 2023), it is possible that differences in aberrant reasoning reflect a more general deficit in schizophrenia. At the same time, any model of delusion formation and maintenance must show specificity to delusions. Thus, comparisons of deluded and non-deluded people with schizophrenia are required to exclude the possibility that the latter also show the same pattern of dysfunctional reasoning.

Perhaps the most extensively researched reasoning bias in the context of delusions in schizophrenia is the 'jumping to conclusions' (JTC) bias. Essentially, evidence indicates that individuals with schizophrenia use fewer data to reach a decision, a finding often explored using variants of the well-known beads task (Dudley et al., 2016; Garety & Freeman, 2013; So et al., 2016). The suggestion is that ambiguous information leads to a delusional conclusion when an individual rapidly appraises the limited evidence, without thoroughly considering possible alternatives. A greater probability of delusions has been observed in those showing the JTC bias when splitting samples into individuals with and without delusions (Dudley et al., 2016). Moreover, a greater tendency to JTC has been shown in people who have schizophrenia with current delusions than in those without (McLean et al., 2017), while recovery from delusions has been associated with an attenuated JTC bias (Peters et al., 2008). However, the literature is limited by the fact that most studies have not been sufficiently powered to compare groups with and without delusions (Fine et al., 2007; Garety & Freeman, 2013; So et al., 2016) and the most recent evidence is mixed: a large meta-analysis across the psychosis continuum reported no reliable association between JTC and delusional ideation once the full range of studies was considered, although patients with active delusions still showed greater JTC than the general population (Doherty et al., 2025). It therefore remains uncertain whether the JTC response pattern is specific to delusions or is a more general feature of schizophrenia.

If JTC represents a bias in data gathering that may influence the formation of delusions, other cognitive models have explored the ability to alter beliefs once formed, i.e., belief flexibility.

This is the process by which a person acknowledges they may be mistaken, reviews their beliefs in light of new evidence, and generates and considers alternatives in order to change their mind (Ward & Garety, 2019). One method of exploring belief flexibility has been to measure the bias against disconfirmatory evidence (BADE; McLean et al., 2017; So et al., 2016; Ward & Garety, 2019). Heterogeneous methods have been used to assess BADE, often involving sequential disambiguation of an initially ambiguous scenario, with participants rating plausibility of interpretations along the way (Ward & Garety, 2019). An association between BADE and schizophrenia has been reported that suggests people with delusions may struggle to integrate new evidence into their reasoning (McLean et al., 2017; So et al., 2016; Ward & Garety, 2019). However, despite a small but specific effect on delusions, there remain methodological weaknesses in many studies investigating BADE and a lack of standardized measurement (Ward & Garety, 2019).

Both JTC and BADE arise from difficulties in recognizing and resolving cognitive conflict due to inconsistent information (Bronstein et al., 2019; Speechley & Ngan, 2008). These difficulties prevent the engagement of analytical reasoning, leading to a preference for fast, error-prone thinking instead of slow, deliberate reasoning (Speechley & Ngan, 2008; Ward & Garety, 2019). Subsequently, a framework using the theory of dual processing was proposed to integrate existing evidence of an association between delusions and such reasoning biases (Ward & Garety, 2019). The theory of dual processing, in which two parallel systems aid normal decision making, was popularized by the work of Kahneman (2011). It suggests that System 1 undertakes fast, automatic and intuitive decision making, while System 2 is a slower, more effortful and analytical process, relying on working memory and general cognitive capacity (Bellini-Leite, 2022; Ward & Garety, 2019; Zander-Schellenberg et al., 2021).

The intuitive operations of System 1 generate impressions of perception and thought, which are involuntary and can lead to heuristic biases (Bellini-Leite, 2022; Evans, 2003; Ward & Garety, 2019). These biases, of which availability, representativeness, and framing effects are common examples, reduce complex tasks to simpler judgmental operations and can be identified by the characteristic errors they tend to cause (Berthet & de Gardelle, 2023). For example, the availability heuristic is a mental shortcut by which people make judgements based on examples that come to mind more readily, or that can be more readily evaluated, than the actual situation (Berthet & de Gardelle, 2023). Meanwhile, the representativeness heuristic is demonstrated when people are asked to judge the probability that an object or event (A) belongs to class or process (B), but they instead judge the degree to which A *resembles* B (Berthet & de Gardelle, 2023). Such an approach fails to account for several factors that affect probability judgements, including prior probability. Finally, the framing effect is when a decision is influenced by the presentation of information, rather than the information itself (Berthet & de Gardelle, 2023). Indeed, Tversky and Kahneman (1989) claimed that variations in the framing of options (e.g., in terms of gains or losses) yield systematically different preferences.

In contrast to these intuitive judgements, the operations of System 2 are intentional and involved in all judgements, whether they originate in impressions or in deliberate reasoning (Bellini-Leite, 2022; Evans, 2003; Ward & Garety, 2019). It can be used to override or correct biased judgements made by System 1. Tasks that require deductive reasoning can be used to assess System 2. For example, syllogistic tasks require deductive reasoning to reach a valid conclusion. They often require individuals to answer whether the outcome of two premises is true or false. Correct answers do not require knowledge about the premises, but can be deduced from the syntactic structure of the sentence (i.e.*, No A are B. All C are A. Therefore: No C are B*). Similarly, conditionals posed as *'if-then'* statements can interrogate more deliberate reasoning. While people habitually make systematic errors in certain contexts, these can be suppressed (Evans, 2003; Gronchi et al., 2024).

Usually, System 1 and System 2 processes act together (potentially serially or in parallel) for flexible, adaptive decision making (Gronchi et al., 2024). However, in the context of delusions, it has been proposed that there is a dysfunction in the normal interactions between these two systems (Ward & Garety, 2019; Zander-Schellenberg et al., 2021). For example, delusions may suggest over-reliance on intuitive System 1 processing and an inability of System 2 to override or intervene when needed. In this way, the JTC bias could be one example of an overactive System 1, which is not effectively modulated by System 2 (Ward & Garety, 2019; Zander-Schellenberg et al., 2021). Similarly, BADE could be explained by a dysfunctional System 2 that fails to incorporate new information and evidence, leading to more heuristic judgements of plausibility (Ward & Garety, 2019; Zander-Schellenberg et al., 2021). Consistent with this framework, recent work indicates that individuals prone to delusions may recruit analytical resources to acquiesce to, rather than override, an intuitive response, implicating alterations in both dual-process dynamics and cognitive control (Liew et al., 2024).

This is an appealing formulation, but few studies have investigated whether aberrant patterns of System 1 and 2 processing are specifically associated with the formation and maintenance of delusions. Several non-clinical studies have explored associations between System 1 processing and paranormal or superstitious beliefs, conspiracy theories, and fake news (Aarnio & Lindeman, 2005; Barron et al., 2018; Bronstein et al., 2019; French et al., 2025; Gagliardi, 2025; Genovese, 2005; Georgiou et al., 2019; Mækelæ et al., 2018; Marks et al., 2008). In clinical populations Hooker et al. (2000) used items requiring counterfactual thinking to demonstrate that patients with schizophrenia made fewer contextually biased responses (Kahneman bias).

Another cross-sectional study used self-report assessment to explore reasoning styles and reported that lower levels of both experiential and analytic reasoning were reported by those with delusions compared with non-clinical participants (Freeman et al., 2014). The authors suggested this might relate to reduced confidence or awareness in relation to reasoning among those with delusions. Speechley et al. (2008) proposed a Dual-Stream Modulation Failure model, and Speechley et al. (2010) reported evidence that people with delusions fail to use conflict to prompt intervention by System 2 and engage in analytic reasoning. More broadly, dual-process and reasoning constructs are increasingly examined across clinical psychology, where cognitive appraisal, salience, and interpersonal factors shape how ambiguous information is processed in psychotic-spectrum conditions (Myles, 2024; Pennisi, 2019; Stang et al., 2024). Situating delusion-related reasoning within this wider literature underscores that biased reasoning is neither unique to, nor uniform across, clinical presentations, reinforcing the need to test its specificity to delusions directly.

The literature therefore provides preliminary evidence for the relevance of dual-process models to delusion formation and maintenance, but the precise patterns of System 1 and System 2 dysfunction, and whether they are specific to delusions rather than a more general feature of schizophrenia, remain unresolved. To this end, the current study investigated how the intuitive judgement of System 1 and the monitoring of System 2 differs between individuals with schizophrenia, and particularly between those with delusions and those without, and controls. Thus, the intuitive operations of System 1 were tested by administering a series of problems shown on cards. Each problem comprised a naturalistic scenario that did not have an objectively right or wrong response, allowing heuristic principles to mediate. To see whether individuals were able to overcome their biases and intervene in their judgement (i.e., System 2 processing), items with incorrect answers showing heuristic bias were re-administered with feedback.

This approach was used to investigate the following hypotheses:

1. Individuals with schizophrenia will show impaired performance compared with controls on tasks requiring the involvement of System 2 (analytical reasoning).
2. Patients with delusions will show greater impairments than (i) those without delusions and (ii) controls on a task requiring System 1 (intuitive reasoning).
3. Patients with delusions will differ from both control and non-deluded individuals in terms of the number of changed responses.

2. Materials and Methods

2.1 Participants

This study included 22 individuals (4 females) without a history of psychiatric illness, serving as a control group. Control participants were recruited from staff at a psychiatric day care centre, non-academic staff at University of Cambridge, and through advertisements posted on central notice boards. In addition, 26 patients diagnosed with schizophrenia (3 females) were included as a patient group. They were prospectively recruited from a population of individuals with stable chronic illness. The patient group was further divided into two subgroups: 14 deluded patients (2 females) and 12 non-deluded patients (1 female). The sample size was dictated by pragmatic reasons (access to individuals diagnosed with schizophrenia).

Classification of patients as deluded or non-deluded was determined through a structured psychiatric interview based on the Present State Examination (PSE), 9th Edition (Wing et al., 1974). The PSE is a widely used structured psychiatric interview with well-documented reliability that formed the basis of the WHO CATEGO classification system (Wing et al., 1994). Exclusion criteria included moderate to severe formal thought disorder and any neurological disease or history of drug or alcohol abuse that warranted clinical attention. Patients were selected based on a criterion of relative intellectual intactness, defined as a current Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) score of 80 or greater. The WAIS-R is among the most extensively validated measures of adult cognitive ability, with high reliability (Full Scale IQ reliability of approximately .97 in the standardization sample) that has been shown to remain comparable in psychiatric populations (Boone, 1992; Ryan et al., 1982; Wechsler, 1981). Detailed demographic data are presented in Table 1.

Controls and patients with schizophrenia were matched for age, U = 374.00, p = .07. No significant age difference was found between the deluded and non-deluded groups, U = 99.00, p = .46. Additionally, participants were matched for estimated IQ, U = 213.50, p = .13, using the National Adult Reading Test (NART; Nelson & Willison, 1991). The NART is an estimate of premorbid intelligence, which evaluates individuals' ability to pronounce irregularly spelled words, such as "ache" and "thyme." The NART has high internal consistency, test–retest, and inter-rater reliability, and shows strong construct validity as a measure of premorbid ability, with reported correlations of approximately .70–.80 with Wechsler verbal IQ (Crawford et al., 1989a, 1989b; O'Carroll, 1987). There was no significant difference in NART-estimated IQ between the deluded and non-deluded patients, U = 82.50, p = .94. Furthermore, the deluded and non-deluded patients did not differ in current IQ, as measured by the WAIS-R (Wechsler, 1981), U = 85.50, p = .42.

Table 1

Demographic Characteristics

	Age (years)	*NART IQ*	*WAIS-R IQ*
Controls (*n* = 22)	39.73 (13.22)	110.64 (10.96)	-
Patients	45.69 (8.27)	106.00 (11.42)	94.38 (11.78)[a]
***Deluded* (*n* = 14)**	44.50 (8.48)	106.29 (12.16)	92.00 (9.63)
***Non-deluded* (*n* = 12)**	47.08 (8.16)	105.67 (11.01)	97.18 (13.85)

Note. Standard deviations in parentheses.

[a] WAIS-R scores were not available for two patients. They both had high NART-estimated IQs (120).

2.2 Materials

Reasoning test. The primary measure of System 1 (intuition) and System 2 (reasoning) was a Reasoning Test specifically designed for this study. It was partly based on previous work on intuitive thinking, demonstrating how heuristics influence reasoning (Kahneman & Tversky, 1982), with additional items used to examine general reasoning (e.g., Kemp et al., 1997), particularly Kahneman's System 2 reasoning skills. Therefore, the Reasoning Test is an adaptation of past research, simplified into forced-choice answers.

A total of 16 items were classified into five categories. Three categories comprised "Kahneman" items to test System 1 (intuition): availability (4 items), representativeness (4 items), and framing effect (1 item). Two categories comprised "non-Kahneman" examples to test System 2 (reasoning): conditionals (3 items) and syllogisms (4 items). All items included a cue to be provided when an incorrect answer showing heuristic bias was given. The objective of the cue was to increase the contribution of System 2 reasoning and thereby enhance the likelihood of detecting and correcting intuitive errors.

Availability. This category related to situations in which people assess the frequency of a class or the probability of an event based on the ease with which instances or occurrences come to mind. For example:

Mr. Crane and Mr. Tees were scheduled to leave the airport on different flights at the same time. They travelled from town in the same limousine, were caught in a traffic jam, and arrived at the airport 30 minutes after the scheduled departure time of their flights. Mr. Crane was told that his flight left on time, while Mr. Tees was informed that his flight was delayed and had just left five minutes ago. Who is more upset?

a) Mr. Crane

b) Mr. Tees

c) They are equally upset

Representativeness. This category comprised questions regarding the probability that object A belongs to class B (three of the items are modified from Kemp *et al.* (1997)). For example:

Linda is 31 years old, single, outspoken, and very bright. She has a degree in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuclear demonstrations. Which of the following statements is most likely to be true?

a) She is a teacher and is active in the feminist movement

b) She is a plumber

c) She is a teacher

A biased response here would misjudge probability based on how similar Linda is to the stereotype of a teacher or feminist. In doing so, it fails to take into account prior probability of outcomes, in which the possibility of somebody having two characteristics is less than having a single one.

Framing effect. Questions in this category used variations in framing to investigate people's judgements of equivalent probabilities. For example:

Imagine that you are diagnosed with a rare form of cancer and you have to choose between the following options. Which one would you choose?

a) Surgery with 90% chance of survival and painful radiation therapy

b) Surgery with 10% risk of death and painful radiation therapy

c) Can't decide

Biased responses would contradict the rational theory of choice, which assumes that equivalent formulations of a choice problem should give rise to the same preference order (Arrow, 1982). As such, while a and b are equivalent, people may base their answer in terms of suppositional gains (i.e. option a).

Conditionals. *Conditional* items required reasoned inferences based on a given *"If-then"* statement. They required people to suppress habitual errors in order to make valid inferences. For example:

If she meets her friend then she will go to the play.

She meets her friend.

What follows?

a) She will go to the play

b) She will not go to the play

c) Can't say

Syllogisms. This category presented two premises and required participants to make a true or false judgement about an outcome. For example:

No musicians are Italians.

All barbers are musicians.

Therefore:

No barbers are Italians

Yes No

Items were presented to participants on a card one at a time in a fixed order. As the above examples show, they consisted of a small scenario at the top and multiple-choice answers at the bottom of the card. After presentation of all cards, the researcher presented again any items that had elicited a Kahneman bias or a distractor response (in the Kahneman items) or had been incorrectly answered in the conditional and syllogistic items, without disclosing this information to the participant. The participant read the scenario again, was informed of the answer given previously, and was also provided with a cue.

Cues consisted of sentences providing an argument countering the Kahneman bias. For example, in the availability case given above, if participants generated the heuristically biased response (Mr. Tees) they were questioned during the cue phase of the experiment with the following prompt: *"Actually, both travellers were expecting to have lost their flight before they reached the airport anyway. Would this make you change your answer?"* Another example of a cue, this time from the representativeness case given above, is: *"Linda cannot be more likely to be a teacher and a feminist than to be a teacher. It is not mathematically possible – there will always be more people who are teachers than teachers who are feminists as well. Would this make you change your answer?"* After being provided with the cue, the participants were asked whether they wanted to change their answer or preferred to stick to the one they gave initially. All items in the Reasoning Test were expressed in everyday language and were based on easily understood naturalistic scenarios. All items were also reviewed for comprehensibility by a clinical population. Scores represent the number of correct answers. Consistent with their distinct theoretical bases, the Kahneman (System 1) and non-Kahneman (System 2) item sets were scored and treated as two separate scales throughout, rather than combined into a single composite score.

General reasoning ability. The Verbal and Spatial Reasoning Test, VESPAR (Langdon & Warrington, 1995) provides a measure of general reasoning ability and consequently, a measure of the efficacy of Kahneman's System 2 type of reasoning. VESPAR is a standardized measure of fluid (inductive) reasoning developed and normed on a healthy standardization sample and validated in neurological patients; it was specifically designed to reduce the influence of working memory and output demands by using untimed administration, high-frequency stimulus words, and a multiple-choice response format (Langdon & Warrington, 1995, 2000). The entire VESPAR test battery consists of matched sets of classification, analogy, and series problems presented in both verbal and spatial stimulus formats. For the present study, the Verbal Odd One Out subtest was chosen for administration.

The Verbal Odd One Out subtest comprised a short practice session of five examples, followed by 25 test items, with all stimulus words being of high frequency. The test was paper based, with participants looking at a set of four words and asked to cross out the odd one (e.g., bright, shadow, darkness, opinion). The answer is based on the meaning of the words, not how they are spelt or what type of word they are. It gradually becomes harder to identify which of the four words is the odd one out, as the relationship amongst the words seems closer.

Individuals complete the test in their own time. The problem and response alternatives are continuously available for the individual's inspection to reduce working memory load. This test is intended to measure participants' inductive reasoning, which is more similar to everyday reasoning problems because there are usually a number of possible solutions.

2.3 Procedure

Data collection for the control individuals took place at the Department of Experimental Psychology, University of Cambridge, while data collection for the patients with schizophrenia occurred at the Mitchell Day Centre, Fulbourn Hospital, and Addenbrooke's Hospital. The study was conducted in compliance with the requirements Internal Review Board. Participants gave written informed consent and were tested one at a time. The experimenter informed participants about the nature of the study and then testing began.

Initially, participants performed the NART, then they completed the Verbal Odd One Out subtest, and finally, they were given the Reasoning Test. All participants undertook the experimental conditions following the same procedure each time. All three tests were free of any time limit, and individuals completed each of them as soon as they had received the appropriate instructions. At the end, any questions regarding the study were answered, and participants were debriefed. The experimenter was blind to the patients' diagnoses as deluded or non-deluded until the analysis of the data began.

2.4 Data analysis

All statistical analyses were conducted using IBM SPSS Statistics v.29.0.2.0 (20) for MacOS (IBM Corp., 2023). Descriptive statistics were computed for the variables of interest to summarize the data distribution, and violin plots were used for their visualization. Spearman's rank-order correlation was used to assess relationships between the key variables. To assess group differences, a series of nonparametric tests were performed due to potential violations of normality assumptions because of the size of the sample. Specifically, the Mann–Whitney *U* test for independent samples was used to compare the scores of individuals with schizophrenia with the scores of controls and the Kruskal–Wallis *H* test was used to compare between three groups (individuals with schizophrenia with and without delusions, controls). Post-hoc comparisons used the Bonferroni correction for multiple tests. The level of significance for all tests was set at an alpha value of .05. To aid interpretation given the modest sample, effect sizes and 95% confidence intervals (CIs) are reported for all primary analyses alongside exact p-values. For Mann–Whitney tests, the rank-biserial correlation (r) is reported, with CIs obtained from 5,000 bootstrap resamples; for Kruskal–Wallis tests, epsilon-squared (ε^2) is reported with bootstrap CIs. Missing data were handled by pairwise (available-case) deletion: each analysis used all participants with complete data for the variables involved, so the denominator varies slightly across tests (one patient did not complete the non-Kahneman items and one patient did not complete the second trial of the Reasoning Test; WAIS-R scores were unavailable for two patients). No data were imputed.

3. Results

3.1 Descriptives

Table 2 and Figure 1 present scores of the different groups for the Verbal Odd One Out subtest and the Reasoning Test. Spearman's correlations were conducted for the tasks that require the involvement of System 2 (i.e., the Verbal Odd One Out subtest and the non-Kahneman items of the Reasoning Test, as well as the number of answers changed in the Reasoning Test). Scores for the Verbal Odd One Out were not correlated with either the score for the non-Kahneman items from the Reasoning Test, rho (47) = .25, 95% CI [-.08, .55], p = .096 for trial 1; rho (46) = .28, 95% CI [-.04, .59], p = .064, for trial 2, or the number of answers changed in the Kahneman items from the Reasoning Test, rho (47) = -.28, 95% CI [-.53, -.01], p = .06 and the non-Kahneman items, rho (46) = -.18, 95% CI [-.43, .10], p = .24.

Table 2

Test scores

	Verbal Odd One Out	***Reasoning Test, Kahneman items***			***Reasoning Test, non-Kahneman items***[a]		
		Trial 1	Trial 2	Number of changed answers	Trial 1	Trial 2	Number of changed answers
Controls	18.18 (2.99)	3.45 (1.62)	5.64 (2.54)	2.23 (1.88)	5.05 (1.33)	6.00 (1.20)	1.00 (1.11)
Patients	15.06 (4.28)	3.50 (1.61)	6.24 (1.54)	3.12 (2.01)	4.40 (.77)	5.25 (1.11)	1.16 (1.09)
Deluded	14.46 (3.96)	3.71 (1.73)	6.69 (1.70)	3.31 (2.02)	4.36 (.75)	5.31 (.95)	1.23 (1.09)
Non-deluded	15.75 (4.70)	3.25 (1.49)	5.75 (1.22)	2.80 (2.07)	4.45 (.82)	5.18 (1.33)	1.09 (1.14)

Note. Standard deviations in parentheses.

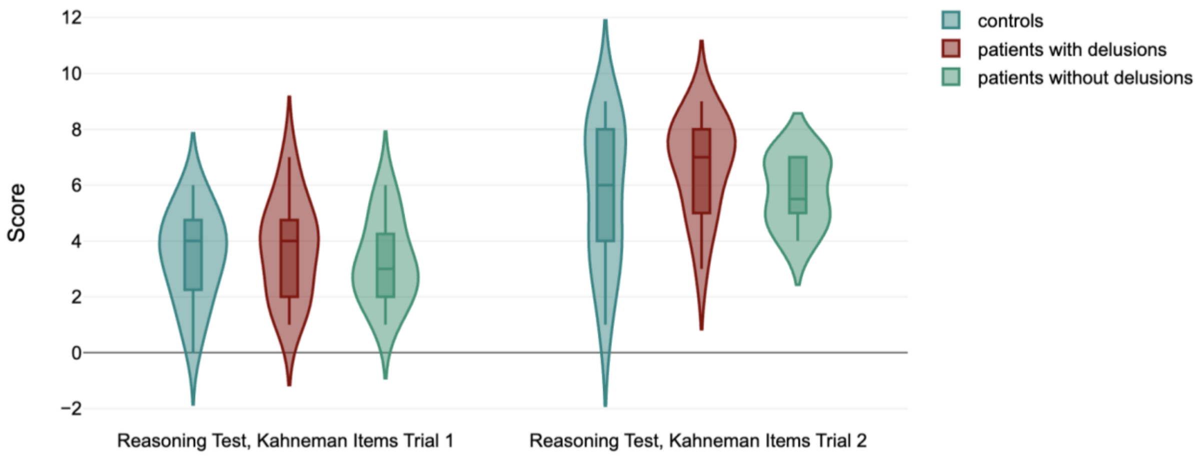
[a] One patient did not complete the non-Kahneman items (but completed both trials for the Kahneman items) and one patient did not complete trial 2 of the Reasoning Test.

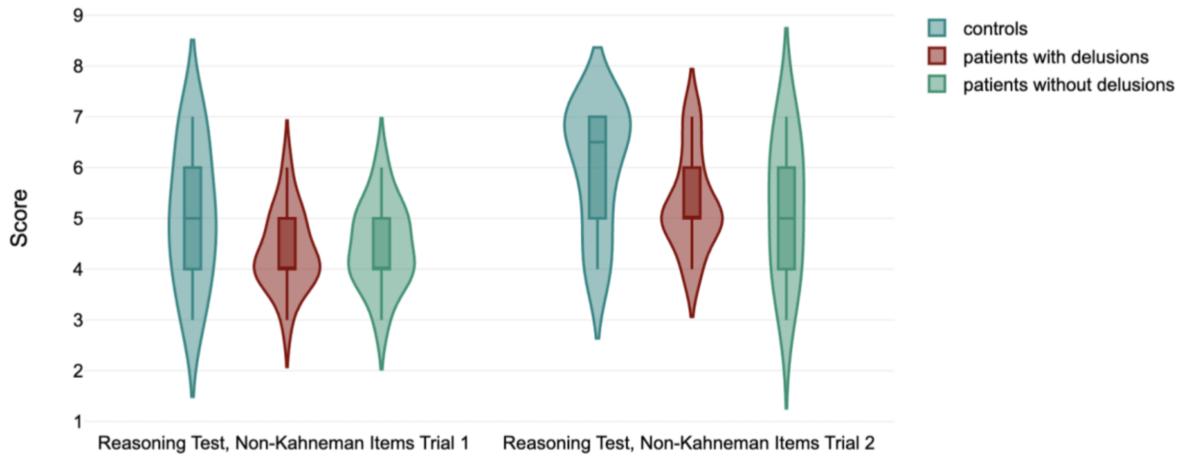
Figure 1

Violin plots show the distribution of the number of correct responses on the 25-item Verbal Odd One Out subtest for controls (n = 22), patients with schizophrenia with delusions (deluded; n = 14), and patients with schizophrenia without delusions (non-deluded; n = 12); higher scores indicate better inductive reasoning (maximum = 25). Within each violin, the central marker denotes the median and the box the interquartile range, while the width of the violin reflects the relative density of scores at each value. Patients with schizophrenia scored significantly lower than controls (Mann–Whitney U = 154.50, p = .006); the deluded and non-deluded groups did not differ (U = 103.00, p = .34)

Figure 2

Distribution of Reasoning Test scores across the three participant groups. Violin plots show the distribution of the number of correct responses on the purpose-built Reasoning Test for controls (n = 22), deluded patients (n = 14), and non-deluded patients (n = 12). Panels distinguish the Kahneman items, indexing System 1 / intuitive reasoning (9 items), from the non-Kahneman items, indexing System 2 / analytical reasoning (7 items); scores are shown for Trial 1 (initial response) and Trial 2 (after the corrective cue). Within each violin, the central marker denotes the median and the box the interquartile range; violin width reflects the relative density of scores. Higher scores indicate more correct responses. Groups did not differ on the Kahneman items at Trial 1 (H(2) = .52, p = .77), whereas patients scored lower than controls on the non-Kahneman items at Trial 2 (U = 170.50, p = .03)





3.2 Hypothesis-driven analysis

Hypothesis 1: Individuals with schizophrenia will show impaired performance compared with controls on tasks requiring the involvement of System 2 (analytical reasoning). Mann–Whitney U tests between controls and individuals with schizophrenia showed a difference in terms of the Verbal Odd One Out scores, $U = 154.50$, $p = .006$, $r = .46$, 95% CI [.16, .74] and a difference in non-Kahneman items trial 2 scores, $U = 170.50$, $p = .03$, $r = .35$, 95% CI [.03, .65]. These effects were in the medium-to-large range. No difference was found for the number of answers changed in the Reasoning Test (after feedback) for either the Kahneman items, $U = 340.00$, $p = .16$, $r = .24$, 95% CI [-.09, .54] or the non-Kahneman items, $U = 291.00$, $p = .53$, $r = .10$, 95% CI [-.23, .41].

Hypothesis 2: Patients with delusions will show greater impairments than (i) those without delusions and (ii) controls on a task requiring System 1 (intuitive reasoning). Processing by System 1 was tested with the Kahneman items of the Reasoning Test (trial 1). There were no differences amongst the three groups, $H(2) = .52$, $p = .77$, $\varepsilon^2 < .01$, 95% CI [.00, .15]. Post-hoc comparisons showed no differences between the possible pairs (Control–Deluded $p = .77$; Control–Non-del $p = .62$; Deluded–Non-del $p = .48$).

Hypothesis 3: Patients with delusions will differ from both control and non-deluded groups in terms of the number of changed responses. To test this hypothesis, we initially ran a Kruskal–Wallis test for three groups, finding no differences in number of changed items for Kahneman items, $H(2) = 2.30$, $p = .32$, $\varepsilon^2 = .01$, 95% CI [.00, .23], and for non-Kahneman items, $H(2) = .51$, $p = .78$, $\varepsilon^2 < .01$, 95% CI [.00, .17]. No differences were found when comparing the three groups in pairs post-hoc (Control–Deluded $p = .14$; Control–Non-del $p = .75$; Deluded–Non-del $p = .75$).

3.3 Exploratory analysis

As part of an exploratory, non-hypothesis driven analysis, we further tested whether delusional and non-deluded individuals with schizophrenia differed on System 2 performance. The two groups did not differ in terms of the Verbal Odd One Out subtest, $U = 103.00$, $p = .34$, $r = .23$, 95% CI [−.23, .67], and the scores for non-Kahneman items trial 2, $U = 68.00$, $p = .87$, $r = .05$, 95% CI [−.52, .43]. When looking at the number of answers changed in the Reasoning Test (after feedback) no difference was found for the Kahneman items, $U = 66.50$, $p = .54$, $r = .15$, 95% CI [−.59, .33], or the non-Kahneman items, $U = 67.50$, $p = .82$, $r = .06$, 95% CI [−.52, .42].

Furthermore, we explored differences in Kahneman items of the Reasoning Test between individuals with schizophrenia and controls, an analysis that was not required by our hypotheses. We did not find any differences for trial 1, $U = 281.50$, $p = .93$, $r = .02$, 95% CI [−.34, .30], or trial 2, $U = 301.00$, $p = .57$, $r = .09$, 95% CI [−.27, .44].

4. Discussion

The present study investigated possible differences in the intuitive judgement of System 1 and the monitoring of System 2 between individuals with schizophrenia, with and without delusions, and controls. To this end, we hypothesized that: (1) individuals with schizophrenia would show impaired performance compared with controls on System 2 tasks; (2) patients with delusions would demonstrate greater impairments than non-deluded patients and controls, on a task requiring System 1 involvement; and (3) patients with delusions would differ from both control and non-deluded patients in terms of the number of changed responses between the two trials of the tasks. Our results provided support only for the first hypothesis.

4.1 Hypothesis testing and result interpretation

Patients with schizophrenia exhibited poorer performance than controls on both a general reasoning task (the Odd One Out subtest) and on the non-Kahneman items of the Reasoning Test specially developed for this study (Hypothesis 1), with medium-to-large effect sizes (r = .46 and r = .35, respectively). This aligns with the widely accepted view that schizophrenia is associated with general cognitive impairments (for an umbrella review see Gebreegziabhere et al., 2022). Moreover, our findings are consistent with Kemp et al. (1997), who reported that patients with schizophrenia tend to make fewer conjunction fallacy decisions than controls on representativeness items. They are also consistent with Hooker et al. (2000), who observed that patients with schizophrenia made fewer contextually biased responses on items corresponding to the availability items used in the present study.

There was no support for the hypothesis that deluded patients would be more impaired than non-deluded patients and controls on tasks involving System 1 reasoning (Hypothesis 2) or System 2 reasoning (exploratory analysis). The corresponding effect sizes were negligible and their confidence intervals were wide (e.g., for the three-group comparison of Kahneman items, $\varepsilon^2 < .01$, 95% CI [.00, .15]). This suggests that patients with schizophrenia, regardless of delusional status, and controls are equally susceptible to heuristic influences in this sample. Our null findings for delusional status converge with the most recent meta-analytic evidence that the association between reasoning biases and delusional ideation is weaker and less consistent than earlier models assumed (Doherty et al., 2025). Our findings contrast with those of Freeman et al. (2014) and Speechley et al. (2010), both of which reported reasoning differences between patients with delusions and non-clinical groups. Additionally, Hypothesis 3 was not supported, as deluded patients were not more resistant to changing their responses. Instead, schizophrenia patients as a group demonstrated similar improvements to controls upon receiving feedback, indicating that delusions do not necessarily impede cognitive flexibility.

Our expectations were thus challenged in that there was no evidence for any difference between deluded and non-deluded patients on any of the measures used. Notably, while patients with schizophrenia showed deficits in conventional tests of logical reasoning (Odd One Out and non-Kahneman Reasoning Test items), they performed comparably to controls on tasks requiring them to ignore contextual biases in reasoning (Kahneman Reasoning Test items). This finding was unexpected, as it may suggest that the capacity for intuitive reasoning is relatively spared in patients with schizophrenia despite impairments in other cognitive domains, although the absence of a group difference here cannot by itself establish that this ability is preserved. Our study extends previous research by suggesting that preserved heuristic reasoning might be unrelated to the presence of delusions. Additionally, we demonstrated that schizophrenia patients are as capable as controls of modifying their responses in response to feedback.

Overall, our findings indicate that patients with schizophrenia show a deficit in conventional logical reasoning, but that we found no evidence of impaired performance on tasks involving "heuristics". The former would be expected in a disorder, such as schizophrenia, where poor performance on virtually all cognitive tasks is found, which affects most if not all domains of neuropsychological function (Gebreegziabhere et al., 2022), and where some degree of IQ decline is common (Ohi et al., 2019). The interpretation of the typical performance on reasoning tasks involving heuristics is more challenging.

One interpretation is that Kahneman's System 1 remains intact in schizophrenia, i.e., that it is an area of relative or completely preserved function. Indeed, previous individual studies have indicated sparing of some areas of cognitive function in the disorder. For example, patients with schizophrenia have been found to achieve the same priming as controls in tasks involving lexical decisions (Marques et al., 2015; Sponheim et al., 2004), perceptual identification (Schwartz et al., 1993), word-fragment completion (Ruiz et al., 2007; Soler et al., 2011), and verb generation (Marques et al., 2016), suggesting a sparing of implicit memory. The meta-analysis of Spataro et al. (2016) indeed showed that while overall implicit memory is slightly, but reliably, impaired in patients with schizophrenia, priming was only reduced in tasks requiring the retrieval of the conceptual properties of encoded items. However, priming remained intact in tasks requiring the retrieval of perceptual properties. Here, we tentatively hypothesize that Kahneman's System 1 reasoning could represent another island of relatively intact cognitive function; however, because this interpretation rests on a null result obtained in a modestly sized sample, it should be regarded as a hypothesis to be tested in adequately powered studies rather than as an established finding.

5. Clinical implications

Although the present study is theoretical in orientation, its findings carry tentative clinical implications. If heuristic (System 1) reasoning is relatively preserved while analytical (System 2) reasoning is impaired, cognitive rehabilitation and metacognitive interventions might be more effective when they scaffold analytical processing and leverage comparatively intact intuitive processing, rather than assuming a global reasoning deficit. Metacognitive training for psychosis, which targets reasoning biases such as jumping to conclusions, has shown modest but consistent benefits for positive symptoms and delusions across meta-analyses (Meinhart et al., 2025), and the present pattern of selective difficulty could help tailor such approaches. In addition, our finding that patients readily revised responses after feedback suggests that interventions incorporating structured, corrective feedback may be well received. Immersive and interactive technologies may offer promising delivery formats: 2D and 3D cognitive-rehabilitation approaches, including virtual reality (VR), serious games, and augmented reality (AR), are increasingly explored as tools for cognitive and social rehabilitation in schizophrenia and can provide ecologically valid, engaging, and individually adaptable training environments (Dahò & Monzani, 2026; Gillouin et al., 2024). Whether preserved heuristic processing can be harnessed within such platforms to support analytical reasoning is an open question for intervention research.

6. Strengths and Limitations

A key strength of the study is the inclusion of both deluded and non-deluded patients with schizophrenia, which allowed a direct test of the specificity of dual-process reasoning deficits to delusions, a comparison that much of the earlier literature lacks. The study also reports effect sizes and confidence intervals throughout and makes its materials, data, and analysis code openly available.

The present study is not without limitations. First, with regards to the participant sample, its size was modest (controls = 22, patients with delusions = 14, patients without delusions = 12), although in the order commonly employed in cognitive studies of schizophrenia (e.g., Hooker et al., 2000, controls = 12 and patients = 14). This limitation restricts the power of the study and therefore potentially significant differences between deluded and non-deluded patients may have been missed. Relatedly, the absence of significant group differences should not be taken as evidence of equivalence; our design was not powered to detect equivalence, and confirming preserved heuristic reasoning would require a formal equivalence-testing approach (e.g., two one-sided tests) in a larger sample. In addition, several clinical characteristics that could influence reasoning performance were not systematically measured and therefore could not be examined or controlled: illness duration, antipsychotic type and dose (e.g., chlorpromazine-equivalent dose), symptom severity beyond delusional status, negative symptoms, and cognitive reserve (e.g., educational attainment). Any of these could plausibly affect cognitive performance and may differ between subgroups; their omission constrains the conclusions that can be drawn and future studies should record and adjust for them. Finally, both the clinical and control groups were predominantly male, which limits the generalizability of the findings to women and underscores the need for more balanced samples in future work.

In terms of study methodology, our methods and analysis plan were not preregistered. Another limitation of this study concerned the IQ matching of the patients and controls. We followed the commonly used practice of matching patients and controls on IQ as estimated using the NART. However, this is a measure of premorbid IQ in patients with schizophrenia, who commonly show a degree of general intellectual impairment, which can be marked in patients with severe and chronic forms of illness (e.g. McKenna et al., 2002). This may be particularly important in a study of reasoning, where performance by typical participants is known to be surprisingly poor, and could result in floor effects in the patients. Therefore, in this study we used a criterion of relative intellectual intactness, namely a current WAIS-R IQ of 80 or greater. This was relatively broad and will inevitably have included some patients with some degree of overall intellectual impairment. An arguably better strategy would have been to employ patients who showed no evidence of intellectual decline, for example a current WAIS-R IQ that was close to the NART-estimated premorbid IQ. However, this would in practice have severely restricted the numbers of patients who could have been recruited. A further limitation concerns the Reasoning Test itself, which was developed for this study and has not undergone formal psychometric validation; although its items were grounded in established reasoning paradigms, its reliability and validity require confirmation in larger, independent samples.

7. Future directions

Future research should employ larger, adequately powered samples, preregistered designs, and refined IQ-matching methods to validate our findings through replication. Both direct replications, using the same methods and procedures as this study, and conceptual replication, testing the same hypotheses but using different methods, measures, or experimental conditions, are needed at this early stage in this line of research. Moreover, examining the neural mechanisms underlying preserved heuristic reasoning in schizophrenia could offer deeper insights into the cognitive architecture of the disorder. If replicated, our findings may support the notion that System 1 reasoning represents an area of relative preservation within the broader cognitive impairments of schizophrenia. Studies should also record and model the clinical and treatment variables noted above and validate the Reasoning Test (including item-level reliability and, ideally, comparison against established heuristics-and-biases inventories). Finally, intervention-oriented work could test whether cognitive-rehabilitation and metacognitive approaches, potentially delivered through VR, AR, or serious-games platforms, can capitalize on preserved intuitive processing to support analytical reasoning in schizophrenia.

8. Conclusions

In conclusion, our findings highlight a clear impairment in conventional logical reasoning among individuals with schizophrenia, while their performance on heuristic-based reasoning tasks remains largely intact. This raises the possibility of a selective deficit in cognitive function rather than a global decline and is consistent with - though it does not establish - the notion that Kahneman's System 1 processes may be relatively preserved in schizophrenia. Importantly, the presence or absence of delusions did not differentiate performance on either type of reasoning task, challenging previous findings that suggested distinct cognitive profiles for deluded and non-deluded patients. Further investigation into the mechanisms underlying heuristic reasoning in schizophrenia could help clarify whether System 1 processing remains an "island" of preserved function in this disorder.

Ethical approval

Ethics approval was secured from the Ethics Committee of the Department of Experimental Psychology, University of Cambridge.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The materials, data and data analysis code are available at the Open Science Framework platform (https://osf.io/6pgs3/overview).

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any potential conflict of interest.

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Authors' Contribution

PT: Conceptualization, data curation, formal analysis, methodology, writing – original draft, writing – review & editing; RG: writing – original draft, writing – review & editing; AA: writing – original draft, writing – review & editing; MPP: formal analysis, writing – original draft, writing – review & editing.

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No AI tools were used for the preparation of the first draft of this manuscript. Claude for Mac (Version 1.13576.0 (1290fc)) was used responsibly to help with proofreading and enhancing the clarity and coherence of the text exclusively at the revisions stage. Any generated text was revised rigorously. The authors take full responsibility for the content of the published article.

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