Social cognition in schizophrenia: cognitive and affective factors

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Abstract

Introduction. Social cognition refers to how people conceive, perceive and draw inferences about mental and emotional states of others in the social world. Previous studies suggest that the concept of social cognition involves several abilities, including those related to affect and cognition.

The present study analyses the deficits of individuals with schizophrenia in two areas of social cognition: Theory of Mind and emotion recognition and processing. Examining the impairment of these abilities in patients with schizophrenia has the potential to elucidate the neurophysiological regions involved in social cognition and may also have the potential to aid rehabilitation.

Methods. Two experiments were conducted. Both included the same five tasks: first- and second-level false-belief Theory of Mind tasks, emotion inferencing, understanding of irony, and matrix reasoning (a WAIS-R subtest). The matrix reasoning task was administered to evaluate and control for the association of the other tasks with analytic reasoning skills. Experiment 1 involved factor analysis of the task performance of 75 healthy participants. Experiment 2 compared 30 patients with schizophrenia to an equal number of matched controls.

Results. (1) The five tasks were clearly divided into two factors corresponding to the two areas of social cognition, Theory of Mind and emotion recognition and processing. (2) Schizophrenics’ performance was impaired on all tasks, particularly on those loading heavily on the analytic component (matrix reasoning and second-order ToM). (3) Matrix reasoning, second-level Theory of Mind, and irony were found to distinguish patients from controls, even when all other tasks that revealed significant impairment in the patients’ performance were taken into account.

Conclusions. The two areas of social cognition examined are related to distinct factors. The mechanism for answering ToM questions (especially ToM2) depends on analytic reasoning capabilities, but the difficulties they present to individuals with schizophrenia is due to other components as well. The impairment in social cognition in schizophrenia stems from deficiencies in several mechanisms, including the abilities to think analytically and to process emotion information and cues.
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The present work addresses the issue of social cognition in schizophrenia. Social cognition is related to the process of drawing inferences about other people’s beliefs and intentions in the social world (Green et al., 2008; Penn, Sanna, & Robert, 2008). In an extensive analysis of research findings, Green et al. (2008) propose that the term “social cognition” covers five areas: Theory of Mind (ToM), social perception, social knowledge, attribution bias, and emotion processing (Green, Olivier, Crawley, Penn, & Silverstein, 2005; Penn, Addington, & Pinkham, 2006). They maintain that there is convincing evidence suggesting that social cognition is not a unitary concept. Understanding the factor structure of social-cognitive task measures may thus be important to better understand these distinct domains of social cognition, which will, in turn, inform studies of the distinct underlying neurophysiological circuits and the development of specific, targeted social-cognitive treatments.

The realisation of the importance of measuring more than one aspect of social cognition has begun to influence studies on schizophrenia (e.g., Pinkham & Penn, 2006b; Sergi et al., 2007). However, this phase is in its initial stages and none of the previous studies have measured the social cognition factor structure. The present work strengthens this approach while focusing on two areas of social cognition: Theory of Mind (ToM) and recognition and processing of emotion cues and information (henceforth: RPE: recognition and processing of emotions).

The body of knowledge that has been gathered on social cognition and mentalising in schizophrenia does not yet permit a satisfactory understanding of the underlying mechanisms and components involved (Harrington, Siegert, & McClure, 2005; Sprong, Schothorst, Vos, Hox, & England, 2007). This study will specifically examine the role of executive dysfunction in social cognition impairment. We will follow the terminology used by Picket (2008) and others, and refer broadly to the range of cognitive functions as we discuss Executive Functions (EF). If an executive deficit is involved in impaired ToM in schizophrenia, it is likely that one of two specific primary EFs are concerned: (1) the ability to disengage from and inhibit salient information, such as the current reality of a situation, so that less salient information (e.g., another person’s beliefs) can be considered; and (2) the ability to manipulate representations of hypothetical situations in order to reason consequentially (e.g., inferring another person’s beliefs about the current state of
affairs). The first EF is typically tested by using the Weigl Test (Weigl, 1941), the Wisconsin Card Sorting Test (Heaton, 1981; Stroop, 1935), or the Stroop Colour-Word Test (Stroop, 1935). The second EF is tested by evaluating strategic planning tasks such as the Tower of London (Shallice, 1982), Key Search, or the Zoo Map (Wilson, Alderman, Burgess, Emslie, & Evans, 1996). We will concentrate on the second, that is expected to entertain contrasting relations with ToM and RPE, the facets of social cognition we will be focusing on.

**Schizophrenia, ToM, and EF**

ToM is defined as the ability to attribute mental states (including beliefs, intentions, desires, and goals) to the self and others. It also involves the ability to understand that behaviour is the result of these mental states (Premack & Woodruff, 1978). Effective ToM abilities are important for normal social functioning because they facilitate the understanding of people’s behaviour (Baron-Cohen, 1995).

There is converging evidence from many sources suggesting that EF plays a significant role in ToM tasks performance. The development of ToM and success in false belief inferences was shown to be based in part on that of EF, allowing for the contribution of planning, response inhibition and cognitive flexibility to ToM function (Carlson, Moses, & Breton, 2002; Carlson, Moses, & Claxton, 2004; Hughes, 2002; Sabbagh, Xu, Carlson, Moses, & Lee, 2006; Wellman, Cross, & Watson, 2001). Further, results from elderly participants indicate that their decreased ability to understand others' beliefs and desires is related to a decline in executive skills, especially inhibition, rather than to an inferior ability to mentalise (German & Hehman, 2006). The extent of performance impairment in belief and desire reasoning among both the elderly and younger adults has been related to the degree of processing demand (McKinnon & Moscovitch, 2007). Similar conclusions were reached with a student population, using a dual-task paradigm that manipulated EF (inhibition, updating and switching) to assess their implication in ToM tasks (Bull, Phillips, & Conway, 2008). For a further and more extensive discussion regarding ToM and EF, see Ziv and Leiser (submitted).

ToM impairment is observed in schizophrenia. Five studies summarising the schizophrenia research conducted in the last three decades were recently published. Three of the studies provided an overview of social cognition: Brüne (2005b), Harrington et al. (2005), and Penn et al. (2008). The remaining two were broad meta-analyses of ToM and schizophrenia conducted by Pickup (2008) and Spong et al. (2007). Each of these studies explored the extent of mentalising impairment in patients with schizophrenia, and all found a robust and serious impairment of ToM abilities. Spong et al. (2007) found that, on average, the ToM performance of participants with schizophrenia was more than one standard deviation below that of healthy controls. Applying Cohen's (1988) statistical power analysis typology, they found that the magnitude of the effect size of patients corresponded to a "large" effect, and the effect size of mentalising impairments in patients in remission demonstrated a "medium to large" effect. This finding was not the result of a verbalisation deficiency (which is also a characteristic of patients suffering from schizophrenia) because tasks relying on cartoon strips and pointing revealed the same impairment (Leiser & Bonshtein, 2003; Sarfati, Hardy-Bayle, Brunet, & Wildloecher, 1999; Sarfati, Hardy-Bayle, Besche, & Wildlocher, 1997; Sarfati, Passerieux, & Hardy-Bayle, 2000). Further, the deficiency in schizophrenia is more severe in individuals with other psychiatric disorders, such as depressive disorder, unless psychotic features are present (Bonshtein, Leiser, & Levine, 2006; Penn et al., 2008).

Results relating to specific schizophrenia symptoms have been ambiguous thus far. Some studies have found connections between ToM impairment and positive symptoms (Harrington, Langdon, Siegert, & Mc-Clure, 2005; Langdon, Coltheart, Ward, & Catts, 2002), while others have found associations with negative symptoms (Bora, Eryavuz, Kayahan, Sungu, & Veznedaroglu, 2006; Langdon, Coltheart, & Ward, 2006). Several have produced no evidence of any relationship (Brüne, 2005; Janssen, Krabbendam, Jolles, & Os, 2003). These findings imply that the mentalising impairment is not just a manifestation of the acute phase of the disorder, but may instead be a permanent trait. This belief stems from the finding that patients in remission continue to show impaired abilities (Herold, Tenyi, Lenard, & Trixler, 2002; Inoue et al., 2006), though the difference between patients in remission and healthy participants was reduced (Bonshtein et al., 2006). Other studies claim that performance returns to normal during periods of remission (Concoran, Cahill, & Frith, 1997; Drury, Robinson, & Birchwood, 1998; Pinkham & Penn, 2006a).
The findings we summarized on the pairwise relations between ToM, EF, and schizophrenia raise the question of the involvement of EF in the ToM impairment observed in schizophrenia. In a recent review, Pickup (2008) examined studies either directly or indirectly addressing the relationship between ToM and EF in schizophrenia. Overall, Pickup (2008) reported that, relative to controls, patients with schizophrenia were significantly impaired both on ToM and EF tasks. Further, of the 17 studies reviewed, 14 reported significant correlations between ToM tasks and EF tasks.

However, having examined the studies closely, Pickup (2008) made some observations that do not support the summary presented above. First, no correlation was found when the relationship between EF and ToM abilities was tested with healthy control participants (as was done in only three studies: Brüne (2005a), Langdon, Coltheart, Ward, & Catts (2001), and Pinkham & Penn (2006a)). Pickup therefore suggested that the correlation that was found with the patient population may be attributable to some other common cause, rather than to an inherent relationship between EF and ToM. Second, Pickup further pointed out that eight superior studies (Brüne, 2005a; Harrington, Langdon, Siegert, & McClure, 2005; Janssen, Krabbendam, Jolles, & Os, 2003; Langdon, Coltheart, & Ward, 2006; Langdon et al., 2001; Langdon, Coltheart, Ward, & Catts, 2002; Langdon, Corner, McLaren, Ward, & Coltheart, 2006; Langdon, Davies, & Coltheart, 2002) that relied on multivariate statistics revealed that even when EF was controlled for, ToM ability continued to predict whether an individual had schizophrenia or was a healthy control.

It remains therefore unclear whether impairment in EF is involved in the deficiency in ToM observed in schizophrenia. There is evidence that impairment to the inhibitory control component of EF does not adequately account for social-cognitive deficits in schizophrenia, while less is known of the relations between social cognition and fluid, analytic reasoning. It also seems reasonable to expect that fluid reasoning is more involved in tasks such as the False Belief tasks, especially those relating to second-order false beliefs, than in the more affective component of social cognition, RPE, to which we now turn our attention.

Emotion recognition and emotion understanding in schizophrenia

Emotion processing is primarily related to the ability to recognise and use emotions (Feldman-Barrett & Salovey, 2002; Slater & Lewis, 2002). It includes four abilities: identifying emotions, facilitating emotions, understanding emotions, and managing emotions (Mayer, Salovey, Caruso, & Sitarenios, 2001; Salovey & Sluyter, 1997). Of these characteristics, two have been extensively studied in schizophrenia research: (1) identifying emotions via facial expressions and affective prosody; and (2) understanding emotions with ironic expressions.

A decade ago, Mandal, Pandey, and Prasad (1998) conducted a general review of previous studies and found evidence that schizophrenia patients are strongly impaired in the ability to recognise other people’s emotions based on their facial expressions, gestures, or voices. This result was repeatedly found in later studies (Brüne, 2005a; Hooker & Park, 2003). The duration of schizophrenia is closely related to this impaired ability, and chronic patients suffering from marked negative symptoms are more impaired than less chronic patients (Brüne, 2005a; Mueser et al., 1996; Penn, Spaulding, Reed, & Sullivan, 1996).

Inferring the emotions involved in a social situation (like that a boy who was tripped by his classmate will feel angry) is a more complicated process than merely identifying facial expressions (Shamay-Tsoory, Tomer, & Peretz, 2005), because it requires a reasoning process.

The same holds for irony. The ironic meaning of a sentence is derived from the difference between the literal meaning of the sentence and the speaker’s meaning (Winner, 1988), that must be inferred. For example, someone who was embarrassed by his friend may state: "you have acted like a gentleman". The listener must understand the difference between the literal meaning, "acted like a gentleman", and the implicit intention, "you have acted badly". As Dennis, Purvis, Barnes, Wilkinson, and Winner (2001) stress, the speaker intends for the listener to identify and understand the deliberate falseness of his expression. Irony is typically used in situations that include negative affect, such as contempt, scorn, or disapproval, and is often used to convey criticism (Sperber & Wilson, 1986). While understanding of irony involves an additional process relative to identifying emotions from facial expressions, the ability to understand the literal meaning is often impaired in schizophrenia patients (Brüne, 2005a; Mueser et al., 1996).
expressions, Shamay-Tsoory et al. (2005) found that both abilities are mediated by the right prefrontal lobe.

The impaired understanding of irony in schizophrenia is well-established (Langdon & Coltheart, 2004; Langdon, Coltheart et al., 2002; Langdon, Davies, & Coltheart, 2002; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Aharon-Peretz, & Levkovitz, 2006; Shamay-Tsoory et al., 2007; Shuliang, Yanjie, Chan, & Jianxin, 2008). The relationship between ToM understanding and irony understanding has also been studied, though the findings are conflicting. Mo, Su, Chan, and Liu (2008) found no support for the claim that insensitivity to irony in patients with schizophrenia was associated with a deficient ToM, whereas Langdon and Coltheart (2004) claimed that an intact ToM is a prerequisite for the interpretation of irony.

Studies of patients with localised lesions revealed dissociable prefrontal networks for ToM and irony (Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Tibi-Elhanany, & Aharon-Peretz, 2006). Based on these dissociable networks, Shamay-Tsoory, Aharon-Peretz, and Levkovitz (2006) distinguish between cognitive ToM, that primarily relates to traditional ToM tasks, and affective ToM, that relates to RPE. This distinction corresponds to two of the social cognition areas identified by Green et al. (2008): ToM and emotion processing. Shamay-Tsoory et al. (2005) argue in favour of the relationship between ToM and irony, claiming that the understanding of irony requires an integration of both components, (cognitive) ToM and emotion processing.

The present study

We aimed to address two main objectives. First, we explored the factor structure of two of the social cognition areas, ToM understanding and emotion processing, as well as their associations with fluid, analytic reasoning. This analysis is useful in elucidating the distinction and commonalities between these areas, and their respective relations with the ability to reason analytically. Second, we studied the independent contribution of each of the social cognition areas in order to discriminate between schizophrenia patients and controls. This was intended to shed light on the on-going debate regarding whether schizophrenia is domain-specific (Brune, 2005b; Bryson, Bell, & Lysaker, 1997; Harrington, Siegert et al., 2005; Langdon et al., 1997) or whether the impairment is fundamentally domain-general (e.g., as in the lack of ‘cognitive coordination’ proposed by Phillips and Silverstein (2003)). The two social cognitive areas behaving as a single factor would suggest that the impairment in schizophrenia is domain-general. The domain-specific hypothesis would be supported by evidence that they function as two distinct factors.

Correspondingly, two experiments were constructed. In the first experiment, we factor-analysed healthy participants performing a range of cognitive and affective social cognition tests, and an analytic reasoning task. In keeping with the distinction between the cognitive and emotional facets of social cognition posited in the literature ("ToM" and "emotion processing" in the list by Green et al. (2008), "cognitive ToM" and "affective ToM", in the terms of Shamay-Tsoory, Aharon-Peretz, and Levkovitz (2006)), we expected to find that the tasks would be divided into two factors. In the second experiment, we compared the performance of schizophrenia patients and a matching control group on the same cognitive and affective social cognition tests, while controlling for analytic reasoning. We expected the performance of schizophrenic patients to be impaired on both the cognitive and the affective social cognition tasks. We also used logistic regression analyses to determine whether the impairments in the cognitive and the affective aspects of social cognition dissociated in the patients. Understanding the factor structure of social-cognitive task measures may be important to better understand these distinct domains of social cognition, which may, in turn, inform studies of the distinct underlying neurophysiological circuits and the development of specific, targeted social-cognitive treatments.

Experiment 1

Method

Seventy-five healthy participants (40 males, 35 females) with no history of psychiatric disorders were recruited from the community. Their mean age was 29.86 (SD=10.69), with mean years of education 13.5 (SD=2.12). All of the participants completed all of the tasks. The order of the tasks was counterbalanced across participants.
Task Assessment

ToM Assessment (False Belief Stories)

This task was based on six ToM false belief stories (Frith & Corcoran, 1996) that test the ability of participants to identify trickery and deal with first- and second-order false beliefs. In first-order stories, the character has a mistaken belief about reality. In second-order stories, there is a mistaken belief about the beliefs of another character. The stories are simple and short. At the end of each story, two questions are presented to the participants. The first can only be answered if the mental state of the character is inferred. More specifically, to realize that a given belief is mistaken, the participants must know the correct belief. The second question serves as a control and to answer it, only the situation must be understood, while the use of ToM is unnecessary. The second question ensures that the participant is cooperating, understands the situation, and remembers the plot. For example, in one of the first-order stories the subject is told about "Betty that put her chocolate in the drawer and left the room. In her absence, her brother moved the chocolate to his closet". The following two questions are: "A. Where will Betty search for her chocolate?" and "B. Where did her brother put the chocolate?"

The second-order stories include an episode about "Dan who plans to visit with Ruth an exhibition that should take place in Tel Aviv. While purchasing a newspaper for their train journey Dan sees an advertisement, announcing that the exhibition was moved to Haifa. On the way to the tickets office, Ruth sees the same advertisement." The following two questions are: "A. To which city does Dan think Ruth buy the tickets?" and "B. What is the new location of the exhibition?" An experimenter read all the questions to each participant and marked the participant’s answer on the questionnaire sheet. The participant's score was the proportion of correct answers.

Emotion Inference Questionnaire (EIQ)

For this novel task, participants were asked to infer an emotion related to a relatively simple social situation presented in a short sentence. The following are examples of the scenarios presented to participants: "In the course of giving a talk, Gil began to stutter and his voice trembled. Did he feel embarrassed?"; “Your mom's garden is blooming like her close friend's garden. Will your mom be jealous of her friend?” and “The neighbour's son did not get any presents for his birthday. Will he be sad?” (see Appendix). In order to successfully complete this task, participants had to grasp the situation and identify the emotion congruent with the situation. The questions were forced-choice (yes/no). The questionnaire included 24 sentences related to seven emotions: three basic emotions (happiness, sadness, and anger), and four advanced emotions (insult, jealousy, embarrassment, and guilt). Each emotion was represented by four sentences, two of which required a “yes” answer and two a “no” answer. The scale yield cronbach's alpha =0.92.

Irony Understanding

This task was devised by Ackerman (1981) and translated into Hebrew by Lapidot, Most, Pik, and Schneider (1998). The task consists of two versions (ironic and neutral) of eight short stories. The sixteen stories were presented in randomised order. The stories all involve some interaction between two characters. At the end of each interaction, one of the characters makes a comment directed at the other. The verbal comment was the same in both versions, but the intonation was manipulated. In the ironic version, the comment was uttered with an ironic intonation, whereas the speaker’s true meaning was negative. In the neutral version, on the other hand, both the literal meaning and the speaker’s intended meaning were positive. To illustrate, an ironic version item described Joe, who came to work but sat down to rest instead of beginning to work. His boss noticed his behaviour and said, "Joe, don't work too hard!" The neutral version was the same but the intonation was sincere and serious. Each story was followed by two questions. The first question assessed the participant’s understanding of the content by asking, “Did Joe work hard?” The second question examined whether the participant appreciated the true meaning of the speaker by asking, “Did the manager believe Joe was working hard?” The participant received a score for the irony question only when both answers were correct. To control for memory load, we discarded the question if the participant failed to answer the content question correctly. Two scores were given to participants for this task: one
for the proportion of correct answers on understanding the irony, and one for the proportion of correct answers on the control questions. Participants who made more than two errors on the neutral version items were excluded and replaced. There was therefore almost no variance in the scores on the neutral versions, and only those on the irony versions of the stories will be used.

Matrix Reasoning

The matrix reasoning test, a WAIS-R subtest, is a standard measure of nonverbal abstract problem solving, inductive reasoning, and spatial reasoning abilities. The materials consist of 25 cards. On each card, a combination of figures is presented. The participants' task is to analyse the relationship between the figures based on several variables (e.g., colour and spatial orientation), and to select a figure that best fits the sequence from a set of options given at the bottom of the card. The cards displayed are increasingly difficult, as answering them requires consideration of an increasing number of variables, such as colour × size or colour × size × spatial orientation.

Procedure

Participants were tested individually. An experimenter read the questions out loud and marked the participant’s answer on a questionnaire sheet for each of the tasks. Filler questions were interspersed as a control. The participant's score was based on the proportion of correct answers on each task.

Results

A principal components factor analysis was conducted including all task expect of the irony control task that yielded a ceiling effect. The number of factors was not restricted. Two factors were extracted using principal-axes factoring and the criteria of eigenvalue >1.0; they were optimised using varimax with Kaiser normalisation rotation. The two factors account for 75.7% of the variance in the data. Table 1 presents the loading upon rotation of the five tasks on the two factors. The variables that loaded on the first factor were matrix reasoning, ToM1, and ToM2. Those that loaded on the second factor were EIQ and understanding of irony. No cross-loadings had weights above 0.20, and the two factors are not correlated (r=-0.07).

Insert Table 1

Discussion

The results of Experiment 1 reveal a two-factor structure. The first factor included ToM1, ToM2, and matrix reasoning; the second factor included EIQ and understanding of irony. Delving into the first factor, we see that both ToM tasks (first- and second-order) and matrix reasoning share the same underlying features. Matrix reasoning is a WAIS-R subtest used to measure nonverbal abstract problem solving, inductive reasoning, and spatial reasoning abilities. Matrix reasoning is strongly related to advanced analytic abilities. The common pattern of loading of ToM1 and ToM2 and Matrix reasoning suggests that both ToM tasks are related to a cognitive-based factor and require analytic skills to successfully tackle the questions. EIQ and irony understanding load on a second factor. Green et al.'s (2008) typology proposes that social cognition covers five areas, including ToM and emotion processing. The current findings suggest that these two areas are related to distinct factors. These results are in line with the growing body of recent evidence that distinguishes between cognitive and affective aspects of interpersonal skills, such as the differentiation between cognitive ToM and affective ToM (Shamay-Tsoory, Aharon-Peretz et al., 2006; Shamay-Tsoory et al., 2007). Recent neurophysiological findings also support this distinction. Shamay-Tsoory, Aharon-Peretz, & Perry (2009) found that subjects with ventromedial prefrontal damage showed impaired cognitive empathy and ToM abilities while still exhibiting intact emotion recognition. Patients with inferior frontal gyrus lesions, on the other hand, presented deficits in emotion recognition while maintaining cognitive empathy and ToM abilities.

We next turn to Experiment 2 in order to identify which factors and tasks were significantly more difficult for schizophrenia patients than for healthy controls.
Experiment 2

Experiment 2 was designed to provide an analysis of the impairment of schizophrenia patients regarding the two-factor structure. An additional goal of Experiment 2 was to create a map of the significant inter-correlations of performance on the tasks for both patients and controls.

Method

Participants and Design

Thirty patients with schizophrenia (21 males, 9 females), diagnosed according to the DSM-IV (American Psychiatric Association, 1994), participated in this study. Participants were treated in a day-care clinic at the Mental Health Centre in Beer Sheva, Israel. They provided informed consent before participating. Patients’ psychopathology was measured using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1989). The researchers rating psychopathology were blind to the patients’ performance on the tasks used in the study. All of the patients were being treated with antipsychotic medication. The patients’ mean age at onset of the disorder was 23.5 years (range: 13–60 years; SD=11 years), with a mean duration of illness of 13.2 years (range: 1–35 years; SD=10.3 years). A similar number of healthy controls (16 males, 14 females) with no history of psychiatric disorders were recruited from the community. All participants performed the tasks presented in Experiment 1: ToM false belief stories (first- and second-order), EIQ, irony understanding, and matrix reasoning. Materials and procedure were identical to those of Experiment 1. Patients and controls were matched according to age and education. Demographic characteristics of the participants, including their psychopathology ratings, are shown in Table 2.

Results

A mixed-design ANOVA Group × Task was used to analyse the data. The score for each task was treated as a within-participant variable, and the group (schizophrenia patient versus control) was a between-participants variable. There is little purpose in comparing the means across tasks, as the questions were heterogeneous and not matched for difficulty. Our interest lies in the differential effect of schizophrenia on the tasks.

Overall, we found the expected significant main effect for schizophrenia, F(1,57)=25.50; p<0.0001, as participants in the control group performed significantly better than those in the schizophrenia group. We also observed a significant interaction effect, F(5,285)=9.835; p<0.0001.

Table 3 presents follow-up t-test analyses (with Bonferroni adjustment of the alpha to 0.05/6=0.00625) contrasting the performance of schizophrenic patients and control group for each task. Both groups performed at similar levels on the irony-control questions, indicating that patients and controls alike could handle a simple conversation that did not include emotionally complicated phrases or analytic understanding. The difference in performance between the groups was larger for the matrix and ToM2 tasks, and slightly less pronounced for the Emotional Inference, ToM1, and Irony Understanding tasks as reflected by the power analysis values. All the differences were significant, except for two – ToM1, and irony-control.

We computed the correlations between the main tasks (see Table 4). Examining the correlation matrix for the patients group, we observe a significant correlation between ToM1 and ToM2, as well as between matrix reasoning and ToM2. The first correlation reflects the shared processes common to ToM1 and ToM2; the second correlation indicates the need for analytic abilities when confronting ToM2 questions. The correlation between matrix reasoning and ToM1 trends in the same direction (p=0.09), though it does not reach significance.

Proceeding to the right side and the data for the control group, the correlations between the matrix task and ToM2 and between ToM1 and ToM2 are more marked. In addition, the correlation between the matrix task and ToM1 is now significant. Lastly, a correlation between ToM2 and the irony understanding task emerges. The control group reflects the cognitive mechanisms required for the tasks, and a
comparison of the two tables may provide information regarding the deteriorated mechanism in the patient group. Table 5 presents the correlations between the PANSS evaluation dimensions and the tasks. Significant relationships were only found when the negative psychological symptoms assessed by the PANSS were correlated with the matrix, ToM2, and irony tasks (all these correlations are negative).

Insert Table 5

We used logistic regression to identify the task performances that discriminate between patients and controls. The predictor variables were the five tasks (matrix reasoning, ToM1, ToM2, EIQ and irony). Three of them -- matrix, ToM2, and irony -- were found to distinguish patients from controls, even when all other tasks that showed significant impairment in the patients' performance were taken into account. The log L-R (likelihood-reduction) $\chi^2$ statistic -- that tests the significance of the decrease in predictive power if a variable is removed from the full model-- is significant for all three tasks (matrix: $\chi^2 = 43.8, p = 0.003$; ToM2: $\chi^2 = 10.646, p = 0.01$; irony: $\chi^2 = 20.486, p = 0.008$).

General Discussion

Analysing the performance of healthy subjects on five tasks, Experiment 1 revealed that the tasks (first- and second-order ToM, EIQ and irony understanding, and matrix reasoning) divide into two distinct factors that correspond to the two areas of the social cognition ability, Theory of Mind (ToM), and EIQ. This pattern of factors is also in accord with the findings of Shamay-Tsoory et al. (2007) and Shamay-Tsoory & Tibi-Elhanany et al. (2006) regarding the distinction between cognitive ToM and affective ToM, that are supported by recent neurophysiological brain studies (Shamay-Tsoory et al., 2009).

Experiment 2 compared schizophrenia patients and healthy controls. The patients and the control groups answered the irony-control questions with equal accuracy. This shows that individuals with schizophrenia have adequate abilities when it comes to comprehending a simple conversation that rarely demands advanced cognitive or affective abilities. Experiment 2 confirmed the serious performance impairment of patients with schizophrenia on all five tasks: ToM1, ToM2, EIQ, irony, and matrix (and not on the irony-control task). These results are congruent with those of Pickup (2008) and in line with previous studies showing that patients with schizophrenia demonstrate impaired performance on all tasks involving EF and RPE (emotion recognition, and the ability to appreciate the mental states of others) (Brüne, 2005b; Evans, Chua, McKenna, & Wilson, 1997; Langdon & Coltheart, 2004; Langdon, Coltheart et al., 2002; Langdon, Davies et al., 2002; Pickup & Frith, 2001; Poole, Tobias, & Vinogradov, 2000; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Aharon-Peretz et al., 2006; Shamay-Tsoory et al., 2007; Shuliang et al., 2008). However, while Brüne (2005a), Langdon, Coltheart, Ward, and Catts (2001), and Pinkham and Penn (2006a) failed to find significant correlations between the ability to reason analytically and their ToM measures, we did find a significant and positive correlation between matrix reasoning scores and performance on ToM2. Our findings regarding the marked negative correlation between the negative psychological symptoms assessed by the PANSS and performance on the tasks are in line with the findings of Shamay-Tsoory et al. (2007), who also found significant negative correlations between ToM measures and negative symptom ratings, but differ from those Brüne (2005a), who failed to find significant correlations of this type.

Negative symptoms signify a lack of certain abilities in schizophrenia patients when compared to healthy individuals. The significant correlations between negative symptoms and ToM2, irony understanding and matrix reasoning indicate a deficiency in the mechanisms underlying these abilities.

What ability is involved? The extent of the difference between the patients group and the control group was the largest for the matrix and ToM2 tasks. Performance on these two tasks is correlated, in both the patients and control groups. This fits well with the finding in Experiment 1 that ToM1 and ToM2 relate to the same factor as matrix reasoning, while irony and emotion inference relate to another. A natural interpretation is that the false-belief tasks require significant analytical competence, and that ToM ability is related to the quality of fluid mental abilities.

The ToM2 and irony tasks were found to be correlated within the control group. Mo et al. (2008) did not find this correlation, though they did produce related findings, namely, that metaphor understanding was correlated with ToM2. For their
part, Langdon and collaborators (Langdon, Coltheart et al. (2002), Langdon, Davies et al. (2002), and Langdon and Coltheart (2004)) found a significant correlation between metaphor comprehension and ToM1. Mo et al. (2008) proposed that the relationship between metaphor and ToM may be explained using the Relevance Theory of Sperber and Wilson (1986, 1998). This theory holds that non-literal speech comprehension is related to the understanding of mental states, such as those assessed by the false-belief tasks. The significant correlation we found between ToM2 and irony supports this notion to some extent, as irony is also a form of non-literal speech understanding.

The results of Experiment 2 provide important complements to the two-factor structure found in Experiment 1 with healthy participants. The logistic regression showed that matrix reasoning, ToM2, and irony all made significant independent contributions to discrimination between patients and controls, even when all other tasks that reveal significant impairment in the patients’ performance are taken into account. This suggests that: (1) the understanding of irony (as assessed in this study) and ToM dissociate in schizophrenic patients; and (2) poor analytic reasoning (indexed by matrix reasoning) does not completely explain the patients’ difficulty with second-order ToM and the understanding of irony.

Taken together, these results suggest several conclusions for social cognition with respect to schizophrenia. First, the two areas of social cognition ability, Theory of Mind and RPE, are related to distinct factors. This finding corresponds to Green et al.’s (2008) typology. Second, while the mechanism needed for answering ToM questions (especially of second-order) is significantly related to fluid intelligence, the ability to reason analytically does not entirely account for the difficulties manifested by schizophrenic patients on this task. The impaired social cognition skills of individuals with schizophrenia appear to be due to the combination of several deteriorated mechanisms, including both the ability to think analytically and the ability to process emotional cues and information. Individuals with schizophrenia suffer from several specific cognitive impairments that not only relate to the semantic network or the inhibitory control ability, as proposed by Brüne (2005a), but also to the interaction of these abilities with the cognitive impairment of analytical reasoning and emotion processing. Accordingly, when discussing social cognition in relation to schizophrenia, it is critical to stress both the emotional components and the cognitive/analytic components. This is extremely important, because it implies that patients could benefit from the development of specific clinical rehabilitation programs that would address these varied and distinct impairments. Moreover, the current results also support the study of separate neurophysiological circuits, as has been done extensively by Shamay-Tsoory and colleagues (2007; 2006; 2009; 2006).

In closing, we wish to stress the importance and the necessity of future studies that will validate and extend the results presented in this paper. We hypothesised that the social cognition areas of ToM understanding and emotion processing were divided into a two-factor structure. The results clearly support this claim. However, this conclusion should be taken with caution, as an experimenter read all the tasks to the participants and may have provided them with prosodic cues. This might account for the irony task and the emotion inference tasks loading on the same factor. Future studies should clarify the role of prosodic cues by using both written and oral stories in modified irony tasks. More importantly, there is a need for broader studies that will clarify whether all the areas of social cognition identified by Green et al (2005) correspond to distinct factors when indexed by a range of suitable tasks, and how this factor structure is modulated by schizophrenia.
References


Evans, J. J., Chua, S. E., McKenna, P. J., & Wilson, B. A. (1997). Assessment of the dysexecutive syndrome in schizophrenia. Psychological Medicine, 27, 635-646.


Appendix – Emotion Inferencing Questionnaire

During the break ToM ran in the garden. One of his classmates tripped him and he fell. Will he be angry with the other boy?

Tomorrow Lisa will have a long day at school. Her mother will prepare her a sandwich for lunch. Will Lisa be angry with her mother?

Dan asked his friend to help him study for a test. Instead, the friend went to sleep. Will Dan be angry with his friend?

On the way to the local grocery, Rina does some shopping for her neighbours as well. Will they be angry with her?

Your friend wrote a love letter for a girl and was rejected by her. Will he feel hurt?

The neighbour’s son cleaned the garden and received from his mother his favourite chocolate. Will he feel hurt?

Nir bought a birthday present for his friend with the money he saved. However, the friend tossed it to the garbage in front of his eyes. Will Nir be hurt?

One of your classmates read his homework answer. Your teacher is enthusiastic about the answer and praises your friend. Will the friend feel insulted?

The neighbour’s son did not get any present for his birthday. Will he be sad?

Rinat won the first prize in the lottery. Will she be sad?

Mica was the only boy that was not invited to the birthday party. Will Mica be sad?

Ben achieved the best grade in the math test in his class. Will he be sad?

Your friend was chosen as “student of the month” and won a prize. Will he be happy?

The bicycle of the neighbour’s daughter was stolen yesterday. Will she be happy?

You friend returned home hungry after a long and intensive basketball training. His older brother made him supper. Will he be happy?

Ruth broke the flower vase in the living room. Her mother shouted at her. Will she be happy?

Your friend studied for the test with her twin sister and received a lower grade than her. Will she be jealous of her sister?

Solomon bought a brand-new car like his cousin. Will he be jealous of him?

Your younger brother asked your parents to buy him a toy he saw at his friend’s house. However, your parents refused. Will your younger brother be jealous of his friend?

Your mom’s garden is blooming like her close friend’s garden. Will your mom be jealous of her friend?

While ToM gave a talk, he started to stutter and his voice trembled. Will he feel embarrassed?

Sera went with her parents to have dinner in a restaurant. When they entered the restaurant, they found out that their table was not prepared even though they made reservations in advance. The parents got angry and shouted at the manager and a fuss broke out. Will Sera be embarrassed?

Miriam was angry with her friend. When she met her, she yelled at her and offended her more than she previously intended. Will she feel guilty?

During a basketball game, the players from the rival team pushed Danny the entire time. After the break, Danny decided to push them back. Will he feel guilty?
### Table 1
Loadings on the two factors upon varimax rotation of the 5 tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>0.72</td>
<td>-0.16</td>
</tr>
<tr>
<td>ToM1</td>
<td>0.71</td>
<td>0.19</td>
</tr>
<tr>
<td>ToM2</td>
<td>0.75</td>
<td>-0.05</td>
</tr>
<tr>
<td>EIQ</td>
<td>0.18</td>
<td>0.76</td>
</tr>
<tr>
<td>Irony</td>
<td>0.04</td>
<td>0.74</td>
</tr>
</tbody>
</table>

### Table 2
Demographic characteristics of schizophrenic patients and healthy controls

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia Patients</th>
<th>Healthy Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Gender ratio (M:F)</td>
<td>(21:9)</td>
<td>(16:14)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>37.83 ± 11.32</td>
<td>35.56 ± 12.64</td>
</tr>
<tr>
<td>Age at onset (years)</td>
<td>24.28 ± 11.08</td>
<td></td>
</tr>
<tr>
<td>Duration of illness (years)</td>
<td>13.20 ± 13.37</td>
<td></td>
</tr>
<tr>
<td>PANSS positive subscale</td>
<td>19.16 ± 7.18</td>
<td></td>
</tr>
<tr>
<td>PANSS negative subscale</td>
<td>17.01 ± 5.17</td>
<td></td>
</tr>
<tr>
<td>PANSS general subscale</td>
<td>39.96 ± 9.48</td>
<td></td>
</tr>
<tr>
<td>PANSS total sum*</td>
<td>58.12 ± 16.53</td>
<td></td>
</tr>
</tbody>
</table>

* Total score – 18 points
### Table 3

t-test analyses (with Bonferroni adjustment) for all tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Controls</th>
<th>Patients</th>
<th>Effect</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>t(58)</td>
<td>P</td>
</tr>
<tr>
<td>Matrix</td>
<td>0.72 0.18</td>
<td>0.36 0.18</td>
<td>7.719**</td>
<td>0.000 1.00</td>
</tr>
<tr>
<td>EIQ</td>
<td>0.97 0.04</td>
<td>0.88 0.15</td>
<td>2.811**</td>
<td>0.006 0.83</td>
</tr>
<tr>
<td>ToM1</td>
<td>0.98 0.06</td>
<td>0.91 0.17</td>
<td>2.304</td>
<td>0.024 ---</td>
</tr>
<tr>
<td>ToM2</td>
<td>0.90 0.18</td>
<td>0.65 0.40</td>
<td>3.088**</td>
<td>0.003 0.98</td>
</tr>
<tr>
<td>Irony</td>
<td>0.95 0.08</td>
<td>0.85 0.16</td>
<td>3.085**</td>
<td>0.003 0.78</td>
</tr>
<tr>
<td>Irony-Control</td>
<td>0.88 0.14</td>
<td>0.89 0.15</td>
<td>0.351</td>
<td>0.726 ---</td>
</tr>
</tbody>
</table>

### Table 4
Correlations between the tasks

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th></th>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Matrix</td>
<td>EIQ</td>
<td>ToM1</td>
<td>ToM2</td>
</tr>
<tr>
<td>Matrix</td>
<td>0.15</td>
<td>0.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EIQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ToM1</td>
<td></td>
<td></td>
<td>0.31</td>
<td>0.34</td>
</tr>
<tr>
<td>ToM2</td>
<td></td>
<td></td>
<td>0.36*</td>
<td>0.41*</td>
</tr>
<tr>
<td>Irony</td>
<td>0.30 (-.11)</td>
<td>(-.08)</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01
Table 5 – Correlations between PANSS evaluations and tasks. (Significant correlations are in bold.)

<table>
<thead>
<tr>
<th></th>
<th>Matrix</th>
<th>EIQ</th>
<th>ToM1</th>
<th>ToM2</th>
<th>Irony</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>-0.192</td>
<td>-0.014</td>
<td>-0.173</td>
<td>-0.191</td>
<td>-0.293</td>
</tr>
<tr>
<td></td>
<td>p=0.358</td>
<td>p=0.944</td>
<td>p=0.407</td>
<td>p=0.36</td>
<td>p=0.155</td>
</tr>
<tr>
<td>Negative</td>
<td><strong>-0.524</strong></td>
<td>-0.083</td>
<td>-0.277</td>
<td><strong>-0.553</strong></td>
<td><strong>-0.423</strong></td>
</tr>
<tr>
<td></td>
<td><strong>p=0.007</strong></td>
<td>p=0.692</td>
<td>p=0.180</td>
<td><strong>p=0.004</strong></td>
<td><strong>p=0.035</strong></td>
</tr>
<tr>
<td>General</td>
<td>-0.202</td>
<td>-0.287</td>
<td>-0.244</td>
<td>-0.192</td>
<td>-0.192</td>
</tr>
<tr>
<td></td>
<td>p=0.331</td>
<td>p=0.165</td>
<td>p=0.239</td>
<td>p=0.562</td>
<td>p=0.917</td>
</tr>
<tr>
<td>Total</td>
<td>-0.363</td>
<td>-0.197</td>
<td>-0.302</td>
<td>-0.326</td>
<td>-0.272</td>
</tr>
<tr>
<td></td>
<td><strong>p=0.074</strong></td>
<td>p=0.344</td>
<td>p=0.142</td>
<td>p=0.112</td>
<td>p=0.188</td>
</tr>
</tbody>
</table>