When a schizophrenic deficit becomes a reasoning advantage

Emmanuel Mellet a,*, Olivier Houdé a, b, Perrine Brazo a, c, Bernard Mazoyer a, b, Nathalie Tzourio-Mazoyer a, Sonia Dollfus a, c

a UMR 6194, CNRS, CEA, Université de Caen and Université Paris-Descartes (Paris-5), France
b Institut Universitaire de France, France
c Centre Esquirol, Centre Hospitalier Universitaire, Caen, France

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Abstract

A deficit in context processing has been proposed to be one of the major deficiencies in schizophrenia. A demanding reasoning task, known to promote a very reproducible bias (i.e., a reasoning error) in healthy subjects, triggered by a misleading context, was administered in 26 schizophrenic patients and 26 healthy participants. Responses at random were checked by including an additional group of 11 schizophrenic patients who performed a control version of the task. We showed that patients presented a surprising imperviousness to the reasoning bias and had significantly better logical performances than their paired healthy participants. This finding demonstrates that there are some problem solving situations where disregarding contextual information, a cognitive deficit that usually impairs schizophrenic patients gives them a cognitive advantage over healthy controls.

Keywords: Schizophrenia; Logical reasoning; Context processing; Cognitive advantage

1. Introduction

A deficit of context information processing has been suggested to account for various cognitive impairments in schizophrenia (Cohen and Servan-Schreiber, 1992; Servan-Schreiber et al., 1996; Stratta et al., 1998; Cohen et al., 1999). This concept refers to the ability to hold in mind the relevant information that promotes the behavior necessary to achieve a task. Contextual information includes prior stimuli, results of prior processing, and/or task instructions (Cohen et al., 1999). In the vast majority of studies, these deficits are evidenced by lower performances of schizophrenic patients in various cognitive tasks than healthy controls. However, it has been shown that in some circumstances, patients could perform better than healthy subjects. For example acute patients are less sensitive to latent inhibition than normal subjects and perform better in the subsequent learning task (Hemsley, 1993). In the same vein, patients perform
better than controls in the Karmin’s blocking task that also relies on an extinction of learning following the repetition of a stimulus (Hemsley, 1993). These results can be seen as a lower sensitivity to the bias promoted by previous context (in this case, the repetition of the stimuli). An adequate processing of the context is crucial for more complex experimental situations such as reasoning tasks. Consider for example syllogistic reasoning. Recent studies have shown that schizophrenic patients performed worse than normals (Goel et al., 2004; but see Owen et al., 2006). It has been suggested that patients use a reasoning method that does not take the context into account and then fail to create an appropriate internal representation of the task (Stratta et al., 1999).

This deficit in context processing has been proposed to be the cause of most of the cognitive deficiencies that accompany schizophrenia (Cohen and Servan-Schreiber, 1992; Cohen et al., 1999; Servan-Schreiber et al., 1996; Stratta et al., 1998). However, one may suggest that neglecting context might improve high-order cognition. In the reasoning domain for example, ignoring contextual information could lead schizophrenic patients to a lower sensitivity than healthy subjects toward specific reasoning biases. We wanted to test this hypothesis by taking advantage of a very demanding reasoning task that is failed by 90% of healthy subjects, who fall into a trap triggered by the context (Evans, 1998).

In an easy version of this task, subjects are instructed to falsify conditional rules such as “If there is a red square on the left, then there is not a yellow circle on the right”. They have to choose and juxtapose two colored geometric figures among a set of 12 in order to falsify the rule. According to formal logic, the unique strategy to falsify a conditional rule is to keep the antecedent true and to make false the consequent. In the above example, making the rule false requires putting a red square on the left (keep the antecedent true) and a yellow circle on the right (make the consequent false). It is firmly established that almost all normal subjects perform correctly in this task. However when the negation is introduced in the antecedent (see Fig. 1), performances change dramatically. The rule to falsify becomes: “If there is not a red square on the left, then there is a yellow circle on the right”. The vast majority of normal subjects produce an incorrect response in juxtaposing a red square on the left and a yellow circle on the right. This time, the correct answer requires ignoring the figures quoted in the rule (e.g., keep the antecedent true: not a red square; make the consequent false: not a yellow circle). Although there are several interpretations of this reasoning bias, one focuses particularly on the role of context. It postulates that the context of the task acts here as a trap: the presence of the word “not” together with the visual presentation of the figures quoted in the rule serves as a trigger to activate the “not-heuristic,” consisting of matching the item that is

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Make the rule False:

"If there is a not a red square on the left, then there is a yellow circle on the right"

One possible correct response

![Correct Response](image1)

Incorrect (biased) response

![Incorrect Response](image2)

Fig. 1. One trial of the conditional-rules-falsification task. The subjects had to juxtapose two figures in order to falsify the conditional rule. A correct response requires keeping the antecedent true (not a red square on the left) and making the consequent false (not a yellow circle on the right).
negated (Evans, 1998). This universal heuristic leads to a correct response in most everyday situations: using an item or performing an action preceded by “not” is generally a good way to break the rule. However, in the particular case of conditional rules having “not” in the antecedent, this matching strategy induces an incorrect answer, while ignoring the contextual cues (red square, yellow circle) protects against erroneous reasoning. We thus predicted that schizophrenics patients could performed better than normal subjects in this task. Such a result would argue against a non-specific cognitive impoverishment in patients and would rather support a domain specific deficit.

2. Methods

2.1. Participants

All participants gave their written informed consent. The study was approved by the ethics committee of Basse-Normandie (Caen, France).

Two groups of 26 outpatients and 26 healthy participants (6 females) were matched one to one by gender (6 females), age (34.9 ± 8.3 and 34.1 ± 9.0 years, respectively; p = 0.28, paired t-test) and educational level (three primary school level, 11 secondary school level, and 12 baccalaureate level in each group). Both groups performed the falsification-of-conditional-rule task with the negation in the antecedent. Although both groups presented an average total IQ, the difference between the two groups was significant (evaluated by the Weslcher Adult Intelligence Scale Revised, 1981, 95 ± 17 for patients and 102 ± 11 for healthy subjects; mean ± S.D., p = 0.04, paired t-test). The patients fulfilled the Diagnostic and Statistical Manual of Mental Disorders IV (DSM IV, American Psychiatric Association, 1987) criteria for schizophrenia. All were under treatment and clinically stable (mean: 340 mg, range: 33–860 mg equivalent chlorpromazine per day, no modification of treatment within the 4 months preceding the inclusion). The healthy volunteers were free from neurological or psychiatric disorders as assessed by the Diagnostic Interview Schedule (Robins et al., 1981).

A third group of 11 additional schizophrenic outpatients (5 females) performed the control task with the negation in the consequent. These additional 11 patients were significantly younger than the first group of 26 schizophrenic participants (25.7 ± 4.8 p = 0.002, unpaired t-test) while their total IQ was not different (98.3 ± 12; p = 0.56, unpaired t-test). The treatment was also equivalent in both groups of patients (for the group of 11 patients: mean: 393 mg, range 0–1000 mg, p = 0.55, unpaired t-test).

2.2. Procedure

Both groups of 26 patients and 26 healthy participants had to falsify eight conditional rules with the negation in the antecedent. The rules were written on a board and presented successively to the participants. The instruction was to “make the rule false.” Participants were tested individually and responded by placing in two contiguous frames, two colored figures they had to choose among a set of 12 (Fig. 1). Remember that according to formal logic, falsifying a conditional rule requires keeping the antecedent true and making the consequent false (antecedent true, consequent false, leading to a false conditional). Hence, when “not” was in the antecedent, the correct response consisted in selecting any colored geometric figures except those cited in the rule.

To ensure that patients’ responses were not a matter of chance, we tested an additional group of 11 patients who had to falsify eight conditional rules with the negation in the consequent; e.g., “If there is a red square on the left, then there is not a yellow circle on the right.” As stated in the Introduction, this task appears very similar to the former but, this time, the correct answer requires conversely using the items cited in the rule and only those items; i.e., a red square on the left and yellow circle on the right. The chance to respond correctly in picking cards at random is less than 1%. It has been shown than healthy subjects perform at ceiling in this case (Evans, 1998): Using the “not-heuristic” and the matching strategy leads here to a correct response.

3. Results

Healthy subjects produced 1.8 ± 2.7 correct responses among the 8 trials (mean ± S.D.).
In the same task, the schizophrenic patients produced $4.8 \pm 3.1$ correct responses (Fig. 2). The size of the effect was $3.0 \pm 4.5$. The difference between the two groups was significant ($p=0.003$, paired t-test, power: 92.5%). Although the performances were variable across subjects, 58% of healthy participants failed in all the eight trials while only 19% of the patients gave an incorrect response in all the trials. On the other hand, only 11% of normal volunteers made at most one error (i.e., at least seven correct responses) while 42% of the schizophrenics performed at this level (chi-square=9.48, $p=0.002$).

The additional 11 schizophrenic patients who performed the control task with the negation in the consequent produced on average $7.7 \pm 0.9$ correct responses among the eight trials (mean $\pm$ S.D.). Ten patients succeed to all the eight rules; one patient gave five correct responses.

4. Discussion

As expected, healthy subjects were victims of the so-called matching bias (Evans, 1998; Houdé et al., 2000; Moutier et al., 2002). In the same task, the schizophrenic patients proved to be considerably less sensitive to the bias than healthy subjects. To our knowledge, this is the first time that such imperviousness to the contextual bias promoted by this task has been reported. It is rather surprising that such performance was found in schizophrenic patients. There are two arguments that make it unlikely that subjects responded at random. First, the 11 schizophrenic patients who performed the control task with “not” in the consequent produced an almost perfect score, similar to the one classically reported for healthy subjects. The instructions were exactly the same in the two versions of the tasks, which

![Fig. 2. Top: Histogram showing the average of correct responses (8 trials) in the 26 schizophrenic patients (rose bar) and their paired healthy participants (orange bar). Middle and bottom: Individual results from patients and healthy subjects. It shows that most patients performed higher than their paired healthy subject.](image)
indicates that schizophrenic patients included in the present study had no difficulties in understanding the reasoning task or in falsifying the rules and actually applied a logical reasoning to produce a response. Second, when “not” was in the antecedent, the patients did produce some incorrect responses (i.e., chose and juxtaposed the figures quoted in the rule) although much less frequently that normal subjects. If patients had responded at random, they should have performed at ceiling because there was less than 1% chance of randomly choosing the two figures cited in the rule. Hence, the fact that patients produced fewer incorrect responses than healthy subjects when “not” was in the antecedent actually reveals that they were unusually impervious to the contextual traps. One major bias in characterizing cognitive profiles in schizophrenia comes from the fact that patients perform lower than normals in most of the tasks. This may suggest that most of the cognitive impoverishment of patients reflects an unspecific loss of attention rather than a deficit limited to particular cognitive process (Servan-Schreiber et al., 1996). Our result is hardly reconcilable with such a view. Rather we suggest that, thanks to their difficulty in processing contextual information, the schizophrenic patients ignored the elements that misled healthy participants. As mentioned in the introduction, this is not the only interpretation possible. Another interpretation postulates that the reasoning bias comes from the difficulty to consider the large set of the possibilities that the negative assertion permits. In the example quoted in the manuscript (“If there is not a red square on the left, then there is a yellow circle on the right.”), the difficulty lies in considering the set of “not a red square” figures (and also the set of not “a yellow circle” to falsify the rule). Yet, keeping the antecedent true requires imagining the “non-red-square” figures (and making the consequent false requires imagining the “non-yellow-circle” figures). In other words it is much more difficult to comprehend a negated item (what you have to do when “not” is in the antecedent) than to negate an explicitly quoted item (what you have to do in the control task). This interpretation does not exclude the “not-heuristic” theory, but provides a complementary framework for the interpretation of the patient’s performances. According to this view, schizophrenic patients might be better in imagining the figures associated with the negative items.

More generally, the outcome of the present work prompts us to not characterise schizophrenia as a collection of cognitive deficits, but rather as a particular cognitive profile that, in some circumstances, can be more suitable than the cognitive profiles found in normal subjects. Interestingly, a recent work supported this hypothesis by showing that schizophrenic patients could perform better than healthy subjects in a syllogistic reasoning task (Owen et al., 2006). The authors argued that their patients were less influenced by common sense and more influenced by theoretical reason, an interpretation which is in agreement with our own observation.

In most circumstances, neglecting context is a handicap for schizophrenic patients. However, in specific situations, standing back from contextual information might allow them to ignore the most evident responses that can be wrong.

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References


