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The comprehension of idiomatic expressions in schizophrenic patients

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ABSTRACT

Recent fMRI and TMS studies on idiom comprehension have shown that the prefrontal cortex is involved in idiom processing. Since schizophrenic patients exhibit prefrontal *structural* changes and dysexecutive *behavioural* deficits, we hypothesised an impairment in idiom comprehension, correlating with performance on executive tasks.

In this study, idiom comprehension was evaluated by means of a sentence-to-picture-matching task in 45 schizophrenic patients and 45 control subjects, matched for age and educational level. The task included 62 idiomatic and 62 literal sentences. Participants were presented with a written sentence, either literal or idiomatic, followed by a picture, which appeared below the sentence. They were instructed to judge whether the picture represented the meaning of the sentence or not, and responded by pressing one of two response keys. Half of the items correctly represented the meaning, half did not. Reaction times and accuracy were measured.

Schizophrenics were impaired in both types of idiomatic sentence. However, their performance was particularly poor in the case of ambiguous idioms. Wisconsin Card Sorting Test and Digit Sequencing were the unique predictors of performance for idiom comprehension in general, while thought disorganization was not. Cognitive decline either did not appear to predict performance.

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1. Introduction

Figurative language allows speakers to communicate meanings that differ in various ways from what they literally say (Gibbs, 1999). Common forms of figurative language include metaphor, metonymy, proverb, irony, hyperbole, indirect requests, and idiom. Idioms are conventionalized expressions, in that there is a relation among a linguistic regularity, a situation of use, and a population that has implicitly agreed to conform to that regularity in that situation out of a preference for general uniformity. Idioms differ from metaphors, since they have the advantage of possessing a stored meaning that can be quickly retrieved, while metaphors need to be interpreted when they are encountered (Nunberg, Sag, & Wasow, 1994). In addition, they typically appear in limited number of syntactic frames or constructions, unlike freely composed expressions (Nunberg et al., 1994), but differ along a number of semantic properties, for example semantic transparency, namely the extent to which the motivation for their structure can be recovered: *transparent* idioms can be originally metaphorical [such as *to empty the sack* (in Italian "vuotare il sacco"), meaning *to reveal something*], even if the speaker may not perceive the figure involved; conversely, an idiom is semantically *opaque*, when the speaker needs to know the stipulated meaning that cannot be derived either from the image evoked or from the constituent word meanings [such as *to make oneself a moustache* (in Italian "farsene un baffo") meaning *to take no care of, to ignore something, such as an order*]. Finally, *unambiguous* idioms do not have any well-formed literal counterpart whereas others, called *ambiguous*, do [such as *to lift the elbow* (in Italian "alzare il gomito"), meaning *to drink too much*].

For a long time, the predominant view assumed that figurative language is exclusively processed in the right hemisphere (Van Lancker & Kempler, 1987). However, recent neurophysiological and fMRI studies in neurologically- and psychiatrically-unimpaired individuals have challenged this view, both for idioms (Fogliata et al., 2007; Rizzo, Sandrini, & Papagno, 2007; Romero Lauro, Tettamanti, Cappa, & Papagno, 2008; Zempleni, Haverkort, Renken, & Stowe, 2007) and metaphors (Lee & Dapretto, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2004; Stringaris, Medford, Giampietro, Brammer, & David, 2007). Additional converging evidence is provided by neuropsychological studies, showing that right-brain-damaged patients are impaired in idiom processing only when the prefrontal cortex is involved (Papagno, Curti, Rizzo, Crippa,

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& Colombo, 2006) or are not impaired at all (Stachowiak, Huber, Poeck, & Kerschensteiner, 1977). On the other side, the most severe impairment in idiomatic comprehension is shown by aphasic patients with left temporal lesions and semantic deficits (Papagno, Tabossi, Colombo, & Zampetti, 2004). Finally, children with agenesis of the corpus callosum have difficulties in idiom comprehension (Huber-Okrainec, Blaser, & Dennis, 2005), suggesting that interhemispheric integration is extremely relevant.

All the brain regions aforementioned show some abnormality in schizophrenia. Concerning the left temporal lobe, a reversed laterality of activation in the superior temporal gyrus (Kircher et al., 2002), as well as morphological asymmetries in the superior temporal lobe (DeLisi, Hoff, Neale, & Kushner, 1994), have been reported. The deficit in the left hemispheric lateralization has been demonstrated in both chronic and first-episode schizophrenia (Bleich-Cohen, Hendler, Kotler, & Strous, 2009; Sommer, Ramsey, & Kahn, 2001; Spironelli, Angrilli, & Stegagno, 2008) and it has been hypothesised that the nuclear symptoms of schizophrenia reflect this failure to establish left hemisphere dominance (Crow, 2000). Recently, functional deficits were shown in the left medial prefrontal cortex during a language comprehension task (Dollfus et al., 2008), which is precisely the most activated region in idiom processing in healthy individuals (Romero Lauro et al., 2008). Post-mortem and functional neuroimaging investigations have provided support for a pathological process in the prefrontal cortex, although structural abnormalities appear to be subtle and circumscribed to ventral portions (Baaré et al., 1999; Crespo-Facorro, Kim, Andreasen, O'Leary, & Magnotta, 2000).

Finally, structural abnormalities in the corpus callosum and perturbed hemispheric interaction or disconnection have been reported (Chua, Sharma, Takei, Murray, & Woodruff, 2000).

Impairments are seen at all levels of language processing, but pragmatics is the level most obviously disordered (Langdon, Coltheart, Ward, & Catts, 2002; Covington et al., 2005). Different explanations have been suggested. Mitchell and Crow (2005) argued that difficulties in processing alternative meanings (such as in the case of metaphors, sarcasm, and irony) is due to the abnormal lateralization. However, their hypothesis (that does not include idioms) is based on the above mentioned old view of a right lateralization of figurative language, which has been falsified by a large number of neuropsychological, neurophysiological and neuroimaging studies (for an extensive review of the literature see Cacciari & Papagno, in press). Langdon et al. (2002) suggested that the pragmatic deficit is equivalent to formal thought disorder (FTD), a configuration of linguistic abnormalities, such as loosening of associations and impaired abstract thought, which make the speech of some psychotic patients"contaminated by idiosyncratic, peculiar, or nonsensical words or phrases" (Nestor et al., 1998). FTD could be linked to both executive and semantic functions (McGrath, 1991; Frith, 1992; Kerns & Berenbaum, 2002). Barrera, McKenna, and Berrios (2005), however, found that performance on executive tests clearly distinguished between the two clinical groups (with and without FTD), subjects with FTD being more impaired than subjects without FTD, thus supporting the dysexecutive hypothesis.

Alternatively, pragmatic language impairment has been considered as secondary to generalized cognitive decline (Linscott, 2005), since no association was found between thought disorder and pragmatic language impairment, which was instead predicted by generalized cognitive decline, as determined from discrepancies between current and pre-morbid *verbal* intelligence. However, both Linscott (2005) and Barrera et al. (2005) assessed conversational behaviour and not specific forms of figurative language comprehension.

Studies dealing more specifically with figurative language *comprehension* deficits have associated poor Theory of Mind (ToM or mind-reading: Gallagher & Frith, 2003; Premack & Woodruff, 1978) with impaired irony comprehension (Langdon et al., 2002; Stratta et al., 2007), language and communication deficits (Sarfati & Hardy-Baylé, 1999), and proverb literal interpretation (Brüne & Bodenstein, 2005). Recently, Mo, Su, Chan, and Liu (2008) investigated comprehension of metaphors in schizophrenia by examining the role of IQ and ToM. They found that comprehension of metaphors significantly correlated with second-order false belief understanding, while IQ and verbal IQ did not explain this deficit. However, two main issues need to be considered. First, as pointed out by Tavano et al. (2008), pragmatic skills are determined by a complex set of abilities relying, beyond ToM capacities, on executive functions and interhemispheric integration. Second, pragmatic, non-literal language is not a homogeneous class, and for example qualitatively distinct impairments of pragmatic comprehension have been demonstrated in the case of metaphor and appreciation of irony in schizophrenic patients (Langdon et al., 2002). Accordingly, idioms could be differently affected from metaphors and, inside the class of idioms, each type could require specific processes. Thus, further research focusing specifically on a particular class of figurative language is warranted. Since executive functions proved to be crucial in idiom processing (see for example Papagno et al., 2006), we would expect that the dysexecutive impairment in schizophrenics would predict their ability to comprehend idiomatic sentences, particularly in the case of ambiguous ones. An advantage in studying idioms is that they appear in very simple syntactic frames, avoiding confounding effects possibly due to deficits in receptive syntax, which are described in schizophrenia (Condray, Steinhauer, van Kammen, & Kasparek, 2002).

Therefore, the aim of our study was to examine idiom comprehension in stable schizophrenic patients and to assess the role of executive functions in particular. Both ambiguous and unambiguous idioms, with a comparable degree of transparency, were tested. The hypotheses were that (i) performance on idiom comprehension should be impaired, especially in the case of ambiguous ones, which require the inhibition of the plausible literal meaning (Iakimova, Passerieux, & Hardy-Baylé, 2006; Titone, Holzman, & Levy, 2002); (ii) idiom comprehension should be affected either by dysexecutive deficits or by cognitive decline or both. Alternatively, the impairment could be secondary to thought disorders; (iii) the schizophrenics' performance on idioms, especially ambiguous ones, should correlate with negative symptoms, since executive function impairment (assessed by means of the Wisconsin Card Sorting task or verbal fluency) seems to be associated with negative symptoms (Berman et al., 1997).

2. Materials and methods

2.1. Materials

Sixty-two Italian idioms and 62 literal Italian sentences were selected for this study (see also Romero Lauro et al., 2008 for a previous application of this test to a healthy population). Thirty idioms were ambiguous (the literal interpretation was plausible) and 32 were not (the literal interpretation was not plausible). A group of 101 subjects of different age (range 22–65), from different regions of Italy, judged all idioms as highly familiar. The degree of transparency was checked by asking 30 healthy subjects (mean age 26, range 20–32) to rate how easily the meaning of the idiom could be inferred from the concrete image evoked by the sentence: a score ranging from 0 to 5 was assigned, where 0 meant "not at all" and 5 "entirely". This index varied between 1.9 (item 55) and 4.4 (item 16) (mean 3.1, SD 0.6) (see Appendix A). Idioms were presented in a syntactically simple sentence formed by a subject followed by the idiomatic string (e.g. "she has a green thumb") and literal sentences were matched for syntactic complexity and length. For each sentence, be it literal or idiomatic, a line-drawing picture was created. Half of these pictures correctly represented the meaning of the sentence, half did not. In the case of idioms, the correct picture represented the figurative meaning, e.g. for the idiom "to have a green thumb", the picture represented a woman well taking care of plants (Fig. 1A). The wrong picture represented the opposite of the figurative meaning, e.g. for the idiom "tirare la cinghia" (to pull the belt, meaning "to starve, being very poor") the picture represented a rich man eating (and paying) a lot in a restaurant (Fig. 1B). The 30 healthy subjects who rated transparency were also asked to rate how closely the picture corresponding to the idiomatic meaning represented the idiom or its

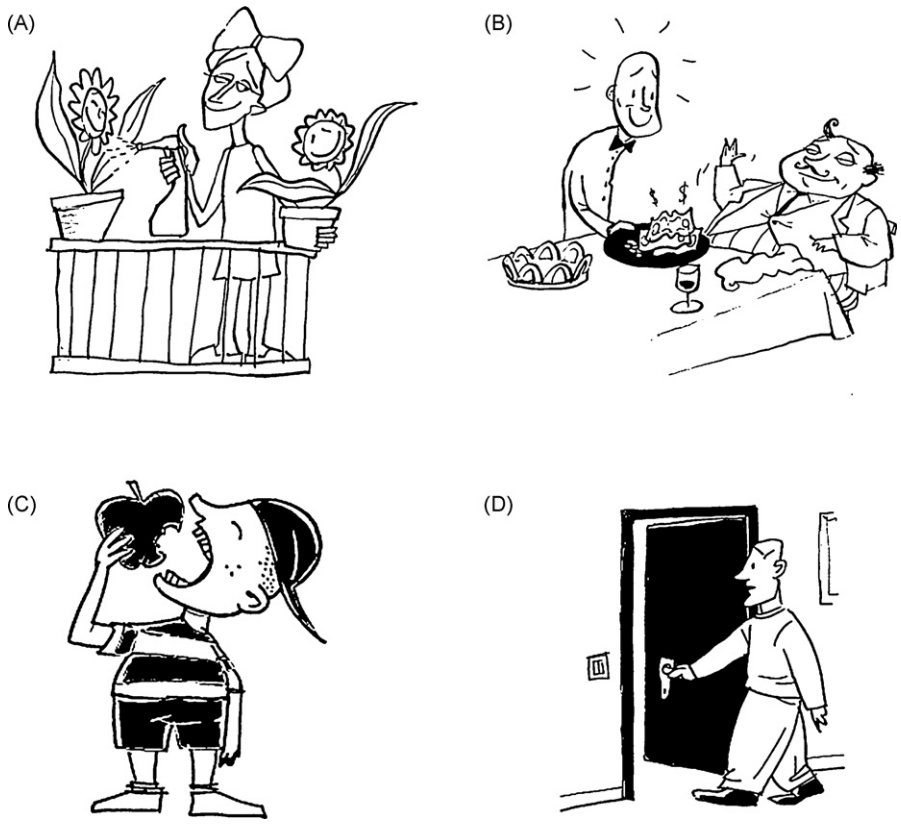

Fig. 1. Examples of the pictures used in the experimental task. A is a correct picture for the idiom "avere il pollice verde"(to have a green thumb). B is a wrong picture representing the opposite of the idiomatic meaning of "tirare la cinghia" (to pull one's belt, meaning "to starve, being very poor"). C is a correct picture for the literal sentence "the boy is eating an apple". D is a wrong picture for the literal sentence "the man is opening the window".

opposite. A score ranging from 0 to 5 was assigned, where 0 meant "not at all" and 5 "perfectly". The mean score for idiomatic relatedness was 3.6 (range 1.6–4.8, SD 0.7). In the case of literal sentences, the correct picture exactly matched the sentence (such as in Fig. 1C), whereas the wrong picture differed in one element, e.g. for the sentence "the man opens the window" the wrong picture represented a man opening a door (see Fig. 1D).

2.1.1. Participants

Forty-five (23 male and 22 female, mean age 39 years, range 18–69, SD 10.2) chronic outpatients with schizophrenia (DSM-IV; APA, 1994), clinically assessed using the Positive and Negative Symptom Scale (PANSS; Kay, Fiszbein, & Opler, 1987), were recruited from the Psychiatric Rehabilitation Unit of the San Raffaele Hospital in Milan. Patients who had been treated with a stable dose of the same antipsychotic therapy for at least 6 months, responsive and clinically stabilized, with no (or only minimal) productive symptoms, were included in the study; in addition, there was no evidence of substance dependence or abuse, comorbid diagnosis on Axis I or II, epilepsy, or any other major neurological illness or perinatal trauma. A control group of 45 healthy volunteers were matched one-by-one for social environment, sex, age (±2) and education (±2) with the patient group. All subjects were right handed (Oldfield, 1971) and native Italian speakers. Exclusion criteria for controls were past or present neurological/psychiatric illness and presence of psychiatric illness in first degree relatives. They were recruited through general practitioners and examiners' acquaintances. Patients had a general IQ > 70 (as assessed by means of the WAIS) and a mean education of 12 years (range 8–18, SD 2.6), the mean duration of their illness was 13 years (SD 8.7), and all of them were on stable doses of atypical antipsychotic single medication, except for three patients who were on aloperidol therapy. For 38 patients the "Test di Intelligenza Breve" (TIB; Sartori, Colombo, Vallar, Rusconi, & Pinarello, 1997) was available. This task is an Italian version of the National Adult Reading Test (NART; Nelson, 1982), used as an index of pre-morbid intellectual functioning.

Executive functions were assessed by means of three tasks: the Wisconsin Card Sorting Task (WCST; Milner, 1963), the Tower of London (Shallice, 1982) and the Digit Sequencing Task, part of the Brief Assessment of Cognition in Schizophrenia (BACS; Keefe et al., 2004); these tests are supposed to tap different aspects of executive functions (set shifting, planning and working memory, respectively).

To assess the role of disorganization symptoms, an additional Disorganization Symptom (DIS) measure was computed adding the scores obtained in a selected subgroup of PANSS items (N7-stereotyped thinking, G11-poor attention, G10-disorientation, P2-conceptual disorganization, N5-difficulty in abstract thinking, G5-mannerism and posturing, G12-lack of judgement and insight, G13-disturbance of volition, G15-preoccupation, and G9-unusual thought content), according to the procedure suggested by Van der Gaag et al. (2006). Also individual scores on P2 and N5 were considered. For 26 patients, the Thought and Language Index (TLI) was also available (Liddle et al., 2002).

Permission for the study was obtained from the local ethical committee. After a complete description of the study to the subjects, written informed consent was obtained.

2.1.2. Procedure

The experiment was run in four blocks, each comprising 30 trials, preceded by four examples. In each trial the participant was presented with a sentence, either literal or idiomatic, in the upper part of the screen, followed after 2 s by a picture: the picture and the sentence remained on the screen for 5 s, during which the participant had to judge, by pressing a key on the keyboard, whether the picture correctly represented the meaning of the sentence. Subjects were instructed that sentences could have a figurative or literal meaning. Accuracy and response times were recorded by the program (Presentation 11.0, Neurobehavioral Systems, Albany, CA). After the experiment, participants were asked to rate their idiom knowledge/familiarity by giving an oral explanation.

2.2. Statistical analyses

Each correct answer in the idiom comprehension task was assigned 1 point. Statistical analyses were then performed by means of General Linear Models (GLMs), in accordance with the measurement scale of explanatory variables: therefore, the effects of group (patients and matched controls) and type of sentence on accuracy and RT were studied in a repeated-measure MANCOVA, after removing confounding effects possibly accounted on performance by covariates such as age, education, and sex; linear regressions were performed to assess the role of familiarity, picture relatedness and transparency on accuracy. Since accuracy scores were expressed as percentages of correct answers, all the analyses were performed on their arcsine square root transformation for stabilizing the variance of the response variable. Adjustments for multiple comparisons and multiple testing were applied when needed. In particular, the overall significance level of ANCOVA models was controlled for, when further insight with multiple comparisons, besides main effects, was to be pursued. In addition, when two (or more) responses were related to the same set of explanatory variables, a multivariate model, such as a MANCOVA model,

was applied, since multivariate models control for global significance level of testing on multiple outcomes in addition to allowing for covariance between dependent variables.

In order to evaluate the unique contribution of executive functions, thought disorganization and intellectual abilities to idiom comprehension and to investigate the effects of idiom properties (literal plausibility, picture plausibility, familiarity, transparency), linear regression analyses were carried out. Each regression fitted a model with a single explanatory variable, so as to assess its unique contribution to idiom comprehension accuracy.

The level of significance for all the analyses was set at 0.05.

3. Results

Demographical and clinical data as well as results of the executive tasks, PANSS and WAIS scores are listed in Table 1.

3.1. Performance on idiom comprehension

Mean percentages of correct responses for patients and controls in the sentence comprehension task are reported in Table 2. Patients produced 75.74% (SD 13.96) and 90.68% (SD 10.69) correct responses, respectively, in the case of idioms and literal sentences, while controls produced 93.1% (SD 4.66) correct responses for idiomatic and 96.9% (SD 3) for literal sentences.

Patients produced generally slower responses and performed significantly worse than controls, according to a repeated-measure MANCOVA on reaction times (RT) and accuracy as dependent variables, with group (patients vs. controls) and sentence type (idioms vs. literal sentences) as within factors. In the case of RT, there was a significant main effect of group [$F(1, 44) = 25.26$, $p < 0.001$, Cohen's $d = 0.63$] and sentence type [$F(1, 44) = 39.07$, $p < 0.001$, $d = 0.94$], since responses were faster for literal than idiomatic sentences. The interaction 'group × sentence' was not significant [$F(1, 44) = 0.674$, $p = 0.42$], showing similar differences in RT of both patients and controls in the two sentence types. No effects of age, education or sex, included as covariates in the analysis, emerged [$F(1, 40) = 1.63$, $p = 0.21$; $F(1, 40) = 0.424$, $p = 0.66$; $F(1, 40) = 1.486$, $p = 0.24$, respectively]. Also in the case of accuracy, the main effect of group (patients vs. controls) was significant [$F(1, 44) = 41.5$, $p < 0.001$, $d = 1.1$]: patients produced 83.2% of correct responses, while controls' correct responses were 94.9%. The main effect of sentence type (literal vs. idiomatic) was significant [$F(1, 44) = 137$, $p < 0.001$, $d = 0.83$]: in the case of idioms 84.4% of responses were correct, while in the case of literal sentences correct responses were 93.8%. The interaction 'group (patients versus controls) × sentence (literal versus idiomatic)' was also significant [$F(1, 44) = 23.9$, $p < 0.001$, $d = 0.51$]: patients performed significantly worse than controls in both literal [$F(1, 44) = 16.7$, $p < 0.001$, $d = 0.76$] and idiomatic sentences [$F(1, 44) = 59.8$, $p < 0.001$, $d = 1.70$]. Overall, patients and controls produced more errors with idioms than with literal sentences; however, while for controls the difference between errors in the two types of sentence was of four items, in the case of patients this difference was of 11. Again, no effects of age, education or sex emerged [$F(1, 41) = 0.846$, $p = 0.36$; $F(1, 41) = 0.021$, $p = 0.88$; $F(1, 41) = 2.92$, $p = 0.095$, respectively].

In order to check whether the results were due to a subset of especially low performing patients, we verified how many patients had a score lower than 2 SD from the mean. Only two patients with such a score were found. The results did not change when they were removed from the analyses. Similarly, no particular items contributed to the results, since errors were equally distributed. Only for one unambiguous item there was a mean accuracy score (30 out of 45 responses) lower than 2 SD from the mean accuracy score (34, SD 6). The analyses did not change removing it. Moreover, also in the case of controls the mean accuracy score (34) for that item was lower than 2 SD from the mean idiom accuracy (mean 48, SD 2).

Finally, item analysis for patients did not show a significant difference between ambiguous and unambiguous items [$t(58) = -1.53$; $p = 0.13$].

The linear relation between response time and accuracy was significant for both idiomatic [$t(44) = 2.06$, $p < 0.05$] and literal sentences [$t(44) = 2.021$, $p < 0.05$] in the case of patients, but also for controls [$t(44) = 4.091$, $p < 0.001$ and $t(44) = 2.46$, $p = 0.018$, respectively].

Table 1
Clinical and demographic data of the schizophrenic patients.

	Mean	Min.	Max.	SD
Sex	M = 23; F = 22			
Age (years)	38.95	18	69	10.18
Education (years)	12.04	8	18	2.59
Years of illness	13.13	1	36	8.69
PANSS (Positive Scale)	16.14	7	34	5.80
PANSS (Negative Scale)	22.19	10	31	4.95
PANSS (General Psychopatology Scale)	35.46	24	65	10.19
PANSS (Total Score)	73.78	47	126	16.57
DIS	26.08	15	45	6.33
WAIS-R (Verbal Scale)	90.80	66	123	13.36
WAIS-R (Performance Scale)	83.93	67	116	12.13
WAIS-R (Total Score)	86.43	70	121	11.20
BACS (Working Memory Test)	16.20	5	27	5.12
Wisconsin Card Sorting Test	15.93	0	38	9.90
London Tower Test	12.24	2	22	3.88

M = male; F = female; DIS = Disorganization Symptom measure.

Table 2
Mean percentage of correct responses for schizophrenic patients and controls in the sentence-to-picture-matching task.

	Patients				Controls			
	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD
Idiomatic sentences	75.74	33.33	98.33	13.96	93.07	80.00	100.00	4.66
Ambiguous idiomatic sentences	73.03	34.48	96.55	17.37	91.80	75.86	100.00	6.29
Unambiguous idiomatic sentences	78.28	32.26	100.00	14.56	94.26	70.97	100.00	5.83
Literal sentences	90.68	41.94	100.00	10.69	96.88	85.48	100.00	3.01
True literal sentences	92.97	29.03	100.00	11.62	96.41	77.42	100.00	4.42
False literal sentences	88.39	51.61	100.00	12.33	97.35	87.10	100.00	3.10

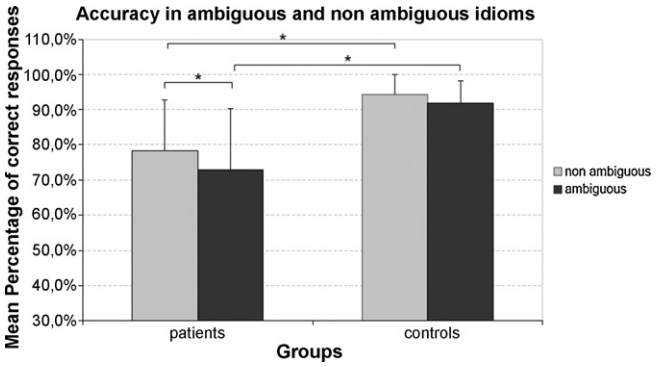

Fig. 2. Patients' and controls' mean percentage of correct responses for ambiguous and unambiguous idioms. *Significant difference.

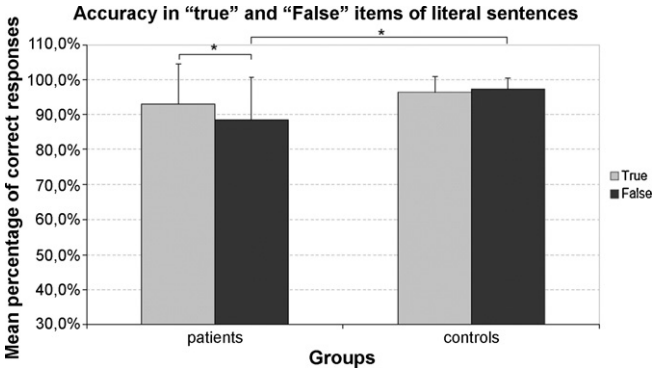

Fig. 3. Patients' and controls' mean percentage of correct responses for "true" and "false" items of literal sentences. *Significant difference.

The linear relation between accuracy and years of illness in the schizophrenic sample was significant both for idiomatic [t (44) = −2.3, p = 0.03] and literal sentences [t (44) = −3.3, p = 0.002].

Gender differences were not significant for idiomatic [t (43) = −1.208, p = 0.23, power estimate (p.e.) = 0.25] or literal sentences [t (43) = 0.35, p = 0.73, p.e. = 0.10].

3.1.1. Ambiguous and unambiguous idioms

Patients produced 73.03% (SD 17.37) correct answers with ambiguous idioms and 78.28% (SD 14.56) with unambiguous ones, while for controls the percentage of correct responses was 91.8% (SD 6.29) for ambiguous and 94.27% (SD 5.83) for unambiguous idioms (see Fig. 2).

A repeated-measure ANOVA, with accuracy as dependent variable, idiom type (ambiguous vs. unambiguous) and group (patients vs. controls) as within factors, showed significant main effects of group [F (1, 44) = 61.8, p < 0.001, d = 1.19] and idiom type [F (1, 44) = 12.4, p < 0.001, d = 1.12]. Patients produced significantly more errors than controls both in ambiguous [F (1,44) = 45.6, p < 0.001, d = 1.8] and unambiguous idioms [F (1,44) = 42.1, p < 0.001, d = 1.4], with a significantly higher number of errors for ambiguous idioms [t (44) = −4.4, p < 0.001, d = 0.46]. Controls produced a similar number of errors for the two types of idioms [t (44) = −1.9, p = 0.06]. The interaction between main factors was not significant [F (1, 44) = 0.35, p = 0.56]. Then, we analyzed the percentage of correct responses for idioms for which the correct answer was "true" or "false". Errors concerned significantly more "true" than "false" responses with ambiguous idioms, 71.53% (SD 21.83) correct responses for "true" and 76.94% (SD 20.81) for "false", respectively [t (44) = 12.1, p < 0.001, d = 0.3]. A reverse pattern emerged with unambiguous idioms [80.98% correct responses (SD 16.85) for true, and 73.91% (SD) 16.71 for false, respectively, t (44) = −17.7, p < 0.001, d = 0.42].

The effect of idiom properties (familiarity, picture relatedness, transparency) was analysed by means of a linear regression. Only familiarity affected performance and *only* in the case of ambiguous items [t (44) = 2.170, p = 0.039, d = 0.65]. No additional significant effects were detected. Finally, we investigated the effect of patients' familiarity for the idioms used; to this aim, patients were asked to report whether the idiom meaning was known and to give an oral explanation of idioms for which they had answered incorrectly in the picture-matching task. The results showed that patients produced a wrong answer in the picture-matching task even when they knew the idiom meaning [t (44) = 7.136, p < 0.001].

3.1.2. Literal sentences

Patients produced a mean percentage of 92.97% (SD 11.62) correct responses when the answer was "true" and of 88.39% (SD 12.33) when the answer was "false". The difference between false and true sentences was significant, with a moderate effect size [t = 2.6, p = 0.01, d = 0.38]. In the case of "true" sentences, the difference between patients and controls was not significant [F (1, 44) = 2.75, p = 0.1], while it was reliable for "false" sentences [F (1,44) = 28.3, p < 0.001, d = 0.99] (see Fig. 3).

3.2. Dysexecutive deficits, cognitive decline, thought disorganization and idiom performance

In order to determine the unique contribution of executive and general intellectual abilities and thought disorders to patients' understanding of idiomatic sentences, linear regression analyses were carried out to test the influence of these variables on accuracy. As far as executive functions were concerned, WCST proved to be a significant unique predictor of correct responses [t (44) = −2.035, p = 0.044] as well as Digit Sequencing [t (44) = 15.749; p = 0.016] for idioms in general; these results did not change even when removing the confounding effect of years of illness [t (44) = −2.08, p = 0.04 and t (44) = 3.19, p = 0.003 for WCST and Digit Sequencing, respectively]. Moreover, WCST significantly affected ambiguous idioms [t (44) = −2.172, p = 0.035], whereas Digit Sequencing affected unambiguous ones [t (44) = 2.74; p = 0.003]. On the contrary, IQ did not appear to be a significant predictor of correct responses [t (44) = 1.872, p = 0.08, p.e. = 0.46], as well as general cognitive decline (measured as the difference between estimated pre-morbid IQ and actual IQ: the higher the value, the more severe the decline) [t (37) = −1.74, p = 0.09, p.e. = 0.39].

Similarly, the DIS factor did not predict either general [t (36) = −1.5, p = 0.14, p.e. = 0.72], or ambiguous [t (36) = −1.46, p = 0.15, p.e. = 0.58] and unambiguous [t (36) = −1.21, p = 0.14, p.e. = 0.76] idiom accuracy. The results did not change when we removed the effect of years of illness [t (36) = −1.65, p = 0.11, p.e. = 0.77].

Values of the power functions, which are low in these tests, certainly impose a more powerful, robust statistical estimation (Linscott, 2005). In order to assess whether these tests failed to reject the null hypothesis because of the sample size, a sensitivity analysis was performed. The association measures were therefore estimated once again with Monte Carlo Methods (MCM), corroborating the previous significance values.

When considering item P2 (conceptual disorganization) alone, linear regression almost reached significance in the case of general idiom accuracy [t (36) = −2, p = 0.055, p.e. = 0.48] but not when considering separately ambiguous [t (36) = −1.8, p = 0.075, p.e. = 0.70] and unambiguous idioms [t (36) = −1.7, p = 0.1, p.e. = 0.84], considered separately. Similarly, N5 (difficulty in abstract thinking) alone did not predict either general [t (36) = −0.35, p = 0.72, p.e. = 0.14] or ambiguous [t (36) = −0.15, p = 0.88, p.e. = 0.13] and unambiguous idiom performance [t (36) = −0.50, p = 0.62, p.e. = 0.16]. Finally, for

the 26 patients who were submitted to the TLI, linear regression analyses showed that TLI did not predict idiomatic comprehension performance either in general [t (24) = −1.88, p = 0.072, p.e. = 0.88] or when ambiguous and unambiguous idioms were considered separately [t (24) = −1.45, p = 0.16, p.e. = 0.77, and t (24) = −2, p = 0.06, p.e. = 0.87, respectively].

3.2.1. Correlation with negative symptoms

No significant partial correlation of accuracy (controlling for the effect of years of illness) was found for idioms in general (r_p = −0.21, p = 0.23, p.e. = 0.69; r_p = −0.16, p = 0.37, p.e. = 0.65; r_p = −0.11, p = 0.53, p.e. = 0.62; negative, positive, and general subscale, respectively) and for unambigous idioms (r_p = −0.12, p = 0.50, p.e. = 0.59; r_p = −0.013, p = 0.94, p.e. = 0.60; r_p = 0.007, p = 0.97, p.e. = 0.52). However, when ambiguous idioms were considered, partial correlation of accuracy with the negative PANSS subscale was significant (r_p = −0.34, p = 0.047). No other correlation proved to be significant for ambiguous idioms (positive subscale: r_p = −0.18, p = 0.31, p.e. = 0.81; general subscale: r_p = −0.17, p = 0.33, p.e. = 0.81). When literal accuracy was considered, partial correlations (controlling for the effect of years of illness) were not significant either with the negative (r_p = −0.14, p = 0.43, p.e = 0.83), positive (r_p = −0.05, p = 0.76, p.e. = 0.81) or general subscale (r_p = −0.22, p = 0.21, p.e. = 0.85).

4. Discussion

Forty-five schizophrenic patients were tested on a sentence-to-picture-matching task and their performance was compared with that of 45 matched controls. Schizophrenics proved to be generally impaired in both literal and idiomatic sentences; nonetheless, ability to recognize false literal sentences was preserved and performance was poorer with idioms than with literal sentences. In line with our prediction, performance was significantly lower for ambiguous than unambiguous idioms. This cannot be due to the fact that ambiguous idioms are more difficult in general than unambiguous ones, since the opposite pattern has been found in aphasic patients (Papagno & Caporali, 2007).

Our second prediction was that the impaired performance with idioms would be due to dysexecutive deficits. At least two data support this hypothesis. First, schizophrenics seem to expect a literal representation in the case of ambiguous idioms, unless the sentence is almost invariably used in its figurative meaning: accordingly, familiarity affected performance only with ambiguous idioms, and "false" correct responses were significantly higher than "true": yet, the "opposite" representation does not match either the literal or the figurative interpretation and it is, therefore, easier to be rejected. In line with a number of studies showing that these patients find it difficult to analyse ambiguous information (Iakimova et al., 2006; Strandburg et al., 1997; Titone et al., 2002), schizophrenics found extremely challenging to interpret ambiguous idioms. All ambiguous idioms contributed to the same degree, which strengthen our conclusion of executive deficits being the cause of loss of control over pragmatic aspects of communication. In addition, in a significant number of cases, patients were able to give a correct verbal explanation of an idiom for which they had given a wrong answer during the picture-matching task: this was the case for both types of idioms. Patients' increased difficulty in a matching task might derive from the fact that the representation of a figurative expression is not necessarily univocal: patients are less flexible to accept *that* particular (figurative) representation of the idiom's meaning. A similar result was found by Titone, Libben, Niman, Ranbom, and Levy (2007) who claimed that schizophrenics are impaired in making flexible use of semantic material.

Second, both the WCST and the Digit Sequencing Task proved to be significant unique predictors of correct idiomatic responses in general, with the former being significant for ambiguous and the latter for unambiguous idioms, when considered separately, suggesting that different executive resources are recruited for the interpretation of ambiguous vs. unambiguous idioms. This result was not affected by years of illness. We might speculate that the WCST requires the inhibition of a "routinary" response, which is similar to suppressing the literal representation of ambiguous idiomatic sentences in favour of the figurative one. On the contrary, the Digit Sequencing Task requires holding and manipulating a string of digits, which is similar to retain a string of apparently unrelated words to retrieve the figurative meaning, as required in unambiguous idiom interpretation. Therefore, unambiguous idiom–picture matching seems to require working memory. This different behaviour with ambiguous and unambiguous idioms was also evident in the pattern of "true" vs. "false" errors.

The cognitive decline itself did not prove to be a significant unique predictor of performance, nor did IQ. However, the power estimates were low and do not allow definite conclusions. This point needs further investigation.

Finally, thought disorganization, evaluated by means of several measures (TLI, DIS, P2, N5), did not predict idiom performance. Since we selected patients with stable and drug responsive residual psychopathology (with no productive symptoms), this result is expected and suggests that disexecutive deficits alone do not explain FTD and that FTD do not explain impaired idiom comprehension.

Consistent with our hypothesis, there was a significant correlation between negative symptoms and ambiguous idiom accuracy, but not with unambiguous ones. No other significant correlations were found with the PANSS subscales. As already mentioned, several studies (see for example Basso, Nasrallah, Olson, & Bornstein, 1998; Berman et al., 1997; O'Leary et al., 2000) have found an association between executive functions and negative symptoms. Based on evidence for this association, it has been suggested that negative symptoms (i.e., psychomotor poverty symptoms, such as lack of spontaneity and flow of conversation, stereotyped thinking, poor rapport, abstract thinking) are "cognitive behaviours" expressing deficits of executive control (Frith, 1992). However, executive functioning includes a number of separate cognitive processes (inhibiting inappropriate responses, shifting attention, working memory). If these processes are fractionable, then they may be selectively related to specific aspects of negative symptoms (Donohoe, Corvin, & Robertson, 2006).

Patients were not impaired in recognizing "true" literal sentences, showing that at least some aspects of language were preserved. The impairment demonstrated with false literal sentences is consistent with the evidence of degraded semantic representation in schizophrenia (Goldberg et al., 1998), or "abnormal" semantics (Langdon & Coltheart, 2004), which would increase the possibility of accepting a semantically-related picture (for example, in the case of "the boy is opening the window" the picture represented a boy opening a door, the two terms belonging to the same semantic category). Concerning a possible role of the reduction in syntactic complexity shown by schizophrenic patients (Tavano et al., 2008), the very simple syntactic structure of our sentences makes this hypothesis unlike; in addition, true and false sentences shared the same syntactic structure, but nevertheless the performance on true sentences was normal.

In conclusion, four main results emerge from our study: first, schizophrenics' behaviour in idiom interpretation is similar to that found in prefrontal brain-damaged patients (Papagno et al., 2006); second, dysexecutive functions seem to be responsible for poor performance; third, the PANSS negative subscale correlated with performance on ambiguous idioms; fourth, different types of idioms must be treated separately, since a qualitatively and quantitatively different performance was obtained with ambiguous and

unambiguous idioms and different cognitive resources proved to be involved.

Of course there are some limitations to our study. First, the two groups of subjects were matched in education, and controlling for education (which accounts for substantial variance in neuropsychological measures) may remove variance directly attributable to the independent variable of interest. This effect, known as the *matching fallacy*, reported by Goldstein, Seidman, and Tsuang (1999), could explain why we found no difference between women and men with schizophrenia (also the power estimates were low), at variance with Goldstein et al.'s (1998) study, where schizophrenic women seemed to be less vulnerable to cognitive deficits involving verbal processing than schizophrenic men. Second, our patients were pharmacologically treated and in a chronic stage, so side effects and chronicity cannot be ruled out. However, difficulty in appreciating metaphor, for example, has also been evidenced in first-episode psychosis (Mitchell & Crow, 2005). Third, we did not assess semantic deficits, which could have account at least in part for the impaired performance. Finally, we explored only one specific aspect of pragmatic comprehension, but we agree with Champagne-Lavau, Stip, and Joannette (2007) that it is more likely that specific cognitive processes are malfunctioning, rather than to assume a global pragmatic dysfunction. Results on idioms could apply to similar forms of non-literal language (e.g. proverbs), but not to others, such as irony or metaphors that are newly interpreted on each encounter. However, studying different forms of figurative language separately has the advantage to improve our knowledge about normal processing, which is one of the goals of neuropsychology.

Appendix A.

	Familiarity index (0–3)	Transparency (0–5)	Picture relatedness (0–5)
Andare al fresco	2.7	2.5	3.8
Andare in bestia	2.9	3.8	4.0
Avere i minuti contati	2.9	4.0	3.4
Avere il cuore in mano	2.2	2.9	3.0
Avere il pollice verde	2.9	3.0	4.5
Avere le mani in pasta	2.5	2.8	3.6
Avere la puzza sotto il naso	2.9	3.0	3.9
Avere poco sale in zucca	2.7	2.7	3.2
Dare del filo da torcere	2.9	2.9	4.4
Dare i numeri	2.9	2.4	1.6
Essere a piede libero	2.4	3.4	4.5
Essere al settimo cielo	2.9	3.7	4.2
Essere di facili costumi	2.9	3.1	4.1
Essere in forma	2.9	4.1	3.5
Essere sul viale del tramonto	2.3	3.4	3.1
Essere sulla cattiva strada	2.8	4.4	4.0
Essere uno stinco di santo	2.7	3.0	4.5
Far venire il latte alle ginocchia	2.6	2.3	3.1
Fare fiasco	2.7	2.4	4.2
Farsene un baffo	2.6	2.1	3.5
Mandare a monte	2.9	2.0	3.6
Mettersi le gambe in spalla	2.1	2.5	3.0
Montarsi la testa	2.9	3.1	2.1
Mordere il freno	1.5	2.3	2.0
Non vedere l'ora	2.9	3.3	2.4
Perdere la faccia	2.7	3.1	2.1
Prendere fischi per fiaschi	2.6	3.3	3.4
Prendere in castagna	2.7	2.6	4.7
Restare con un palmo di naso	2.6	2.3	4.2
Rimetterci le penne	2.8	3.6	4.8
Spremere le meningi	2.8	3.9	2.0
Stare alle costole	2.6	3.3	2.6
Stare in campana	2.3	2.3	2.7
Tendere le orecchie	2.5	3.9	4.1
Tenere banco	2.4	2.8	2.4
Vendere cara la pelle	2.3	3.6	4.1
Venire alle mani	2.7	3.6	4.0
Alzare i tacchi	2.7	3.4	3.4
Alzare il gomito	2.8	3.0	2.3
Attaccare bottone	2.9	2.7	4.2
Avere le mani bucate	2.8	3.2	3.7
Chiudere un occhio	2.9	3.7	3.8
Essere al verde	2.9	2.6	3.9
Gettare la spugna	2.9	2.9	4.4
Levare le tende	2.5	3.8	4.0
Mangiarsi il fegato	2.7	2.7	4.0
Mettere la pulce nell'orecchio	2.8	3.0	3.9
Mettersi le mani nei capelli	2.8	3.6	3.5
Perdere il filo	2.8	2.9	4.0
Perdere la bussola	2.5	3.8	3.8
Perdere la testa	2.9	3.9	2.2
Prendere la porta	2.3	3.1	3.9
Prendere un granchio	2.6	2.6	4.4
Rompere il ghiaccio	2.9	2.7	3.7
Saltare la mosca al naso	2.0	1.9	2.4
Scendere a rotta di collo	2.2	3.0	4.1
Sputare il rospo	2.9	2.8	3.4
Stringere i denti	2.9	3.6	3.7
Tagliare la corda	2.8	2.9	4.8
Tirare la cinghia	2.8	3.0	3.8
Vedere le stelle	2.8	2.9	4.4
Vuotare il sacco	2.8	3.5	4.0

Appendix A (*Continued*)

Literal meaning	Figurative meaning
To go in the cool	To go to jail
To go in beast	To become very angry
To have the minutes counted	To have very little time
To have the heart in hand	To be very generous
To have a green thumb	To be very good at gardening
To have the hands in dough	To have his/her finger in the pie
To have a bad smell under the nose	To be snooty
To have few salt in pumpkin	To have nonsense in his head
To give some thread to twist	To make things hard for someone
To give the numbers	To talk nonsense
To be at free foot	To be on bail
To be at the seventh sky	To be in the seventh heaven
To be of easy customs	To be of easy virtue
To be in shape	To be very well
To be on the sunset boulevard	To be on the wane
To be on the bad path	To make bad things
To be a shin bone of a saint	To be an angel
To make the milk come to the knees	To be particularly boring
To make flask	To fail badly
To make a moustache of it	To not give a damn
To send to mountain	To make something fail
To put the legs on shoulders	To flee
To mount the head	To become swollen-headed
To bite the brake	To champ at the bit
To not see the hour	To look forward
To loose the face	To loose face
To take whistles for flasks	To misunderstand something
To take in chestnut	To catch out
To remain with a span of nose	To be badly disappointed
To leave the feathers	To loose life
To squeeze his/her meninges	To rack one's brains
To stay at the ribs	To dog someone's heels
To stay in bell	To be very careful
To stretch the ears	To prick up his/her ears
To hold bench	To be a person who talks a lot in a group of people paying attention to him
To sell at a high price the skin	To fight hard
To come to the hands	To come to blows
To lift the elbow	To drink too much
To attach a button	To speak too much
To have holes in the hands	To spend too much
To close an eye	To be indulgent
To be at the green	To be broke
To threw away the sponge	To give up

Appendix A (*Continued*)

Literal meaning	Figurative meaning
To remove the curtains	To leave
To eat the liver	To wear himself out
To put the flea in the ear	To suggest something
To put the hands in the hair	To be in despair
To loose the thread	To get lost
To loose the compass	To loose his bearings
To loose the head	To get mad
To take the door	To go away
To take a crab	To make an error
To break the ice	To start talking in an embarrassing situation
To have a fly jumping on the nose	To get angry
To go down breaking the neck	To behave riskily
To spit the toad	To reveal a secret
To tighten the teeth	To strongly pursue a goal
To cut the rope	To escape
To pull the belt	To become very poor
To see the stars	To experience a pain

References

American Psychiatric Association. (1994). *DSM-IV. Diagnostic and statistical manual of mental disorders* (4th Ed.). Washington, DC: APA.

Baaré, W. F. C., Hulshoff Pol, H. E., Hijman, R., Mali, W. P. T., Viergever, M. A., & Kahn, R. S. (1999). Volumetric analysis of frontal lobe regions in schizophrenia: Relation to cognitive function and symptomatology. *Biological Psychiatry*, *45*, 1597–1605.

Barrera, A., McKenna, P. J., & Berrios, G. E. (2005). Formal thought disorders in schizophrenia: An executive or a semantic deficit? *Psychological Medicine*, *35*, 121–132.

Basso, M. R., Nasrallah, H. A., Olson, S. C., & Bornstein, R. A. (1998). Neuropsychological correlates of negative, disorganized and psychotic symptoms in schizophrenia. *Schizophrenia Research*, *31*, 99–111.

Berman, I., Viegner, B., Merson, A., Allan, E., Pappas, D., & Green, A. I. (1997). Differential relationships between positive and negative symptoms and neuropsychological deficits in schizophrenia. *Schizophrenia Research*, *25*, 1–10.

Bleich-Cohen, M., Hendler, T., Kotler, M., & Strous, R. D. (2009). Reduced language lateralization in first-episode schizophrenia: An fMRI index of functional asymmetry. *Psychiatry Research: Neuroimaging*, *171*, 82–93.

Brüne, M., & Bodenstein, L. (2005). Proverb comprehension reconsidered–"theory of mind" and the pragmatic use of language in schizophrenia. *Schizophrenia Research*, *75*, 233–239.

Cacciari, C., & Papagno, C. (in press). Neuropsychological and neurophysiological correlates of idiom understanding: How many hemispheres are there involved? In: Faust, M. (ed.) *Neuropsychology of Language: Advances in the neural substrates of language: Toward a synthesis of basic science and Clinical Research*. Oxford: Oxford University Press.

Champagne-Lavau, M., Stip, E., & Joannette, Y. (2007). Language functions in right-hemisphere damage and schizophrenia: Apparently similar pragmatic deficits may hide profound differences. *Brain*, *130* doi:10.1093/brain/aw1311

Chua, S. E., Sharma, T., Takei, N., Murray, R. M., & Woodruff, P. W. (2000). A magnetic resonance imaging study of corpus callosum size in familial schizophrenic subjects, their relatives, and normal controls. *Schizophrenia Research*, *41*, 397–403.

Condray, R., Steinhauer, S. R., van Kammen, D. P., & Kasparek, A. (2002). The language system in schizophrenia: Effects of capacity and linguistic structure. *Schizophrenia Bulletin*, *28*, 475–490.

Covington, M. A., Congzhou, H., Brown, C., Naçi, L., McClain, J. T., Fjordbak, B. S., et al. (2005). Schizophrenia and the structure of language: The linguist's view. *Schizophrenia Research*, *77*, 85–98.

Crespo-Facorro, B., Kim, J. J., Andreasen, N. C., O'Leary, D. S., & Magnotta, V. (2000). Regional frontal abnormalities in schizophrenia: A quantitative gray matter volume and cortical surface size study. *Biological Psychiatry*, *48*, 110–119.

Crow, T. J. (2000). Schizophrenia as the price that Homo sapiens pays for language: A resolution of the central paradox in the origin of species. *Brain Research Reviews*, *31*, 118–129.

DeLisi, L. E., Hoff, A. L., Neale, C., & Kushner, M. (1994). Asymmetries in the superior temporal lobe in male and female first-episode schizophrenic patients: Measures of the planum temporale and superior temporal gyrus by MRI. *Schizophrenia Research*, *12*, 19–28.

Dollfus, S., Razafimandimby, A., Maiza, O., Lebain, P., Brazo, P., Beaucousin, V., et al. (2008). Functional medial prefrontal cortex during a language comprehension task in patients with schizophrenia. *Schizophrenia Research*, *99*, 304–311.

Donohoe, G., Corvin, A., & Robertson, I. H. (2006). Evidence that specific executive functions predict symptom variance among schizophrenia patients with a predominantly negative symptom profile. *Cognitive Neuropsychiatry*, *11*, 13–35.

Fogliata, A., Rizzo, S., Reati, F., Miniussi, C., Oliveri, M., & Papagno, C. (2007). The time course of idiom processing. *Neuropsychologia*, *45*(*14*), 3215–3222.

Frith, C. D. (1992). *The cognitive neuropsychology of schizophrenia*. Hove: Psychology Press.

Gallagher, H. L., & Frith, C. D. (2003). Functional imaging of 'theory of mind'. *Trends in Cognitive Sciences*, *7*(2), 77–83.

Gibbs, R. W. (1999). Figurative language. In R. A. Wilson, & F. C. Keil (Eds.), *The MIT encyclopedia of cognitive sciences* (pp. 314–315). Cambridge, MA: MIT Press.

Goldberg, T. E., Aloia, M. A., Gourovitch, M., Missar, D., Pickar, D., & Weinberger, T. E. (1998). Cognitive substrates of thought disorder 1: The semantic system. *American Journal of Psychiatry*, *155*, 1671–1675.

Goldstein, J. M., Seidman, L. J., Goodman, J. M., Koren, D., Lee, H., Weintraub, S., et al. (1998). Are there sex differences in neuropsychological functions among patients with schizophrenia? *American Journal of Psychiatry*, *155*, 1358–1364.

Goldstein, J. M., Seidman, L. J., & Tsuang, M. T. (1999). Dr. Goldstein and Colleagues reply (Letters to editor). *American Journal of Psychiatry*, *156*, 1665–1666.

Huber-Okrainec, J., Blaser, S. E., & Dennis, M. (2005). Idiom comprehension deficits in relation to corpus callosum agenesis and hypoplasia in children with spina bifida meningomyelocele. *Brain and Language*, *93*, 349–368.

Iakimova, G., Passerieux, C., & Hardy-Baylé, M. C. (2006). Interpretation of ambiguous idiomatic statements in schizophrenics and depressive patients. Evidence for common and differential cognitive patterns. *Psychopathology*, *39*, 277–285.

Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, *13*, 261–276.

Keefe, R. S., Goldberg, T. E., Harvey, P. D., Gold, G. M., Poe, M. P., & Coeghenour, L. (2004). The brief assessment of cognition in schizophrenia: Reliability, sensitivity, and comparison with a standard neurocognitive battery. *Schizophrenia Research*, *68*, 283–297.

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. Journal of. *Abnormal Psychology*, *111*, 211–224.

Kircher, T. T. J., Liddle, P. F., Brammer, M. J., Williams, S. C. R., Murray, R. M., & McGuire, P. K. (2002). Reversed lateralization of temporal activation during speech production in thought disordered patients with schizophrenia. *Psychological Medicine*, *32*, 439–449.

Langdon, R., & Coltheart, M. (2004). Recognition of metaphor and irony in young adults: The impact of schizotypal personality traits. *Psychiatry Research*, *125*, 9–20.

Langdon, R., Coltheart, M., Ward, P. B., & Catts, S. V. (2002). Disturbed communication in schizophrenia: The role of poor pragmatics and poor mind-reading. *Psychological Medicine*, *32*, 1273–1284.

Lee, S., & Dapretto, M. (2006). Metaphorical vs. literal word meanings: fMRI evidence against a selective role of the right hemisphere. *Neuroimage*, *29*, 536–544.

Liddle, P. F., Ngan, E. T. C., Cassie, S. L., Anderson, C. M., Bates, A. T., Quested, D. J., et al. (2002). Thought and language index: An instrument for assessing thought and language in schizophrenia. *British Journal of Psychiatry*, *181*, 326–333.

Linscott, R. J. (2005). Thought disorder, pragmatic language impairment, and generalized cognitive decline in schizophrenia. *Schizophrenia Research*, *75*, 225–232.

McGrath, J. (1991). Ordering thoughts on thought disorder. *British Journal of Psychiatry*, *158*, 307–316.

Milner, B. (1963). Effects of different brain lesions on card sorting. *Archives of Neurology*, *9*, 90–100.

Mitchell, R. L. C., & Crow, T. J. (2005). Right hemisphere language functions and schizophrenia: The forgotten hemisphere? *Brain*, *128*, 963–978.

Mo, S., Su, Y., Chan, R. C. K., & Liu, J. (2008). Comprehension of metaphor and irony in schizophrenia during remission: The role of theory of mind and IQ. *Psychiatry Research*, *157*, 21–29.

Nelson, H. E. (1982). *National adult reading test. Manual*. Windsor: NFER-Nelson.

Nestor, P. G., Shenton, M. E., Wible, C., Hokama, H., O'Donnell, B. F., Law, S., et al. (1998). A neuropsychological analysis of schizophrenic thought disorder. *Schizophrenia Research*, *29*, 217–225.

Nunberg, G., Sag, I. A., & Wasow, T. (1994). Idioms. *Language*, *70*, 491–538.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, *9*, 97–113.

O'Leary, D. S., Flaum, M., Kesler, M. L., Flashman, L. A., Arndt, S., & Andreasen, N. C. (2000). Cognitive correlates of the negative, disorganized, and psychotic symptom dimensions of schizophrenia. *Journal of Neuropsychiatry and Clinical Neurosciences*, *12*, 4–15.

Papagno, C., & Caporali, A. (2007). Testing idiom comprehension in aphasic patients: The modality and the type of idiom effects. *Brain and Language*, *100*, 208–220.

Papagno, C., Curti, R., Rizzo, S., Crippa, F., & Colombo, M. R. (2006). Is the right hemisphere involved in idiom comprehension? A neuropsychological study. *Neuropsychology*, *20*, 598–606.

Papagno, C., Tabossi, P., Colombo, A., & Zampetti, P. (2004). Idiom comprehension in aphasic patients. *Brain and Language*, *89*, 226–234.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*, 515–526.

Rapp, A. M., Leube, D. T., Erb, M., Grodd, W., & Kircher, T. T. J. (2004). Neural correlates of metaphor processing. *Cognitive Brain Research*, *20*, 395–402.

Rizzo, S., Sandrini, M., & Papagno, C. (2007). The dorsolateral prefrontal cortex in idiom interpretation: An rTMS study. *Brain Research Bulletin*, *71*, 523–528.

Romero Lauro, L. J., Tettamanti, M., Cappa, S. F., & Papagno, C. (2008). Idiom comprehension: A prefrontal task? *Cerebral Cortex*, *18*, 162–170.

Sarfati, Y., & Hardy-Baylé, M. C. (1999). How do people with schizophrenia explain the behaviour of others? A study of theory of mind and its relationship to thought and speech disorganisation in schizophrenia. *Psychological Medicine*, *29*, 613–620.

Sartori, G., Colombo, L., Vallar, G., Rusconi, M. L., & Pinarello, A. (1997). TIB Test di intelligenza breve per la valutazione del quoziente intellettivo attuale e premorboso. *Giornale dell'Ordine Nazionale degli Psicologi*, *1*, 2–24.

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London: Series B, Biological Sciences*, *298*, 199–209.
Sommer, I. E. C., Ramsey, N. F., & Kahn, R. S. (2001). Language lateralization in schizophrenia, an fMRI study. *Schizophrenia Research*, *52*, 57–67.
Spironelli, C., Angrilli, A., & Stegagno, L. (2008). Failure of language lateralization in schizophrenia patients: An ERP study on early linguistic components. *Journal of Psychiatric Neuroscience*, *33*, 235–243.
Stachowiak, F., Huber, W., Poeck, K., & Kerschensteiner, M. (1977). Text comprehension in aphasia. *Brain and Language*, *4*, 177–195.
Strandburg, R. J., Marsh, J. T., Brown, W. S., Asarnow, R. F., Guthrie, D., Harper, R., et al. (1997). Event-related potential correlates of linguistic information processing in schizophrenics. *Biological Psychiatry*, *42*, 596–608.
Stratta, P., Riccardi, I., Mirabilio, D., Di Tommaso, S., Tomassini, A., & Rossi, A. (2007). Exploration of irony appreciation in schizophrenia: A replication study on an Italian sample. *European Archives of Psychiatry and Clinical Neuroscience*, *257*, 337–339.
Stringaris, A. K., Medford, N. C., Giampietro, V., Brammer, M. J., & David, A. S. (2007). Deriving meaning: Distinctive neural mechanisms for metaphoric, literal, and non-meaningful sentences. *Brain and Language*, *100*, 150–162.
Tavano, A., Sponda, S., Fabbro, F., Perlini, C., Rambaldelli, G., Ferro, A., et al. (2008). Specific linguistic and pragmatic deficits in Italian patients with schizophrenia. *Schizophrenia Research*, *102*, 53–62.
Titone, D., Holzman, P. S., & Levy, D. L. (2002). Idiom processing in schizophrenia: Literal implausibility saves the day for idiom priming. *Journal of Abnormal Psychology*, *111*, 313–320.
Titone, D., Libben, M., Niman, M., Ranbom, L., & Levy, D. L. (2007). Conceptual combination in schizophrenia: Contrasting property and relational interpretations. *Journal of Neurolinguistics*, *20*, 92–110.
Van der Gaag, M., Cuijpers, A., Hoffman, T., Remijsen, M., Hijman, R., de Haan, L., et al. (2006). The five-factor model of the Positive and Negative Syndrome Scale II: A ten-fold cross-validation of a revised model. *Schizophrenia Research*, *85*, 280–287.
Van Lancker, D., & Kempler, D. (1987). Comprehension of familiar phrases by left but not by right hemisphere damaged patients. *Brain and Language*, *32*, 265–277.
Zempleni, M. Z., Haverkort, M., Renken, R., & Stowe, L. A. (2007). Evidence for bilateral involvement in idiom comprehension: An fMRI study. *Neuroimage*, *34*, 1280–1291.