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Schizophrenic patients treated with clozapine or olanzapine perform better on theory of mind tasks than those treated with risperidone or typical antipsychotic medications

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Abstract

Theory of mind (ToM), the ability to attribute mental states to others, is associated with medial prefrontal cortical (mPFC) activity and is impaired in schizophrenia. Olanzapine or clozapine but not typical antipsychotics or risperidone preferentially affect *c-fos* expression in mPFC in animals. We tested the hypothesis that schizophrenic patients treated with different antipsychotics would perform differently on ToM tasks. Groups receiving Typicals ($n=23$), Clozapine ($n=18$), Olanzapine ($n=20$) or Risperidone ($n=23$) and a Control group of healthy volunteers ($n=24$) were matched for age, gender, handedness and education. ToM functioning was assessed with picture sequence, second-order belief and faux-pas tests. Schizophrenic groups performed similarly to controls on non-ToM conditions. The Olanzapine and Clozapine groups performed similarly to Controls on ToM tasks. The Typicals and Risperidone groups performed worse than the other groups on ToM tasks. We concluded that ToM performance of schizophrenic patients is influenced by the antipsychotic they are taking. Our results suggest that olanzapine or clozapine but not typicals or risperidone may improve or protect ToM ability.

Keywords: Schizophrenia; Antipsychotics; Atypical; Typical; Social cognition; Theory of mind

1. Introduction

Schizophrenic patients are treated with antipsychotic medications. Studies with rodents and monkeys showed that different antipsychotics had different effects on expression of the immediate early gene *c-fos* and dopamine release in different brain regions (e.g., Robertson and Fibiger, 1992). Different brain regions have been implicated in different cognitive functions (Squire and Knowlton, 2000). This suggested the hypothesis that cognitive abilities in schizophrenia may depend on the antipsychotic, the particular cognitive ability being tested and the brain regions upon which it relies.

Studies of metabolic activation in animals provided evidence of regionally specific actions of antipsychotics. Thus, both typicals and atypicals increased *c-fos* expression in the nucleus accumbens (Deutsch and Duman, 1996; Fujimura et al., 2000; Kovacs et al., 2001; Robertson and Fibiger, 1992; Wan et al., 1994; Wirtshafter and Asin,

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2003). However, haloperidol, chlorpromazine and risperidone preferentially affected the dorsal striatum, whereas clozapine and olanzapine preferentially increased *c-fos* expression in the medial prefrontal cortex (mPFC) (Deutch and Duman, 1996; Fujimura et al., 2000; Kawashima et al., 2001; Ohashi et al., 2000; Wan et al., 1994; Weinberger and Lipska, 1995; Wirtshafter and Asin, 2003). Whether risperidone activates mPFC is so far inconclusive: one study reported an increase in mPFC *c-fos* following risperidone but another reported no effect (Fujimura et al., 2000; Wan et al., 1994). Furthermore, clozapine and olanzapine increased dopamine outflow in the mPFC, but not in the striatum or nucleus accumbens; whereas haloperidol had no effect in the mPFC but increased dopamine outflow in the striatum (Heidbreder et al., 2001). Taken together, these results show that chlorpromazine, haloperidol or risperidone preferentially affect the striatum and clozapine or olanzapine preferentially affect the mPFC.

These findings suggest that antipsychotics may act differently on cognitive functions that rely on the striatum vs. mPFC. Beninger et al. (2003) found that schizophrenic patients treated with typicals were preferentially impaired on a memory task that depends on the striatum (Knowlton et al., 1996). In contrast, patients treated with atypicals were preferentially impaired on a task that relies on the mPFC. Bedard et al. (2000) also found that schizophrenic patients treated with typicals performed worse on a "striatal" task; however, patients treated with clozapine performed better on a "PFC" task. These findings suggest that the performance of schizophrenic patients on cognitive tasks depends on the combination of a particular task being used and the particular medication.

Theory of mind (ToM) is defined as the ability to understand behavior in terms of underlying mental states such as beliefs and intentions. Although ToM appears to be supported by a widely distributed neural system (Frith and Frith, 2001), most studies agree that regions of the PFC maybe a possible core substrate for this ability. Thus, the paracingulate area is most consistently active in normal volunteers during ToM tasks (Brunet et al., 2000; Gallagher et al., 2000; Fletcher et al., 1995), and impaired ToM has been found with ventromedial/orbitofrontal damage (Stone et al., 1998). Russell et al. (2000) found decreased activation in the left middle/inferior PFC and impaired ToM in schizophrenic people. Similarly, Brunet et al. (2003) detected increased activations in the posterior orbital and mPFC during ToM performance in controls but not in schizophrenic patients. Findings link ToM deficits in schizophrenia to regions of the PFC.

ToM ability is a part of social cognition — a domain that includes a number of different components: perception of self and others, our knowledge of social situations, and the rules describing appropriate behaviors in those situations. Previous research shows that treatment with the atypicals risperidone and olanzapine enhanced some indices of social cognition in schizophrenic patients (Kee et al., 1998; Littrell et al., 2004). To the best of our knowledge, besides ours, there is only one study that investigated the effect of antipsychotics specifically on ToM: Mazza et al. (2003) found that risperidone administered together with dopenzil improved ToM after one year treatment relative to haloperidol and clozapine, or risperidone alone. Given these findings, we hypothesized that ToM performance of schizophrenic patients treated with typicals or risperidone would differ from that of normal controls and patients treated with clozapine or olanzapine.

2. Methods

2.1. Participants

Patients with schizophrenia ($n=77$) or schizoaffective ($n=7$) disorder according to DSM-IV received clozapine ($n=18$), olanzapine ($n=20$), risperidone ($n=23$) or typicals ($n=23$), including perphenazine ($n=2$), fluphenazine ($n=8$), flupenthixol ($n=6$), zuclopenthixol ($n=4$), stelazine ($n=1$) and haloperidol ($n=2$), for at least 4 months. Most were also receiving mood stabilizers or other medications, but these were not systematically recorded. However, treating physicians were asked not to refer patients who received anticholinergic medication. The Control group consisted of 24 volunteers.

Exclusion criteria included mental retardation, drug/alcohol abuse within 2 wk, history of neurological disorder or organic brain disease, head injury with loss of consciousness and presence of a co-morbid psychiatric disorder. Control participants who had received psychoactive drugs within the past 5 years were excluded.

Approved by the Queen's University's and Affiliated Teaching Hospitals Health Sciences Human Research Ethics Board.

2.2. Procedure and materials

Informed consent was obtained and participants received medical history and demographics questionnaires and Mini-Mental State Examination (MMSE). Testing was conducted by a researcher trained in administering the instruments and blind to the patients' medications.

2.2.1. First-order belief task

To test participants' understanding of the beliefs/intentions of others (first-order belief) performance on 3 types of picture sequences (Baron-Cohen et al., 1986) was compared: 1). "mechanical" depicting physical–causal relations, 2 conditions; 2). "behavioral" depicting people engaging in various activities and interactions, 2 conditions; and 3). "intentional" requiring attribution of mental states, 1 condition. There were 3 sequences per condition (Appendix A). Mechanical and behavioral sequences assessed understanding of non-ToM relations. The picture sequences were black-and-white images (10 × 10 cm) drawn on white cardboard cards using a computer. Each sequence of 4 pictures was placed in front of the participant. The correct first picture was presented as the start of the sequence. Participants arranged the other pictures in a sequence that made a story. The order of presentation of the conditions was invariant. Correct sequences were scored 2; 1 for placing the last card correctly; 0 for all other orderings.

2.2.2. Second-order belief tasks

These tasks measured ability to understand embedded mental states. The prototypical test, "Ice-cream van" (Perner and Wimmer, 1985) and its modified version, "Family" (Baron-Cohen, 1989, cited in Hughes et al., 2005) each told a story wherein two people had different knowledge about what would happen. The stories were read and enacted using toy characters and props in the same manner for all participants. They were asked what one character believed about the belief of another character and to justify this answer. Correctly answering these questions required understanding the mental states of the characters. Non-ToM abilities were assessed using memory, reality and two prompt questions (Appendix B). The order of story presentation was randomized. Participants were awarded a score of 0 or 1 on the belief and justification questions and on each of the control questions. All participants answered the control questions correctly.

2.2.3. Faux-pas test

Detecting a faux pas requires more advanced ToM functioning: appreciation of the difference between the knowledge of the speaker and that of the listener, as well as recognition of the emotional impact of the unintended statement. Five faux-pas and 5 stories controlling for memory, comprehension and attention load, identical to the faux-pas stories in content and length but without the social blunder, were presented in a random order to participants (Baron-Cohen et al., 1999). Participants were asked comprehension and faux-pas understanding questions (Appendix C). All participants answered all comprehension questions correctly. Answers to faux-pas understanding questions were scored either 1 or 0.

2.2.4. Brief Psychiatric Rating Scale (BPRS)

The BRPS, assessing severity of current psychiatric symptoms, consisted of 18 items each rated on a scale from 1 to 7 according to participants' self-report and the researcher's observations (Overall and Gorham, 1962).

2.3. Statistical analyses

Group comparisons of the demographic variables, MMSE or BPRS scores were performed by one-way analyses of variance (ANOVA) followed by pairwise comparisons. Sex, Handedness and Diagnosis were analyzed by Chi-square (χ^2). ToM test results were analyzed using mixed design ANOVA followed by tests of simple effects and post-hoc Tukey Unequal N Honest Significant Difference pairwise comparisons, which provide correction for cumulative type I error. A correlation matrix was constructed to assess relationships among the variables. For all correlations, a Bonferroni correction for multiple comparisons was performed.

3. Results

3.1. Demographic, clinical variables and MMSE

No significant differences were found among groups on Age, Education, Sex, Handedness or MMSE (Table 1). For schizophrenic groups, no differences emerged on Age of Onset, Duration of the illness or Diagnosis (Table 2).

3.2. BPRS scores

Mean BPRS score was highest for the Clozapine group and lowest for the Typicals and Olanzapine groups with the Risperidone group in between (Table 2). Omnibus ANOVA revealed a significant difference among groups ($F(3,80)=2.83, p<0.044$). No significant differences were found in pairwise comparisons.

3.3. Picture-sequence test

On the mechanical and behavioral sequences, the performance for all drug groups was comparable to controls and did not differ significantly either within or

Table 1
Demographic variables

Group	N	Education		MMSE		Gender	Age		Hand
		Mean	S.D.	Mean	S.D.	Male	Mean	S.D.	Right
C	24	13.458	1.888	29.125	0.992	54.2%	44.000	13.603	75.0%
T	23	11.870	3.494	28.174	2.059	87.0%	47.304	12.879	91.3%
R	23	11.826	2.871	29.174	1.230	69.6%	42.391	14.317	82.6%
O	20	12.975	2.526	28.950	1.905	80.0%	40.700	11.093	95.0%
CL	18	12.278	2.740	28.444	2.121	61.1%	44.278	9.646	94.4%

Groups: Control (C), Typical (T), Risperidone (R), Olanzapine (O), Clozapine (CL).

between groups, therefore scores on mechanical and behavioral sequences were averaged to form the control condition. The groups performed similarly on the control tasks but differed on the intentional task: the Typicals group scored lowest, the Control and Olanzapine groups scored highest, with the Risperidone and Clozapine groups in between (Fig. 1). ANOVA revealed a significant interaction ($F(4,103)=2.49$, $p<0.05$) as well as significant main effects of Group ($F(4,10)=4.098$, $p=0.004$) and Sequences ($F(1,103)=32.922$, $p<0.0001$).

In pairwise comparisons no significant differences were found among groups on the control sequences. In the intentional condition, the Typicals group was impaired compared to the Control and Olanzapine groups ($ps<0.0003$) and the Clozapine compared to the Olanzapine group ($p<0.05$); the Risperidone group was in between and not significantly different from any groups. Additionally, the Typicals and Clozapine groups showed impairment on the intentional compared to the control sequences ($ps<0.0003$ and 0.05, respectively).

3.4. Second-order false belief tasks

The Typicals and Risperidone groups had the lowest performance with the other treatment groups performing better (Fig. 2). ANOVA revealed no significant Order effects or interactions. The main effect of Group was significant ($F(4,103)=5.86$, $p<0.0003$) and the main effect of Test approached significance ($F(1,98)=3.703$, $p<0.06$) with the "Family" test being more difficult than the "Ice-cream van" test. Pairwise comparisons indicated that the Control and Olanzapine groups performed better than the Typicals group ($ps<0.001$ and 0.05, respectively) and the Control group performed better than the Risperidone group ($p<0.01$).

3.5. Faux-pas test

On the control stories the Typicals group performed worst, and on the faux-pas stories the Risperidone group performed worst (Fig. 3). ANOVA revealed no significant order effects or interactions involving order. There was a main effect of Group ($F(4,98)=7.027$, $p<0.0001$) and an interaction between drug treatment groups and participants' performance on the two story types that approached significance ($F(4,98)=2.370$, $p<0.058$).

In post-hoc comparisons, the Control group performed better on control stories than the Typicals group ($p<0.002$). In the faux-pas stories condition, the Control and Olanzapine groups performed better

Table 2
Schizophrenic patients demographics

Group	N	BPRS		Age of onset		Diagnosis	Duration	
		Mean	S.D.	Mean	S.D.	Schizophrenic	Mean	S.D.
T	23	30.174	5.750	25.435	8.805	91.3%	21.870	12.614
R	23	33.826	10.254	23.478	8.733	95.7%	18.913	13.403
O	20	29.050	5.491	25.600	7.029	85.0%	15.100	10.523
CL	18	36.222	12.047	26.722	9.074	94.4%	17.556	9.167

Groups: Control (C), Typical (T), Risperidone (R), Olanzapine (O), Clozapine (CL).

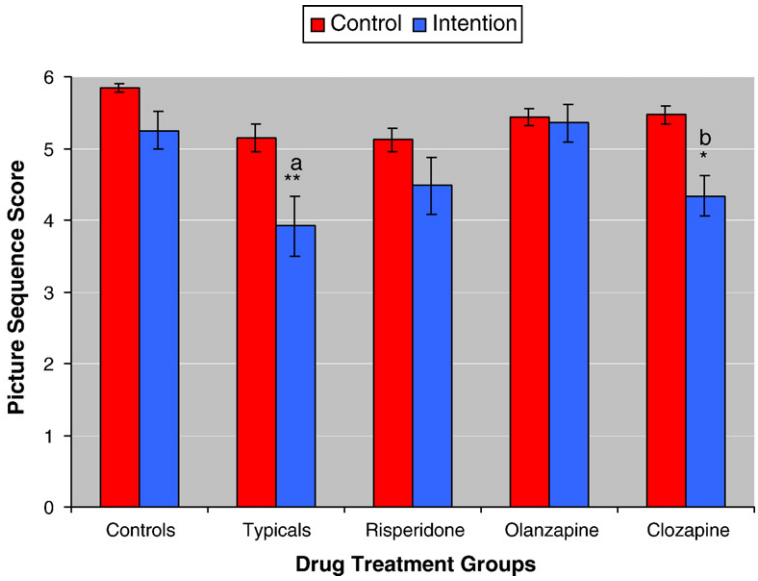


Fig. 1. Mean (±EM) scores on control and intentional sequences for drug treatment groups. Groups did not differ on the control condition, but differed significantly on the intentional condition.

than the Risperidone group ($ps < 0.0005$ and 0.001, respectively). None of the groups differed significantly in performance between control and faux-pas stories.

3.6. Co-varying out BPRS

Re-analysis of ToM tests co-varying out BPRS yielded the same pattern of results.

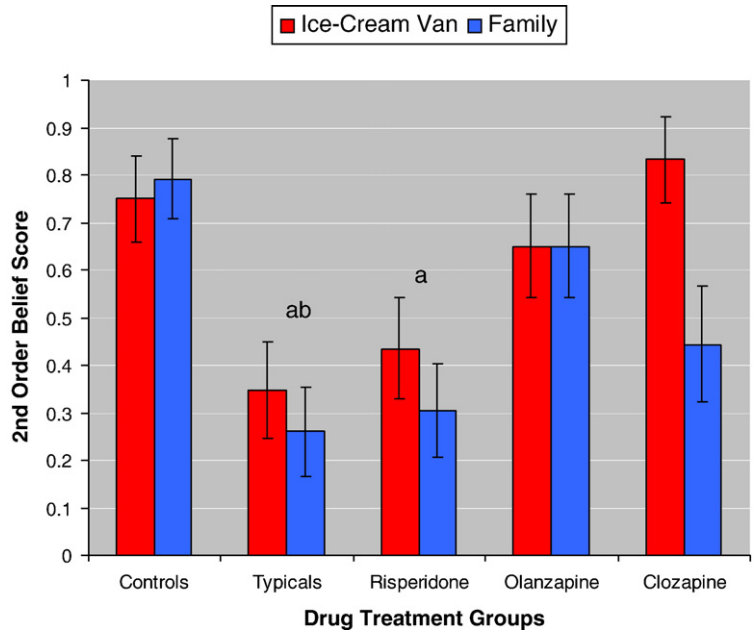


Fig. 2. Mean (±SEM) scores on "Ice-cream Van" and "Family" tests for drug treatment groups.

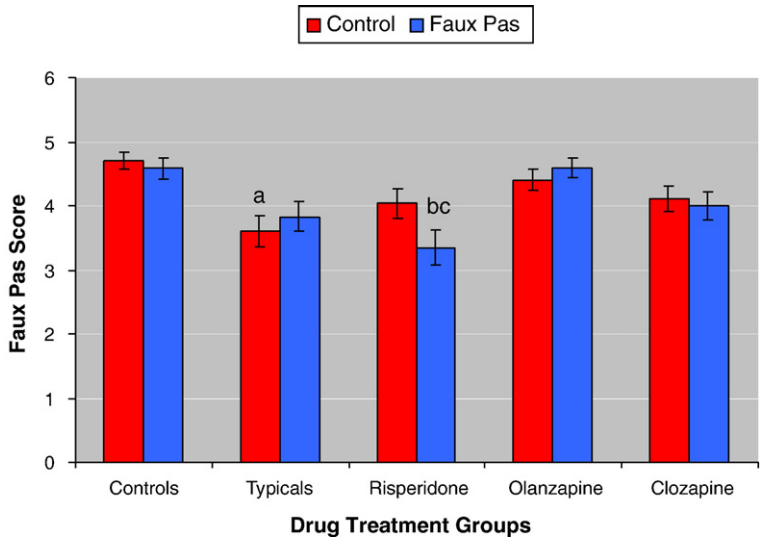


Fig. 3. Mean (±SEM) scores on control and faux-pas stories for drug treatment groups.

3.7. Correlations

Education was significantly correlated with performance on the intentional picture sequences ($r=0.37$, $p<0.05$). Performance on the intentional picture sequences significantly correlated with performance on second-order false belief stories ($r=0.35$ for "Ice-cream van" and $r=0.39$ for "Family", $ps<0.05$). Performance on the faux-pas test did not significantly correlate with performance on the other ToM tests.

3.8. Co-varying out education

The results did not change from those already reported, except the Olanzapine and Clozapine groups no longer differed significantly in performance on the intentional picture sequences.

3.9. ToM battery composite (TBC)

TBC performance scores were calculated in four steps. 1) All scores were converted to percentages relative to maximum possible scores on individual tests. 2) For each test, a difference score was calculated by subtracting performance on the ToM condition from performance on the control condition. For the second-order false belief test, performance on the two stories was combined and subtracted from performance on the control questions (maximum score of 2 was assigned, since all participants passed). 3) The average of the three difference scores was computed. 4) A performance score was calculated by subtracting the ToM composite impairment score from 100%. The formula was:

$$\mathrm{TBC} = 100\% - [\Sigma(\%\ \mathrm{Control} - \%\ \mathrm{ToM}\ /3)]$$

On the TBC scores the Typicals and Risperidone groups scored lowest, the Control and Olanzapine groups scored highest and the Clozapine group scored in between (Fig. 4). ANOVA revealed that groups differed ($F(4,103)=5.566$, $p<0.005$). Pairwise comparisons revealed that the Typicals and Risperidone groups performed worse than the Control ($p<0.02$) and Olanzapine groups ($p<0.02$).

4. Discussion

Schizophrenic participants treated with different antipsychotics performed differently on ToM tasks. ToM performance was near control levels in patients treated with olanzapine or clozapine but significantly below control levels in those treated with typicals or risperidone. These findings supported our hypotheses.

4.1. ToM and cognitive ability in schizophrenic patients

Schizophrenic patients were impaired on ToM tasks but not on control tasks that made similar demands on memory and other cognitive abilities. Thus, in picture sequencing some medication groups were impaired on the intention–inference sequences, but all groups had normal performance on mechanical or behavioral

sequences. In the second-order false belief tasks groups did not differ in answering memory and reality questions that required similar levels of memory and concentration as in answering the belief question. In the faux-pas test, Olanzapine, Clozapine and Risperidone groups were not impaired on control stories without the social blunder; otherwise these stories were identical to the stories containing a faux pas. The Typicals group was impaired on the control stories in the faux-pas test suggesting that either this test made greater overall cognitive demands, or patients treated with typicals have deficits in understanding social situations.

Our findings suggest that the ToM impairments of schizophrenic groups were specific and could not be attributed to deficits in memory, attention, general cognitive processing or understanding representation. However, the present study did not include direct measures of general cognition, intelligence or executive functioning. Although schizophrenic and control groups were matched on MMSE and on education, measures that may reflect cognitive and intellectual capacities, the unlikely possibility remains that our schizophrenic groups might have differed in general cognitive functioning. Future studies should include a battery of various cognitive, executive functioning and intelligence tests.

4.2. Non-random assignment and possible prescribing bias

Participants were not randomly assigned to medication groups raising the possibility that differences among groups reflected a prescribing bias. For example, the Typicals and Clozapine groups might have been over-represented by patients with more severe symptoms as these medications are often prescribed to treatment-resistant patients in current psychiatric practice. The severity of psychotic symptoms might affect cognitive capacity in general and ToM in particular. Non-random assignment is a limitation of the present study but, as discussed below, it does not preclude our conclusions.

Although the Clozapine group indeed had the highest BPRS score (M=36.2), it did not differ significantly from the other groups. Additionally, a BPRS score of 36 corresponds to very mild symptoms (total scores range from 18–126). Performance of the Clozapine group did not differ significantly from the Control group on any of the ToM tests or from the Olanzapine group on the second-order false belief and faux-pas tests, mitigating the putative prescribing-bias argument. On the picture-sequencing test, the Clozapine group performed significantly worse than the Olanzapine group (the lower performance of this group on the other tests was not statistically significant). Although we cannot explain this finding, others have shown similar results. Thus, in their review Meltzer and McGuirk (1999) observe that the magnitude of the effects of olanzapine on several measures of general cognitive functioning in schizophrenia was greater than that reported for clozapine or risperidone.

The prescribing-bias argument cannot explain the performance of any of the other groups. Thus, the Typicals group (M=30.2) had a BPRS score similar to that of the Olanzapine group (M=29.1) yet it consistently performed more poorly than the Olanzapine group on ToM tasks. The Risperidone group (M=33.8)

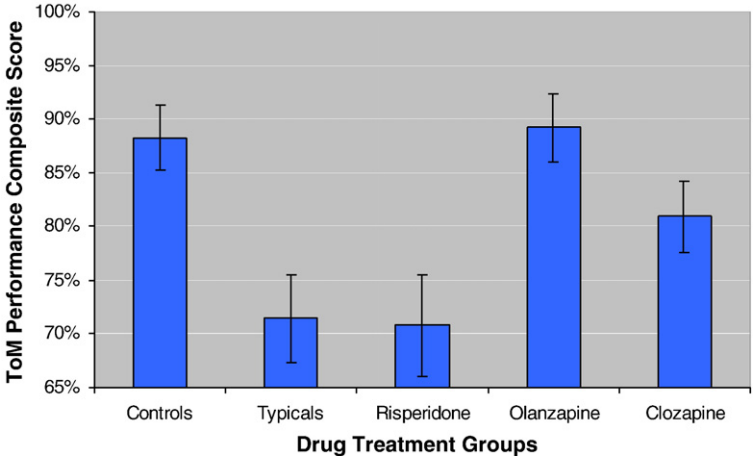


Fig. 4. Mean (±SEM) scores on the ToM battery composite for drug treatment groups.

performed worse than the Control group on two ToM tasks; if risperidone is an initial choice in prescribing antipsychotics, it is difficult to conclude that the poor performance of the Risperidone group reflects prescribing habits. Thus, available evidence strongly suggests that our results are unlikely to be attributed to putative differences in the levels of cognitive functioning resulting from prescribing biases.

4.3. Effects of different antipsychotics on ToM in schizophrenia

Is ToM impaired in schizophrenia and improved or protected from deterioration by olanzapine, or is ToM impaired by typicals and risperidone, or both? It is yet unknown whether ToM is impaired at the onset of schizophrenic symptoms as this ability, to the best of our knowledge, has never been directly evaluated in prodromal individuals. There is, however, evidence of poor premorbid perspective-taking, an ability closely linked to ToM, of schizophrenic patients (Schiffman et al., 2004). Furthermore, ToM impairment may be a trait characteristic of schizophrenia: deficits in ToM have been found in schizophrenic patients in remission (Herold et al., 2002), non-psychotic relatives of schizophrenic patients (Janssen et al., 2003), and non-clinical adults with schizotypal traits (Langdon and Coltheart, 1999). These findings support the suggestion that ToM is impaired in schizophrenia and improved by olanzapine.

ToM has been associated with the mPFC. Brain *c-fos* activation and dopamine release data from animal studies suggest that olanzapine or clozapine, but not haloperidol or risperidone, preferentially act on the mPFC (Deutch and Duman, 1996; Heidbreder et al., 2001; Kawashima et al., 2001; Wan et al., 1994; Ohashi et al., 2000). Taking into consideration that ToM maybe a trait characteristic of schizophrenia, we propose a hypothesis that olanzapine and clozapine may improve or protect ToM ability by restoring or improving neuronal activation in the mPFC. A recent study by Lund et al. (2002) supports this hypothesis. Two schizophrenic patients treated with olanzapine for 12 months showed improved cognitive performance and bilateral restoration of neuronal activity in the inferior/middle frontal lobes. These areas showed impaired activation in schizophrenic patients during ToM performance (Deutch and Duman, 1996; Waddington et al., 1997).

However, this hypothesis is tentative as it is first critical to establish the premorbid ToM ability of schizophrenic individuals. We also caution that this hypothesis was derived on the basis of *c-fos* expression data for antipsychotic agents in rodents and one primate study. The effects of these agents on *c-fos* expression in humans are not known.

4.4. Mood stabilizers and ToM performance

Most schizophrenic patients in our study were also receiving a variety of mood stabilizers and other drugs. It is as yet unknown if these medications affect ToM. Several studies have found that ToM ability in psychiatric outpatients treated for depression or anxiety does not differ from this ability in normal controls (Pickup and Frith, 2001; Corcoran et al., 1995, 1997). There is no reason to suspect that there was a systematic bias in prescription of particular mood stabilizers for particular antipsychotic treatment groups in our study. However, a possibility remains that ToM performance might have been affected by medications other than antipsychotics.

4.5. Conclusions

Results underscore the importance of evaluating cognitive effects of medications used in the treatment of schizophrenia (Beninger et al., 2003). To the best of our knowledge, this is the first study to investigate ToM in schizophrenic patients grouped according to antipsychotic treatment. Medications used in the treatment of schizophrenia may significantly influence ToM ability of these individuals. Previous research on ToM in schizophrenia did not consider different antipsychotics as potential contributing variables, therefore their findings cannot be attributed solely to the disease process. ToM ability in schizophrenia is influenced by antipsychotics.

Role of the Funding Source

This Research was supported by a Special Research Award from Queen's University to Dr. Beninger. This award had no further role in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Contributors

This manuscript is the product of Dr. Savina's doctoral thesis work, under the supervision of Dr. Beninger. Both authors have contributed substantially to the scientific process leading to the writing of this paper. Dr. Savina has written the manuscript and Dr. Beninger provided valuable critical revisions. The authors are entirely responsible for the scientific content of this paper. Both authors contributed to and have approved the final manuscript.

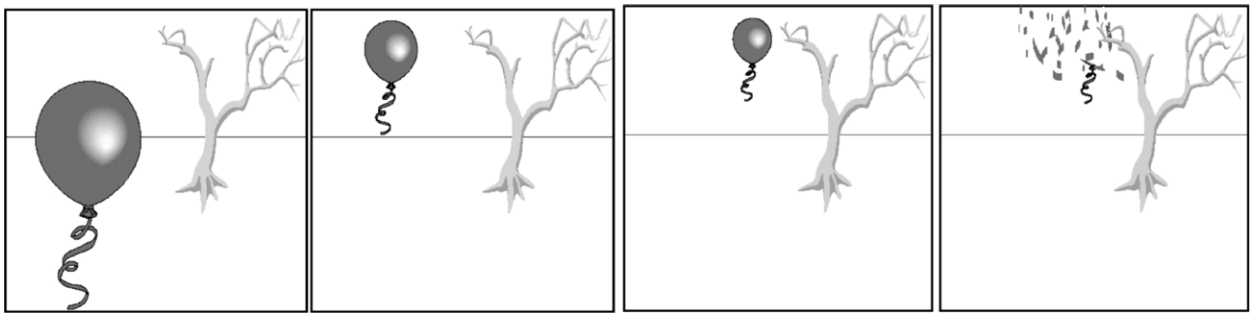
Acknowledgements

This research was supported by a Special Research Award from Queen's University to Dr. Beninger.

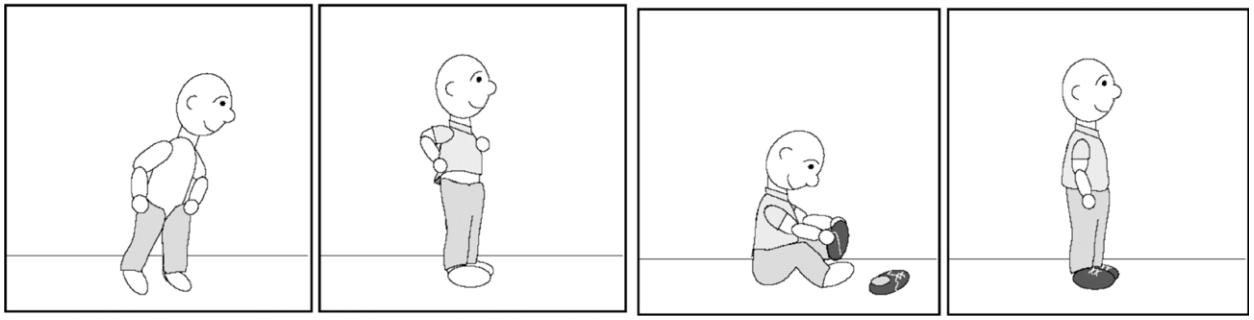
Appendix A

A.1. Examples of picture sequences

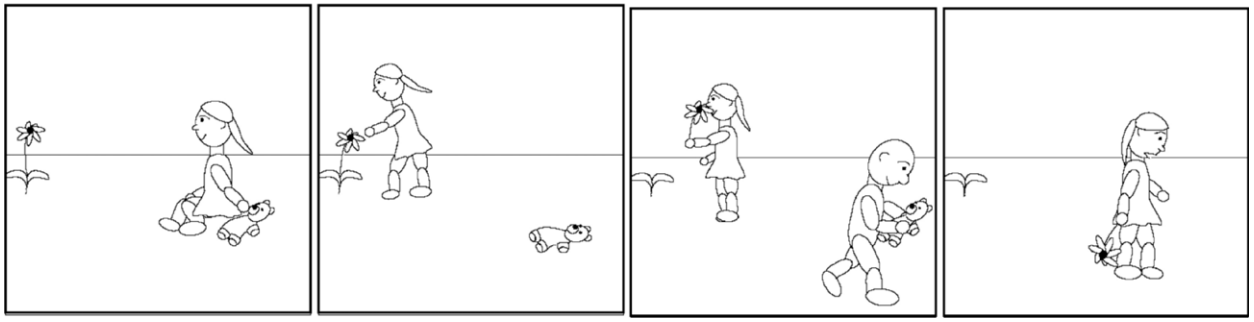
A.1.1. Mechanical



A.1.2. Behavioral



A.1.3. Intentional



Appendix B

B.1. Second-order false belief stories

B.1.1. The "Ice-cream van" story

This is John and this is Mary. They live in this village. Here they are in the park. Along comes the ice-cream man. John would like to buy an ice cream but he has left his money at home. He is very sad. "Don't worry" says the ice-cream man, "you can go home and get your money and buy some ice cream later. I'll be here in the park all afternoon". "Oh good" says John, "I'll be back in the afternoon to buy an ice cream".

So John goes home. He lives in this house. Now, the ice-cream man says "I am going to drive my van to the church to see if I can sell my ice creams outside there".

The ice-cream man drives over to the church. On his way he passes John's house. John sees him and says, "Where are you going?" The ice-cream man says, "I'm going to sell some ice cream outside the church." So off he drives to the church.

Prompt question: Where did the ice-cream man tell John he was going?

Prompt question: Does Mary know that the ice-cream man has talked to John?

Now Mary goes home. She lives in this house. Then she goes to John's house. She knocks on the door and says "Is John in?" "No," says his father, "He is gone to buy an ice cream"."

Belief question: Where does Mary think John has gone to buy an ice cream?

Justification question: Why?

Reality question: Where did John really go to buy his ice cream?

Memory question: Where was the ice-cream man in the beginning?

B.1.2. The "family" story

Please, note: the characters were changed from those in the original story because of the availability of the toy props (Granny, Johnny and Granddad in the original vs. Mother, Father and Mary in our story), but the story itself is exactly the same.

One day mother said "I'm going to take baby for a walk in the park, do you want to come with us Mary?" It's a hot day so Mary said "I'm too hot, I don't want to go for a walk!" So mother went off to the park with baby, while Mary went to play in the back garden, and father sat at the front of the house. A little later, father saw mother coming back from the park. "Where are you going?" he said. Mother replied "The park was closed, so I'm going to take baby to the sea instead". Father said "OK, I'm going to have a little sleep". Next, mother and baby walk by the back garden. "Hello mother, I'm here!" waved Mary from the backyard. Mother told Mary that she and baby were going to the seaside.

Prompt question: Does father know that mother talked to Mary?

Prompt question: Where are mother and baby really?

A little later, Mary was bored, and decided to go and find her mother and the baby. She ran back through the house and called out "Father, I'm going off to play with mother and the baby".

Belief question: Where does father think Mary will go?

Justification question: Why does father think Mary will go there?

Reality question: Where are mother and the baby really?

Memory question: Where did mother and the baby go at the beginning of the story?

Appendix C

C.1. Examples of the control and faux-pas stories

Comprehension (C) and False belief (FB) Questions are shown following each story

C.1.1. Control story

Michelle had just moved into a new house. Michelle went shopping with her Mom and bought a new rug for her bedroom. When Michelle had just put it down, her best friend, Samantha, came around and said, "Oh, your new rug is just like my new one."

C: What had Michelle just bought?

FB: Did Samantha know the rug was new?

C.1.2. Faux-pas story

Jill had just moved into a new house. She went shopping with her Mom and bought some new curtains. When Jill had just put them up, her best friend Lisa came round and said, "Oh, those curtains are horrible, I hope you're going to get some new ones."

C: What had Jill just bought?

FB: Did Lisa know the curtains were new?

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