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Pragmatic and executive dysfunction in schizophrenia

Maud Champagne-Lavau [a,c,*], Emmanuel Stip [b,c]

[a] Hôpital du Sacré-Cœur de Montréal, Pavillon Albert-Prévost, Montreal, Canada
[b] Centre de recherche Fernand-Seguin, Hôpital Louis-H. Lafontaine, Montreal, Canada
[c] Psychiatry Department, University of Montreal, Montreal, Canada

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ABSTRACT

Many studies have reported that patients with schizophrenia (SZ) can be impaired in their pragmatic abilities, typically affecting the processing of non-literal speech acts (e.g., metaphors, indirect requests). Various hypotheses have been proposed to account for impairments in understanding non-literal language, such as executive dysfunction or problems attributing mental states to others; the latter is referred to as theory of mind (ToM) abilities. The aim of this study was to explore whether pragmatic deficits do or do not coexist with ToM impairments and/or impairments of executive functions in schizophrenia. Twenty SZ patients and twenty matched healthy control (HC) participants – all right-handed and native French-speakers – were tested individually for three abilities: (a) pragmatic, (b) ToM (original first- and second-order mental state attribution tasks) and (c) executive functions. The main results showed that SZ patients exhibit pragmatic impairments which co-occurred with an executive dysfunction such as a lack of flexibility and a ToM deficit. Subsequent analyses of covariance suggested that ToM could play a role in pragmatic understanding while flexibility did not. Our study gives partial support to neuroimaging literature showing an impaired involvement of the prefrontal cortex in such processing in schizophrenia.

1. Introduction

The ability to process pragmatic aspects of language (e.g. non-literal language) is a social skill that contributes to individual and social well-being. Daily, verbal communication usually relies on

* Corresponding author. Hôpital du Sacré-Cœur de Montréal, Pavillon Albert-Prévost, 6555 Gouin Blvd. West, Montreal, Quebec H4K 1B3, Canada. Tel.: +1 514 338 2222x4415.
E-mail address: maud.champagne-lavau@umontreal.ca (M. Champagne-Lavau).

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the transmission of non-literal messages rather than a straightforward transmission of literal information. Therefore, a deficit in the processing of such pragmatic aspects of language may be a significant factor in the social isolation experienced by many individuals with schizophrenia (SZ). SZ patients have been shown to exhibit pragmatic deficits, particularly deficits in understanding non-literal utterances such as irony, metaphor, or indirect requests that require the ability to process more than the literal meaning of an utterance in order to grasp the speaker's intention in a given context (see Champagne-Lavau, Stip, & Joanette, 2006; Mitchell & Crow, 2005 for exhaustive reviews of these deficits). Studies have also described pragmatic impairments in SZ patients such as failure to decode violations of conversational implicatures (Tenyi, Herold, Szili, & Trixler, 2002). SZ patients may also exhibit an absence of semantic priming for targets that are metaphorically rather than literally related to the prime (Spitzer, 1993; Titone, Holzman, & Levy, 2000; Titone, Holzman, & Levy, 2002).

These studies clearly show that although they are able to understand literal language, SZ patients have problems understanding non-literal language, suggesting that only high-level language processing is impaired in schizophrenia. Given SZ patients' assorted impairments affecting the understanding of irony and metaphor, different cognitive processes such as intention decoding (e.g. ability to understand speaker's mental states such as intention or belief), executive dysfunction might be involved in such processing (Champagne-Lavau et al., 2006; Martin & McDonald, 2003). Therefore, a deficit in non-literal language understanding may reflect the presence of dysfunctions at different levels. Thus, in this paper, we explore the relationship between three different cognitive abilities that seem to have substantial overlap (pragmatic understanding, intention decoding and executive dysfunction) in schizophrenia.

1.1. Relationship between pragmatic and ToM in schizophrenia

Pragmatic interpretation such as non-literal language processing has been defined as a *mind-reading* exercise involving inferences concerning the speaker's mental state (Grice, 1969). A deficit in decoding such intentions might result in an impairment affecting the understanding of non-literal language. In the case of non-literal language, the hearer must be able to distinguish what the speaker actually says from what he or she intends to convey. To understand how a hearer can interpret an ironic or false utterance, for example, one must comprehend what the hearer knows and what the speaker thinks the hearer knows. Thus, a correct interpretation of meaning relies on a correct comprehension of the speaker's intentions. SZ patients have been shown to have difficulties assessing speakers' mental states and understanding their intentions (Frith, 2004; Lee, Farrow, Spence, & Woodruff, 2004).

The ability to form representations of other people's mental states and to use these representations to understand, predict and judge their statements and behaviors is referred to as a "theory of mind" (ToM) (Baron-Cohen, Leslie, & Frith, 1985; Premack & Woodruff, 1978). Pickup and Frith (2001) showed that various studies evidencing impaired non-literal understanding in SZ patients have associated those problems with a deficit in ToM ability (Corcoran, Cahill, & Frith, 1997; Corcoran, Mercer, & Frith, 1995; Janssen, Krabbendam, Jolles, & van Os, 2003). Corcoran et al. (1995) studied the comprehension of non-conventional indirect requests (e.g., "it is cold here" meaning "close the window"); they showed that SZ participants had more trouble than normal controls performing this task, which depends on an ability to attribute mental states (ToM). The Corcoran et al. (1997) results revealed that SZ patients show a lack of appreciation of visual jokes, when understanding the humor depends upon inferred mental states but not when it depends upon non-mentalistic inferences. These results agreed with those of Frith and Corcoran (1996), who applied a ToM paradigm used in autism and showed that SZ patients had impairment in attribution of mental states. SZ patients may show poor understanding of false beliefs and deception in story-comprehension tasks (Doody, Gotz, Johnstone, Frith, & Owens, 1998; Drury, Robinson, & Birchwood, 1998; Frith & Corcoran, 1996). In addition, correlations have been evidenced between attribution of mental states (ToM) and the interpretation of non-literal language such as irony (Langdon, Coltheart, Ward, & Catts, 2002) or proverb (Brune & Bodenstein, 2005) in schizophrenia.

1.2. Relationship between pragmatic and executive dysfunction

Executive functions include set switching, strategic uses of memory, selective focusing of attention, strategic planning for the future, multi-tasking/scheduling, and inhibitory control (Stone, Baron-Cohen, & Knight, 1998). Given that the executive function (EF) system coordinates behavior and enables people to use their cognitive abilities flexibly in a variety of different situations, and considering that the "rules" of conversation change with the context in which each particular conversation occurs, it appears that an intact EF system is necessary for normal individuals to engage in motivated, adaptive and effective communication. Barkley (2001) postulated a link between executive functions and communication and social behavior. Very few studies of non-literal language understanding in schizophrenia have evaluated participants' executive functions (Brune & Bodenstein, 2005; Janssen et al., 2003; Langdon et al., 2002; Sponheim, Surerus-Johnson, Leskela, & Dieperink, 2003). Among those that have tested executive functions, most evaluated inhibition and they did not necessarily find any correlation between lack of inhibition and a deficit in non-literal language understanding (Langdon et al., 2002). Brune and Bodenstein (2005) and Sponheim et al. (2003), on the other hand, found a correlation between reduced flexibility and the ability to understand proverbs. These results underlie the difficulty to confirm or infirm hypotheses of a relationship between pragmatic impairments and executive dysfunction. Until now, there has been no clear answer as to the relationship between the ability to understand pragmatic aspects of language and executive functions. The literature remains contradictory, with some studies showing an association between pragmatic performance and executive functions (Channon & Watts, 2003) whereas others, in different populations, did not (Martin & McDonald, 2005). Such absence of consensus probably relies on the different tasks and different types of pragmatic language used to assess pragmatic processing in these studies.

In summary, patients with schizophrenia have been shown to have impaired communicative abilities. The ability to communicate depends on high-level capacities through which different cognitive systems interact. Thus, impairment of one or more cognitive levels should entail a deficit in non-literal language understanding. While hypotheses related to a deficit in ToM and/or an executive dysfunction have been proposed to account for these deficits, no studies have focused specifically on the relationship between non-literal language understanding, ToM abilities and executive functions in schizophrenia. The aim of this study was, therefore, to explore whether pragmatic deficits do or do not coexist with ToM impairments and/or impairments of executive functions in schizophrenia. To this end, pragmatic abilities were assessed with two types of non-literal language: metaphor and indirect request understanding. Given that all types of non-literal language did not have the same communicative function and comprehension demands, we supposed that the absence of consensus concerning the relationship between pragmatic and executive functions and ToM ability might rely on the different types of non-literal language used to assess pragmatic processing. For example, to understand a metaphor, the listener must have knowledge about the source and target domains in order to recognize similarities between them (Winner & Gardner, 1993). Unlike the processing of indirect request, the processing of metaphor may not require taking into account the speaker's intention and belief in order to reject the nonsensical literal meaning (Colston & Gibbs, 2002).

2. Method

2.1. Participants

Twenty individuals (15 males, 5 females) with a DSM-IV diagnosis of schizophrenia were recruited from the *Hôpital du Sacré-Cœur de Montréal* and from the *Hôpital Louis-H. Lafontaine*. All patients were stable and on antipsychotic medication with a normal recommended range of dosage (mainly olanzapine, risperidone, and quetiapine). The mean duration of illness in the patients was 15.2 years (S.D. ±10.6) (cf. Table 1). Psychopathology was measured using the Positive and Negative Symptom Scale (PANSS; Kay, Fiszbein, & Opler, 1987). The patients' mean age at time of assessment was 42.7 years (S.D. ±12.6) and the mean years of education amounted to 11.5 (S.D. ±2.9). The comparison control group consisted of 20 healthy control subjects matched to the SZ patients for age and educational level, with no history of psychiatric disorders (cf. Table 1). They were recruited from the community. The SZ

Table 1
Demographic, clinical and neuropsychological data on individuals with schizophrenia and healthy control participants.

	Schizophrenia		Healthy control		*p*-Value
	Mean	S.D.	Mean	S.D.	
Age	42.7	12.6	43.4	12.1	.742
Educational level	11.5	2.9	12.5	2.5	.271
Gender (male/female)	(15/5)		(11/9)		
Duration of illness	15.2	10.6			
PANSS (positive)	19.0	6.4			
PANSS (negative)	19.2	5.0			
PANSS (general)	40.0	8.9			
NART	45.4	9.6	42.7	8.0	.073
Fluency	35.4	12.6	40.9	13.9	.213
Stroop (completion time)	29.7	11.4	27.7	9.6	.567
Hayling (inhibition condition)	12.3	1.2	12.8	.9	.303
Trail A (completion time)	46.1	15.6	32.2	9.6	.002
Trail B (completion time)	111.1	42.9	64.2	19.5	<.0001
WCST (categories)	3.2	2.2	5.9	.3	<.0001
WCST (% perseverative errors)	37.1	27.1	5.4	2.7	<.0001

and control groups did not differ significantly with regard to age ($t(38) = -.33$, $p > .05$), educational level ($t(38) = -1.12$, $p > .05$) or IQ measured by the NART (Nelson, 1982) ($t(38) = 1.8$, $p > .05$). All participants were right-handed and native French-speakers with no previous neurological history.

Written consent forms were obtained from all participants. All participants' data included in this study were obtained in compliance with regulations of the University of Montreal, the Hôpital du Sacré-Cœur de Montréal, and the Hôpital Louis-H. Lafontaine. This research adheres to the ethical guidelines set out by these institutions.

2.2. Procedure

All participants were tested individually over two sessions in a quiet room. Tasks were administrated to all participants in random order.

2.3. Executive functions assessment

Participants were evaluated on their executive functioning (e.g. inhibition, set shifting, flexibility, verbal fluency) with standardized neuropsychological tests (Spreen & Strauss, 1998). The following tests were administered to determine: 1) their ability to inhibit irrelevant visual information with the classical Stroop test (Stroop, 1935) and verbal information with the French version of the Hayling test (Rouleau, 1998). In the inhibition condition of the Hayling test, participants were asked to complete predictable sentences (*Most cats see very well at…*) with a word that fills the gap, does not make sense and is unrelated to the expected ending; 2) their ability to shift from one set to another with the Trail-making test (Reitan & Wolfson, 1993); 3) their flexibility, with the Wisconsin Card Sorting Test (WCST) (Heaton, 1981). Number of perseverations was recorded as a measure of flexibility. 4) Participants were also evaluated on their verbal fluency, i.e. number of words beginning with the letter P, L, T, with the Neurosensory Center Comprehensive Examination for Aphasia (NCCEA) (Spreen & Benton, 1977).

Participants followed the standard protocol for the administration of the executive functioning tasks. Number of errors and/or times was recorded according to guideline of each test.

2.4. Pragmatic assessment

Participants were tested on their metaphor and indirect request comprehension since we supposed that different cognitive abilities were implied in these two types of non-literal language. They were given the metaphor comprehension sub-test and the indirect requests comprehension task from

a standardized protocol, the *Montréal Evaluation de la Communication* protocol (Joanette, Ska, & Côté, 2004). The protocol has been validated and norms are available for different age and education levels.

2.4.1. Metaphor comprehension task

Patients were asked to explain 10 idiomatic metaphors such as *mon ami a le coeur gros* ('my friend has a heavy heart') versus 10 non-idiomatic (new) metaphors such as *cet autobus est une tortue* ('this bus is a turtle'). If they were not able to give the correct answer, a multiple choice was proposed, including the literal interpretation, a non-literal correct interpretation and an incongruent interpretation.

2.4.2. Indirect request comprehension task

Participants were asked to explain 20 utterances presented either after a context suggesting a literal interpretation or after a context implying a non-literal interpretation of the utterance such as an indirect request (see example in Appendix). If they were not able to give the correct answer, a multiple choice cue was proposed, including the literal interpretation and a non-literal correct interpretation.

In these two tasks, answers were scored according to the *Montréal Evaluation de la Communication* guideline. Answers were scored 0, 1 or 2, with 2 being awarded for a full and explicitly correct answer and 1 for a partial or implicit answer for a maximum score of 20 per category (idiomatic metaphor, non-idiomatic metaphor, non-literal interpretation: indirect request, literal interpretation).

2.5. Theory of mind (ToM) assessment

Participants had to read aloud 18 stories requiring attribution of false belief.[1] After that, they had to answer three questions: a question about the attribution of mental state (Ment-Q) in order to judge participants' ability to make inferences about protagonists' mental states (ToM), that is, to understand that the protagonist might have a false belief; a factual question (Fact-Q) in order to evaluate participants' understanding of relevant information in the given context; and an inferential question (Inf-Q) in order to assess participants' general inferential abilities. Indeed, a problem with the processing of general inferences is often suggested to explain problems attributing mental states to others. This last question did not require attribution of mental state but only general inference.

The stories were of two levels of complexity, involving the attribution of either first-order or second-order mental state (see example in Appendix). These were randomly presented. Answers were recorded and scored 0, 1 or 2, with 2 being awarded for a full and explicitly correct answer and 1 for a partial or implicit answer.

3. Results

t-Tests were performed on pragmatic and neuropsychological data. Repeated measures ANOVA was performed on ToM data. Given multiple testing, the threshold of significance was set to $p < .01$.

3.1. Pragmatic assessment

The results revealed significant differences between the two groups for non-idiomatic metaphor understanding ($t(38) = -5.79$, $p < .0001$), idiomatic metaphor understanding ($t(38) = -4.20$, $p < .0001$), and indirect requests understanding ($t(38) = -4.35$, $p < .0001$). No differences were found between groups for the understanding of literal interpretation ($t(38) = -1.50$, $p > .05$).

The results of the pragmatic evaluation showed that SZ patients perform worse than normal control participants specifically on non-literal language (non-idiomatic metaphor, idiomatic metaphor, indirect request) by contrast to literal language (cf. Fig. 1).

[1] Originally, there were 20 stories – 10 in the first-order condition and 10 in the second-order condition. Due to their complexity, two stories in the second-order condition were eliminated.

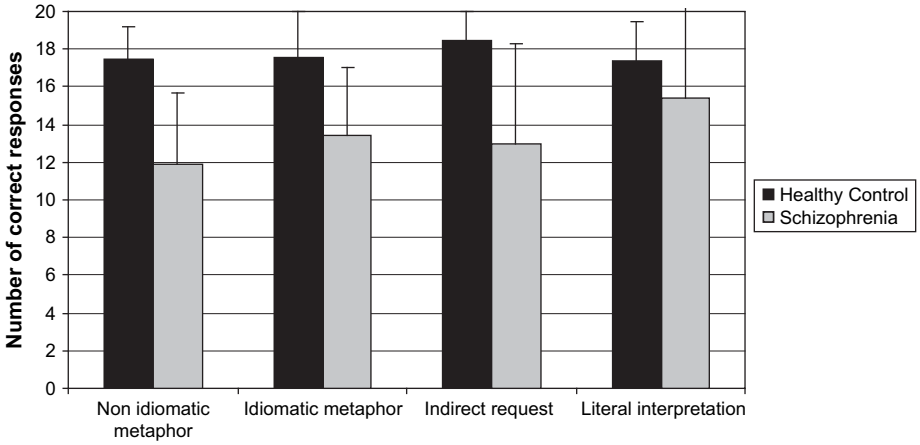

Fig. 1. Pragmatic assessment in SZ and HC groups.

3.2. ToM evaluation

A $2 \times 2 \times 3$ repeated measures ANOVA was performed on the ToM data: group (SZ, HC) $\times$ complexity level (first order, second order) $\times$ type of question (Ment-Q, Fact-Q, Inf-Q). The results showed a main effect of group ($F(1,38) = 23.43$, $p < .0001$), where SZ participants performed worse than HC participants, and a main effect of type of question ($F(2,76) = 107.24$, $p < .0001$). There was no main effect of complexity ($F(1,38) = 5.47$, $p > .01$). The group $\times$ complexity $\times$ type of question interaction was significant ($F(2,76) = 10.36$, $p < .001$). The group $\times$ type of question ($F(2,76) = 7.11$, $p = .004$) was also significant. The group $\times$ complexity interaction was not significant ($F(1,38) = .10$, $p > .05$). Decomposition of the interaction group $\times$ type of question revealed that in first-order condition, SZ patients made significantly more errors than healthy control participants on Ment-Q ($p < .0001$) and on Inf-Q ($p < .01$) while no difference was found between groups for Fact-Q ($p > .05$) (cf. Fig. 2). The same differences were found between groups in second-order condition.

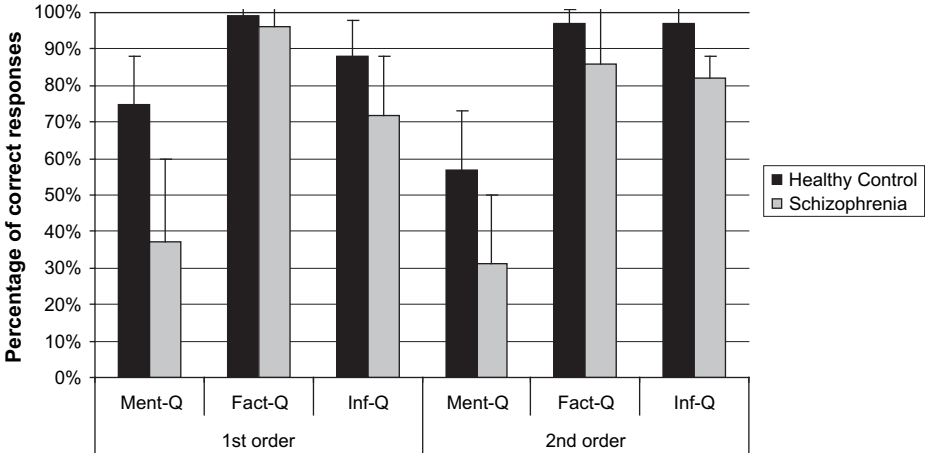

Fig. 2. ToM assessment in SZ and HC groups. Ment-Q: question about the attribution of mental state; Fact-Q: factual question; Inf-Q: inferential question. Stories were presented in two levels of complexity: first order and second order.

To sum up, results of the ToM evaluation showed that SZ participants performed worse than HC participants on Ment-Q and Inf-Q while they performed as HC participants on Fact-Q in both levels of complexity.

3.3. Executive functions evaluation

t-Tests were performed on executive functions performance (Fluency, Stroop, Hayling, Trail-making A & B and WCST) between the two groups. The results revealed a significant effect only for Trail-making A ($t(38) = 3.21$, $p < .01$), Trail-making B (time) ($t(38) = 4.34$, $p < .0001$), WCST (category) ($t(38) = -5.09$, $p < .0001$), and WCST (perseverative errors) ($t(38) = 4.30$, $p < .0001$). No statistical differences were found for the other tests (cf. Table 1). Thus, the SZ group performed significantly worse than the control group on tests that evaluate set shifting and flexibility.

3.4. Relationship between pragmatic, ToM and executive function performances

A non-parametric correlation analysis (Spearman correlation) performed in both patient and control groups, revealed that performance on new metaphor understanding, idiomatic metaphor understanding and indirect request understanding correlated significantly with performance on the number of categories in the WCST, and the number of perseverative errors in the WCST. Performance on new metaphor understanding and idiomatic metaphor understanding correlated with performance on Trail-making B. Performance on idiomatic metaphor understanding also correlated with performance on Fluency and on the Hayling test. As expected, no correlation was found with understanding of literal interpretation. Performance on first-order ToM and second-order ToM correlated with performance on Fluency, Hayling, Stroop, Trail-making B, number of categories in the WCST, and number of perseverative errors in the WCST (cf. Table 2). No significant correlation was found in the patient or healthy control group alone.

3.5. ANCOVA on pragmatic data

Given that differences were found between groups for ToM performances (mainly Ment-Q) and flexibility assessed by the WCST and the Trail-making B, two sets of one-way ANCOVAs were performed on pragmatics data to determine whether flexibility and/or ToM ability could play a role in the SZ participants' performances on pragmatic assessment. The first one-way ANCOVAs were performed on non-idiomatic metaphor, idiomatic metaphor, indirect request and literal interpretation data with performances on the first- and second-order Ment-Q of the ToM task as covariates. After adjustment by the covariate Ment-Q, the difference between SZ and HC participants was no more significant for idiomatic metaphor and indirect request while the difference remained significant for non-idiomatic metaphor. The absence of significant difference between groups initially obtained for literal interpretation remained (cf. Table 3). The second one-way ANCOVAs were performed on non-idiomatic metaphor, idiomatic metaphor, indirect request and literal interpretation data with WCST (category), WCST (perseverative errors) and Trail-making B (time) as covariates. Results of these analyses showed that difference between HC and SZ participants on indirect request understanding, idiomatic and non-idiomatic metaphor understanding remained significant after adjustment by the covariates WCST

Table 2
Correlation analyses in both schizophrenia and healthy control group.

	Fluency	Stroop (time)	Stroop (errors)	Hayling test	Trail-making B (time)	WCST (categories)	WCST (perseverative errors)
New metaphor	.31	−.17	−.16	.30	−.50**	.71**	−.79**
Idiomatic metaphor	.45**	−.09	.03	−.39*	−.43*	.58**	−.59**
Indirect request	.07	.02	.05	.16	−.26	.31*	−.44**
Literal interpretation	.27	−.09	.09	−.24	.14	.03	.07
ToM – first order	.41*	−.45*	−.40*	.51**	−.76**	.69**	−.62**
ToM – second order	.55**	−.42*	−.24	.60**	−.65**	.70**	−.56**

*$p < .05$; **$p < .01$.

Table 3
Results of covariance analyses on pragmatic data.

	ANCOVA	
	F-value	*p*-Value
Ment-Q as covariate		
Non-idiomatic metaphor	7.86	.01
Idiomatic metaphor	1.60	.22
Indirect request	1.08	.31
Literal interpretation	.31	.58
WCST (cat), WCST (perseverative errors), Trail B as covariate		
Non-idiomatic metaphor	7.34	.01
Idiomatic metaphor	4.98	.03
Indirect request	13.06	.001
Literal interpretation	.22	.64

(category), WCST (perseverative errors) and Trail-making B (time) (cf. Table 3). The absence of significant difference between groups initially obtained for literal interpretation remained using WCST (category), WCST (perseverative errors) and Trail-making B (time) as covariate.

Taken as a whole, these results suggested that the difference between groups initially obtained for indirect request and idiomatic metaphor might be due to the differences in the cognitive processes believed to underlie performance on Ment-Q assessment, while flexibility did not seem to play a role in performances of SZ participants for pragmatic.

3.6. Relationship between symptomatology, demographic information and pragmatic performances

A non-parametric correlation analysis (Spearman correlation) performed in the patients group revealed no correlation between pragmatic assessment and age, educational level, number of illness, score on PANSS positive, negative and general (cf. Table 4).

4. Discussion

The aim of this study was to explore the relationship between pragmatic understanding – as assessed by the comprehension of metaphors and indirect requests – executive functions and ToM ability in schizophrenia. The main results confirmed that SZ participants had specific difficulties understanding non-idiomatic and idiomatic metaphors and indirect requests while they performed as well as HC participants on literal interpretation condition. Results also evidenced a ToM deficit and a lack of flexibility in SZ participants, as assessed by the WCST and the Trail-making B.

4.1. Relationship between pragmatic deficit and executive dysfunctions

Analyses of covariance suggested that no relationship exists between this lack of flexibility and non-literal language understanding (indirect request, metaphor understanding). This result is consistent

Table 4
Correlation analyses in schizophrenia.

	Age	Educational level	Duration of illness	PANSS positive	PANSS negative	PANSS general
Non-idiomatic metaphor	$r = .03$; $p = .90$	$r = .21$; $p = .38$	$r = -.12$; $p = .63$	$r = -.28$; $p = .25$	$r = -.48$; $p = .05$	$r = -.33$; $p = .17$
Idiomatic metaphor	$r = .15$; $p = .52$	$r = -.13$; $p = .58$	$r = .15$; $p = .55$	$r = -.18$; $p = .46$	$r = -.47$; $p = .05$	$r = -.25$; $p = .31$
Indirect request	$r = .06$; $p = .80$	$r = .19$; $p = .41$	$r = -.16$; $p = .54$	$r = -.20$; $p = .42$	$r = -.20$; $p = .42$	$r = -.32$; $p = .18$
Literal interpretation	$r = -.06$; $p = .82$	$r = -.55$; $p = .02$	$r = .31$; $p = .23$	$r = .23$; $p = .37$	$r = .12$; $p = .63$	$r = .15$; $p = .56$

with earlier studies in schizophrenia (Langdon et al., 2002) or on different populations (Martin & McDonald, 2005) that found co-occurrence of executive dysfunction and pragmatic deficits without correlation between them. Martin and McDonald (2005), for example, found traumatic brain injury patients to have reduced flexibility. However, this lack of flexibility was not significantly associated with their ability to distinguish irony from deceit. Langdon et al. (2002) showed evidence in patients with schizophrenia for a lack of inhibition not associated with irony or metaphor understanding. Brune and Bodenstein (2005) and Sponheim et al. (2003) found correlations between lack of flexibility and impaired proverb interpretation. However, they performed regression analyses and evidenced that ToM performances best predict impairments in proverb interpretation than lack of flexibility. It seems that pragmatic deficits cannot be completely explained by executive dysfunction.

4.2. Relationship between pragmatic and ToM deficits

Analyses of covariance pointed out that differences found between groups for non-literal conditions (indirect request, idiomatic metaphor) seemed to depend on participants' performances on ToM task (Ment-Q). This finding, in particular for indirect request, is congruent with other researches that found a relationship between ToM and pragmatics in schizophrenia (Langdon et al., 2002) and in other clinical populations such as individuals with right-hemisphere lesions, autism and traumatic brain injury (Champagne-Lavau & Joanette, 2009; Happé, 1993; Winner, Brownell, Happe, Blum, & Pincus, 1998). These results confirm the hypothesis that pragmatic interpretation is a *mind-reading* exercise involving inferences concerning the speaker's mental state (Grice, 1969). The speaker's intention plays a specific role in understanding pragmatic aspects of language, particularly in the comprehension of irony and indirect requests.

The relationship found between ToM and idiomatic metaphor processing is consistent with the result of Brune and Bodenstein (2005) who found that ToM ability was the best predictor of proverb interpretation performances in schizophrenia. However, such link was surprising since metaphor processing, according to psycholinguistic theory, may not require taking into account the speaker's intention. Brune and Bodenstein (2005) argued for different levels of non-literal complexity but idiomatic metaphor is expected to be easier to process than indirect request or non-idiomatic metaphor. Indeed, according to Giora (2002), idiomatic and non-idiomatic metaphors are supposed to require different processes to be understood. Idiomatic metaphor would be coded in the mental lexicon by contrast to non-idiomatic metaphor. Therefore, non-idiomatic metaphor should require a literal interpretation by contrast to idiomatic metaphor.

However, the different results found for indirect request and non-idiomatic metaphor confirm psycholinguistic hypotheses according to which indirect request and metaphor understanding probably rely on different cognitive processes taking into account the speaker's intention or not (Winner & Gardner, 1993). Indeed, metaphor describes or shows something in a different way, whereas indirect request, as irony, tells something about the speaker.

4.3. Right-hemisphere-dependant mechanism or involvement of the prefrontal cortex

Lesion studies (Mitchell & Crow, 2005; Myers, 1998) suggested that right-hemisphere-dependent mechanisms are particularly involved when understanding pragmatic aspects of language which go beyond syntax and vocabulary comprehension. However, literature on neuroimaging of metaphor processing remains controversial; some studies show a specific role of the right hemisphere for pragmatic processing (Lee & Dapretto, 2006; Mashal, Faust, Hendler, & Jung-Beeman, 2007) whereas others did not (Kircher, Leube, Erb, Grodd, & Rapp, 2007; Rapp, Leube, Erb, Grodd, & Kircher, 2007).

More interestingly, neuroimaging studies in healthy and SZ participants give more and more evidence for an involvement of the prefrontal cortex in pragmatic, ToM and executive tasks involving set shifting. Gallagher et al. (2000) showed in their fMRI study, that the medial prefrontal cortex, known to be involved in ToM tasks, was activated in metaphor comprehension tasks. Evidence for an abnormal haemodynamic response in this brain region has been found in SZ patients relative to healthy participants during ToM task (Brunet-Gouet & Decety, 2006). In addition, Bonilha et al. (2008) evidenced that a prefrontal cortical atrophy was associated with poorer performances on WCST and

Trail-making B in SZ patients. They measured a significant decreased volume of gray matter in prefrontal cortex in SZ patients. More precisely, under-activation has been found in dorsolateral prefrontal cortex when SZ patients performed the WCST (Weinberger, Berman, & Zec, 1986).

All these results argue for an abnormal recruitment of the medial and dorsolateral prefrontal cortex in SZ patients while they respectively perform metaphor and ToM tasks and WCST. Impairments in these different brain regions might underlie the independent deficits in pragmatic and executive functions found in SZ participants of our study. However, further researches are needed to confirm this hypothesis since no study has assessed indirect request understanding in fMRI.

The present study contains some limitations that need to be mentioned. The sample size is small. Therefore, results of the present study have to be confirmed by testing more SZ participants. Medication effects need to be controlled in further studies since our knowledge concerning possible medication effects on pragmatic abilities is still limited.

In conclusion, this study showed that SZ patients exhibit pragmatic impairments which co-occurred with a lack of flexibility and a ToM deficit. A relationship has been found between ToM and pragmatic performances (except on non-idiomatic metaphor). However, although the executive function model has been suggested to be valid, because it is probably the only model of pragmatic deficits that can account for heterogeneous verbal behavior in patients (Martin & McDonald, 2003), our study found that pragmatic deficits cannot be completely explained by executive dysfunction. These behavioural results were partially consistent with neuroimaging literature showing an impaired involvement of the prefrontal cortex in such processing in schizophrenia.

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Appendix

Sample stimuli for indirect request task (MEC, Joanette et al., 2004)

Story inducing non-literal interpretation: indirect request

Jean est dans sa chambre et écoute de la musique. Son père lui dit: «Jean, la porte de chambre est ouverte»./Jean is in his room listening to music. His father tells him: "Jean, your bedroom door is open."

Question: D'après vous, que veut dire son père?/In your opinion, what does the father mean?

Story inducing literal interpretation

Monsieur Lavoie est au salon lorsque le téléphone se met à sonner. Il dit à sa femme: «je le prends»./Mr. Lavoie is in the living room when the phone rings. He says to his wife: "I'll take it."

Question: D'après vous, que veut dire Monsieur Lavoie?/In your opinion, what does Mr. Lavoie mean?

Sample stimuli for the ToM task

First-order ToM

For the Halloween party, Marie disguises herself as a witch with a dress and a black pointy hat. She meets her friend Isabelle and takes her hat off so Isabelle will recognize her. A child dressed as a ghost appears behind Marie where Marie can't see him. Isabelle screams in terror. Marie then tells her, "Don't worry, it's me, Marie."

Ment-Q: Why does Marie say this to Isabelle?

Scoring example: Because she believes that Isabelle is afraid of her (2 pts); because she thinks that Isabelle does not recognize her (1 pt).

Fact-Q: What is Marie dressed as?

Inf-Q: Why is Isabelle screaming?

Second-order ToM

Paul has invited Simon to play at his home. Simon is clumsy. He often breaks his friends' toys. They go to Paul's bedroom. A truck is broken, but Paul does not know it. When Paul picks up the truck, Simon says, "It wasn't me who broke the truck."

Ment-Q: Why does Simon say this to Paul?

Scoring example: Because he thinks that Paul believes he has broken the truck (2 pts); because they know that when Simon is here, he always breaks toys (1 pt).

Fact-Q: Which child is clumsy?

Inf-Q: Whose toys are they?

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