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Emotion recognition, 'theory of mind,' and social behavior in schizophrenia

Martin Brüne*

Center for Psychiatry and Psychotherapy, University of Bochum, Alexandrinenstrasse 1-3, Bochum, D-44791 Germany

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Abstract

Several studies have demonstrated that patients with schizophrenia are impaired in recognizing emotions from facial expressions and in appreciating other people's mental states—the latter commonly referred to as 'theory of mind.' The question as to how social cognitive skills relate to patients' actual social behavior is, however, largely unanswered. This study examined emotion recognition, 'theory of mind,' and social behavior in schizophrenia. Emotion recognition, 'theory of mind,' executive functioning, 'crystallized' verbal intelligence, psychopathology, and social behavior were assessed in patients with schizophrenia compared with a healthy control group. Patients were significantly impaired on all tasks involving executive functioning, emotion recognition, and 'theory of mind.' Impaired executive functioning did, however, only partially account for the deficits in social perception and social cognition. Social perception and cognition in schizophrenia predicted the odds of being a patient significantly better than nonsocial cognition. Severe social behavioral abnormalities were linked to the duration of the illness, and even more so to 'theory of mind' deficits. Considering impaired social perception and social cognition significantly contributes to the understanding of social behavioral problems in schizophrenia.

Keywords: Social cognition; Executive functioning; Social behavior; Schizophrenia

1. Introduction

The term 'schizophrenia' refers to a group of psychotic disorders that are characterized by cognitive symptoms such as thought disorder and delusions, and by behavioral symptoms such as catatonia or negative symptoms (American Psychiatric Association, 1994).

From a clinical perspective, the most outstanding characteristic of schizophrenia is the inapt, often bizarre behavior of affected individuals. In other words, it is almost always the deviant *social* behavior in schizophrenia that renders patients 'abnormal.' The importance of social behavioral problems in schizophrenia cannot be overestimated, since impaired social functioning in schizophrenic patients frequently precedes the onset of psychosis. Social deficits are often already present in first-episode patients, and may be relatively impervious to

* Tel.: +49 234 5077 155; fax: +49 234 5077 235.
E-mail address: Martin.Bruene@rub.de.

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antipsychotic treatment. Moreover, social impairments in schizophrenia frequently worsen over the course of the disorder and probably contribute to the rate of relapse (recently summarized by Pinkham et al., 2003).

Over the past decades, however, most neuropsychiatric studies in schizophrenia have largely focused on disorders of 'nonsocial' cognitive processes such as executive functioning, attention, or memory (e.g., Evans et al., 1997; Cirillo and Seidman, 2003), deficits that certainly affect patients' psychosocial skills. Only quite recently have researchers shifted their attention towards social cognition in schizophrenia (Penn et al., 1997; Pinkham et al., 2003), questioning to what extent an impaired *perception* of social signals or impaired *social cognition* may directly account for the poor social functioning in schizophrenia. There is indeed some evidence that, statistically, social cognitive measures may better distinguish between patients and nonpatients than 'nonsocial' tests (Penn et al., 1997). The association of social perceptual and cognitive skills in schizophrenic patients with patients' actual social behavior is, however, to a certain extent still unclear (overview in Brüne, in press). It seems to turn out that patients with chronic schizophrenia suffering from marked negative symptoms are more impaired in their ability to recognize emotions from facial expressions and in their social skills, relative to less chronic patients (Mueser et al., 1996; Penn et al., 1996).

With regard to social cognition, a compelling theoretical framework to explain certain cognitive aspects of the marked social deficits in schizophrenia was put forward by Frith (1992). He hypothesized that many symptoms typical of schizophrenia may be accounted for by a specific cognitive incapacity of schizophrenic patients to accurately attribute mental states to themselves or others (commonly referred to as 'having a theory of self and others' minds'; ToM), leading to what Frith called 'disorders of willed action,' 'disorders of self-monitoring,' and 'disorders of monitoring other persons' thoughts and intentions' (Frith, 1992). For example, if patients with schizophrenia have difficulties in perceiving their behavior as the result of their own enacted goals or to suppress inappropriate responses, their behavior may become disorganized. Secondly, if patients are unable to appreciate their behavior as the result of their own intentions, they may falsely interpret their actions as being under alien control or experience voice-commenting hallucinations. Thirdly, if patients confuse their subjective representations with reality, they may maintain false beliefs about other people's intentions, for instance, in the form of delusional convictions of being poisoned or persecuted.

Frith and Frith (1999) have proposed that the perception of emotional states of other individuals is represented in a dedicated brain system different from (though overlapping with) a second one subserving ToM. The former involves a 'ventral' stream including the amygdala and the orbitofrontal cortex; the latter, a 'dorsal' pathway comprising the superior temporal sulcus, the inferior frontal regions, and the medial prefrontal cortex including parts of the anterior cingulate cortex (Frith and Frith, 1999, 2001).

With respect to schizophrenic disorders, there is a host of studies providing evidence that schizophrenic patients are profoundly compromised in recognizing other people's emotions from facial expressions, gestures, or voices (reviewed in Mandal et al., 1998), and in inferring the mental states of others (i.e., ToM; overview in Brüne, in press). Many studies suggest that the deficits in these domains are specific rather than secondary to a general cognitive decline in schizophrenia (e.g., Bryson et al., 1997; Langdon et al., 1997).

Emotion recognition and ToM have, however, not been assessed simultaneously in adults with schizophrenia so far. Moreover, only a few studies have directly focused on the question as to whether patients' compromised social perceptual skills account for their actual social behavioral problems, and only one study has looked at ToM and its relation to social behavior in schizophrenia (Roncone et al., 2002).

The present study attempts to clarify the following hypotheses: (1) compared with healthy controls, patients with schizophrenia are impaired in both emotion recognition and ToM tasks; (2) the performance on social cognitive tasks contributes a significant proportion of the amount of variance to distinguish between patients and controls, the amount of variance being possibly greater than that of nonsocial task performance; and (3) measures of social perception and cognition contribute to explain patients' actual social behavioral abnormalities.

2. Methods

2.1. Participants

Twenty-three schizophrenic patients (18 males, 5 females) with schizophrenia according to DSM-IV (American Psychiatric Association, 1994) who were treated as in-patients or attended a day clinic and who had given informed consent to participate were included. All patients received antipsychotic medication. Patients' mean age at onset of the disorder was 26.5 years (12–59 years; S.D.±10 years), and their mean duration of illness was 12.3 years (0–35 years; S.D.±7.9 years). Eighteen healthy control subjects (8 males, 10 females) with no history of psychiatric disorders were recruited from the community and in part from hospital staff (nurses, technicians, and secretaries). Patients and control group were paralleled for 'crystallized' verbal intelligence as measured by the 'Mehrfachwahlwortschatztest' (MWT; which may best be translated as 'Multiple Choice Verbal Comprehension Test'; Lehrl, 1976), and for age. English readership may note that the German MWT is similar to the widely used 'Spot-the-Word Test' (Baddeley et al., 1993). Demographic characteristics of the participants, including ratings of psychopathology and social behavior in the patient group, are shown in Table 1.

Table 1
Demographic characteristics for schizophrenic patients and healthy controls, including comparison of 'crystallized' intelligence and index age

	Schizophrenia	Healthy controls	Statistics
n	23	18	
Sex ratio (M:F)	18:5	8:10	
Index age (years)	38.8±12.2	35.5±12.8	*P*=0.402, n.s.
Age at onset (years)	26.5±10	–	
Duration of illness (years)	12.3±7.9	–	
'Crystallized' IQ (MWT score)	100 (27±5.2)	105 (29.3±4.3)	*P*=0.136, n.s.
PANSS positive	15.1±4.7		
PANSS negative	20.7±6.3		
PANSS general	35.6±9.7		
PANSS sum	70.3±20.1		
BSM	10.2±7.6		
BSS	6.7±6.2		
SBS	15.8±9.5		

2.2. Executive functioning tasks

The following three tests of executive functioning were given to the participants: (1) a computerized and simplified version of the Wisconsin Card Sorting Test (WCST; Nelson, 1976), where participants were notified of changes to the rules of allocating the cards as displayed on the screen. Errors and perseverations were rated separately. Two additional tests of executive functioning were taken from the Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson et al., 1996) (i.e., the Key Search Test and the Zoo Map Test, both involving executive planning skills).

2.3. Social cognition tasks

(1) Perception of facial expressions of emotions was assessed using 36 still photographs taken from Ekman and Friesen's (1976) Pictures of Facial Affect. The photographs depicted six basic emotions of each of three male and female actors (happiness, sadness, fear, surprise, anger, and disgust; thus, 18 male and 18 female faces). Subjects were asked to name the respective emotion. An answer sheet with the six possible choices was continuously presented to make patients' choices unambiguous. (2) ToM was assessed using a novel series of six cartoon picture stories (Brüne, 2003b). There were three types of stories depicting (1) a scenario where two characters cooperated; (2) a scenario where one character deceived a second character; and (3) a scenario showing two characters cooperating to deceive a third. Each picture story consisted of four cards. The cards were presented face-down in mixed order. The participants were asked to turn the cards over and to order them in a logical sequence of events. Two examples were adopted from Langdon et al.'s (1997) picture stories. The sequencing time was measured for each picture story. The method of rating the sequencing task was taken from Langdon et al. (1997) (i.e., two points were given for the first and last correctly sequenced cards, and one point

each for correct sequencing of the two middle cards; thus, six points maximum per picture story, with a maximum sum score of 36 points). (3) In addition, a ToM questionnaire comprising 23 questions was given to the subjects to test their ability to appreciate the mental states of the characters involved in the cartoon stories. The questions referred to the mental states of the characters of the picture stories according to different levels of complexity. For example, a so-called 'first-order question' was: What do you think (1) this person (pointing to the respective character) intends? An example of a second-order question was: What do you think (1) this person believes (2) the other intends to do? Overall, questions addressed the participants' ability to perceive cooperation in deception, to detect cheating detection, and to recognize true and false beliefs of the characters in the picture stories. In addition, reality questions were asked, basically to rule out major attention problems. A total score of sequencing and questionnaire subscores was calculated (59 points maximum).

2.4. Behavioral measures

Patients' psychopathology was measured using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1989) and patients' social behavior was rated using the Social Behaviour Scale (SBS; Wykes and Sturt, 1986). The SBS represents a rating scale designed for and mainly used by nursing staff or other professionals in close contact with patients. The SBS scores were evaluated according to the severity of socially deviant behavior; in addition to the total score of the SBS, two cutoff scores were calculated: one comprising mild to severe behavioral problems (BSM), and the other taking into account severe social behavioral problems only (BSS; Wykes and Sturt, 1986).

The rating of psychopathology was carried out blind to the patients' performance on the MWT, executive tests, and social perception and cognition tasks. Members of the nursing staff, who rated the patients' social behavior using a German translation of the SBS, were unaware of both measures of psychopathology and task performance.

Statistical analyses were carried out using SPSS 11.0 for Macintosh.

3. Results

3.1. Between-group differences

Since IQ measures and age were normally distributed, a parametric one-way analysis of variance (ANOVA) was carried out. Patients did not differ from controls with respect to age [$F(1,40)=0.719$, $P=0.402$] or 'crystallized' verbal IQ [$F(1,40)=2.322$, $P=0.136$].

Due to large differences between the groups in amount of variance, Kruskal–Wallis nonparametric tests were carried out to compare patients' and controls' performance on the executive functioning and the social perception and cognition tasks. Both groups differed significantly on all measures of executive functioning, emotion recognition, and ToM tasks, with the exceptions of their responses to the reality questions of the ToM questionnaire [χ^2 (1,41)=2.468, $P=0.116$], first-order belief questions [χ^2 (1,41)=2.674, $P=0.102$], appreciation of reciprocity [χ^2 (1,41)=3.303, $P=0.069$], and recognition of 'happiness' [χ^2 (1,41)=2.468, $P=0.116$]. In particular, with respect to executive functioning, patients made more errors [WCSTerr: χ^2 (1,41)=15.109, $P<0.001$] and more perseverative errors on the WCST [WCSTpers: χ^2 (1,41)=10.293, $P=0.001$], and scored significantly lower on the Key Search Test [χ^2 (1,41)=11.162, $P=0.001$] compared with controls. The difference in task performance on the Zoo Map Test marginally missed the 5% significance level [χ^2 (1,41)=3.787, $P=0.052$]. Moreover, patients were significantly slower overall on the ToM sequencing task [ToMseq-t: χ^2 (1,41)=6.978, $P=0.008$], made more sequencing errors [ToMseq: χ^2 (1,41)=17.654, $P<0.001$], performed more poorly on the ToM questionnaire than did healthy subjects [ToMquest: χ^2 (1,41)=16.608, $P<0.001$], and thus had significantly lower ToM sum scores (ToMtot: χ^2=21.242, $P<0.001$; a summary of group comparisons is given in Table 2).

To control for confounding effects of executive functioning and intelligence, patients with subnormal IQ (<22 points in the MWT) and patients with more than three perseverative errors on the WCST were excluded from the analysis. There was no difference in age between the remaining 12 patients and the control group [$F(1,29)=0.253$, $P=0.619$]. For further group comparisons, we used the nonparametric Mann–

Table 2
Kruskal–Wallis nonparametric between-group comparisons for executive functioning, theory of mind variables, and emotion recognition

Item	Mean ranks	Schizophrenia	Healthy controls	Statistics
WCST errors	8.0±5.8	27.41	12.81	χ^2=15.109, P<0.001
WCST perseverations	4.2±7.7	26.17	14.39	χ^2=10.293, P=0.001
Key Search Test	2.78±1.6	16.0	27.39	χ^2=11.162, P=0.001
Zoo Map Test	2.22±1.1	17.96	24.89	χ^2=3.787, P=0.052
ToM sequencing	29.32±8.4	14.33	29.53	χ^2=17.654, P<0.001
ToM sequencing time	167±158.1	24.02	14.22	χ^2=6.978, P=0.008
First-order belief	1.49±0.71	18.65	24.0	χ^2=2.674, P=0.102, n.s.
First-order false belief	2.27±0.92	18.11	24.69	χ^2=3.693, P=0.055
Second-order belief	1.66±0.58	18.0	24.83	χ^2=5.2, P=0.021
Second-order false belief	2.17±1	16.8	26.36	χ^2=7.581, P=0.006
Reality	1.9±1.2	19.83	22.5	χ^2=2.468, P=0.116, n.s.
Reciprocity	2.37±0.77	18.28	24.47	χ^2=3.303, P=0.069, n.s.
Deception	2.49±0.9	17.48	25.5	χ^2=6.718, P=0.01
Cheating detection	1.61±0.7	17.48	25.5	χ^2=7.501, P=0.006
Third-order false belief	1.9±1.2	14.96	28.72	χ^2=15.09, P<0.001
ToM questionnaire	17.95±5.5	14.33	29.53	χ^2=16.608, P<0.001
ToM total score	47.27±12.9	13.41	30.69	χ^2=21.242, P<0.001
Happiness	5.9±0.37	19.83	22.5	χ^2=2.468, P=0.116, n.s.
Sadness	4.56±1.6	16.83	26.33	χ^2=6.853, P=0.009
Fear	4.44±1.5	17.17	25.89	χ^2=5.66, P=0.017
Surprise	4.76±1.6	15.3	28.28	χ^2=13.382, P<0.001
Disgust	4.54±1.6	16.13	27.22	χ^2=9.431, P=0.002
Anger	4.83±1.3	15.33	28.25	χ^2=12.939, P<0.001
Emotions total score	29.02±5.6	13.61	30.44	χ^2=20.214, P<0.001

Whitney U test for nonnormally distributed variables. Patients did not differ from controls regarding the number of perseverative errors in the WCST (Mann–Whitney U=74.0, Z=−1.523, P=0.128). The remaining group of schizophrenic patients still performed more poorly on the ToMquest (Mann–Whitney U=24.0, Z=−3.609, P<0.001), made more sequencing errors (Mann–Whitney U=39.5, Z=−3.171, P=0.002), and thus had lower ToMtot scores (Mann–Whitney U=16.5, Z=−3.911, P<0.001). The between-group difference in sequencing time (ToMseq-t), however, disappeared (Mann–Whitney U=61.0, Z=−1.626, P=0.104, n.s.). Similarly, patients had more difficulties in identifying the emotional expressions of surprise (Mann–Whitney U=54.0, Z=−2.598, P=0.009) and anger (Mann–Whitney U=32.5, Z=−3.426, P=0.001), and the difference between patients and controls approached significance for disgust (Mann–Whitney U=67.0, Z=−1.859, P=0.063), whereas happiness, fear, and sadness recognition did not significantly differ between patients and controls, when IQ and perseverative errors in the WCST were taken into account.

3.2. Correlations within the control group

Within-group correlations in the control group revealed fairly strong and highly significant negative associations of ‘crystallized’ verbal IQ with the number of errors (WCSTerr: r=−0.644, P=0.004) and with the number of perseverations (WCSTpers: r=−0.610, P=0.007) in the WCST, and a strong correlation of the total score of ToM tasks (ToMtot) and emotion recognition (r=0.782, P<0.001). The sequencing part of the ToM task (ToMseq), the questionnaire part of the ToM task (ToMquest) and ToMtot did not correlate with any of the executive functioning tasks. Likewise, none of the emotion recognition subscores for happiness, sadness, fear, surprise, disgust, or anger, or the total score of the emotion recognition task (ERtot) correlated with any of the executive functioning measures in the control group. Whereas neither ToMseq nor ToMtot correlated with IQ (MWT), ToMquest correlated significantly with IQ (r=0.526, P=0.025) and highly significantly with emotion recognition scores except for fear (r=−0.021, P=0.933, n.s.). In contrast, no correlations were found between emotion recognition scores and IQ, except for the 'disgust' subscore, which significantly correlated with IQ (r=0.572, P=0.013; see Table 3).

3.3. Correlations within the patient group

Correlation analysis in the entire patient group (n=23) revealed a different picture. The ToM sum score (ToMtot) and the ToM questionnaire score (ToMquest) correlated significantly with 'crystallized' verbal IQ and with the performance on the Key Search Test and on the Zoo Map Test. Patients' performance on the emotion recognition task (ERtot) correlated negatively with the number of perseverative errors in the WCST, and positively with the Zoo Map Test. In contrast to the control group, no correlation was found between ERtot and ToMquest or ToMtot (Table 3).

3.4. Behavioral measures, executive functioning, and social perception and cognition

With respect to the behavioral measures, ToMquest, ToMtot, or ERtot did not correlate with any of the psychopathology scores, such as positive, negative, general, or total scores as assessed using the PANSS. Neither the BSM nor the BSS subscore correlated with psychopathology or any of the executive functioning tests. The total SBS score did, however, significantly correlate with negative symptoms, general psychopathology, and with the PANSS sum score, but not with positive symptoms. Inverse correlations were found between ToMquest and ToMtot with the duration of illness and severe social behavioral problem (BSS). Furthermore, the duration of illness correlated negatively with the sequencing score and positively with the sequencing time. Moreover, the ToMquest alone correlated significantly with the BSM. BSS correlated significantly with the duration of illness and negatively with 'crystallized' verbal IQ (summarized in Table 4).

Partial correlations revealed that ToMtot did not correlate with BSS when the duration of illness was taken into account (r=−0.28, df=19, P=0.217, n.s.) or when IQ was controlled for (r=−0.27, df=18, P=0.247, n.s.). Likewise, BSS did not correlate with the duration of illness when controlling for ToMtot (r=0.38, df=19, P=0.089, n.s.) or with IQ when controlling for ToMtot (r=−0.27, df=18, P=0.251, n.s.).

However, whereas BSS did not correlate with ToMquest when controlled for IQ (r=−0.4, df=18, P=0.083, n.s.), a significant correlation between BSS and ToMquest remained even when the duration of illness was accounted for (r=−0.46, df=19, P=0.036). No correlation was found between ERtot and BSM, BSS, or SBS.

Regression analyses were carried out to tackle a number of questions. (1) To further address the question as to whether executive functioning deficits could account for impaired emotion recognition and ToM in schizophrenia, the scores of the WCSTpers, Zoo Map Test, emotion recognition (ERtot), and ToM tasks (ToMtot) were fitted as independent variables into a logistic regression equation predicting the odds of being a patient. The full model was highly significant [χ^2 (4,41)=34.103, P<0.001, Nagelkerke R^2=0.757] and classified 94.4% of controls and 91.3% of patients correctly (92.7% of all subjects). All variables were significant zero-order predictors [WCSTpers: χ^2 (1,41)=13.874, P<0.001, Nagelkerke R^2=0.385; Zoo Map Test: χ^2 (1,41)=4.207, P=0.04, Nagelkerke R^2=0.131; ToMtot: χ^2 (1,41)=27.178, P<0.001, Nagelkerke R^2= 0.649; ERtot: χ^2 (1,41)=21.679, P<0.001, Nagelkerke R^2=0.55]. The classification tables revealed that WCSTpers could classify 70.7% of participants correctly; the values for the Zoo Map Test, ToMtot, and ERtot were 65.9%, 82.9%, and 82.9%, respectively.

In addition, a backwards-stepwise logistic regression analysis using the same set of variables was carried out. After three steps, the model accounted for successful classification of 94.4% of controls and 82.6% of patients (87.8% of all subjects). The scores for WCSTpers (change in −2 log likelihood=5.491, df=1, P=0.019) and ToMtot (change in −2 log likelihood=18.796, df=1, P<0.001) remained in the equation as the only significant predictors of the odds of being a patient [χ^2 (2,41)=32.669, P<0.001, Nagelkerke R^2=0.736], whereas scores for the Zoo Map Test and emotion recognition were successively removed from the equation (Table 5).

Table 3
Correlations of task measures for patients and control group (in italics)

	MWT	WCSTerr	WCSTpers	KST	ZMT	ToMseq	ToMseq-t	ToMquest	ToMtot	Hap	Sad	Fear	Surpr	Disg	Anger	ERtot
MWT		−0.196 (*−0.644*)**	−0.346 (*−0.610*)**	0.453* (*−0.305*)	0.463* (*0.247*)	0.488* (*0.071*)	−0.097 (*0.107*)	0.473* (*0.526*)*	0.540** (*0.426*)	−0.222[a]	0.375 (*−0.159*)	0.268 (*0.313*)	−0.032 (*0.461*)	0.208 (*0.572*)*	0.162 (*0.452*)	0.305 (*0.456*)
WCSTerr			0.075 (*0.308*)	−0.174 (*0.003*)	−0.221 (*−0.410*)	−0.213 (*0.154*)	0.373 (*0.058*)	0.059 (*−0.222*)	−0.114 (*−0.093*)	0.128[a]	0.037 (*0.014*)	−0.227 (*−0.373*)	−0.324 (*−0.038*)	−0.061 (*0.039*)	−0.361 (*−0.004*)	−0.274 (*−0.087*)
WCSTpers				−0.515* (0.213)	−0.639** (*−0.182*)	−0.374 (*−0.254*)	0.307 (*0.114*)	−0.232 (*−0.023*)	−0.354 (*−0.137*)	0.044[a]	−0.250 (*0.352*)	−0.285 (*−0.096*)	−0.475* (*−0.386*)	−0.386 (*−0.311*)	−0.058 (*−0.044*)	−0.492* (*−0.140*)
KST					0.558** (*−0.095*)	0.544** (*−0.236*)	−0.256 (*−0.183*)	0.535** (*0.014*)	0.605** (*−0.101*)	−0.213[a]	0.314 (*−0.310*)	0.001 (*−0.039*)	0.278 (*−0.170*)	0.001 (*−0.088*)	0.064 (*−0.177*)	0.204 (*−0.198*)
ZMT						0.444* (*0.009*)	−0.483* (*−0.395*)	0.431* (*0.033*)	0.492* (*0.029*)	−0.170[a]	0.325 (*−0.060*)	0.456* (*−0.019*)	0.387 (*0.066*)	0.533** (*−0.106*)	0.349 (*−0.085*)	0.656** (*−0.064*)
ToMseq							−0.569** (*−0.303*)	0.578** (*0.314*)	00.928** (*0.705*)**	−0.149[a]	0.215 (*−0.203*)	0.192 (*0.221*)	0.311 (*0.555*)*	0.136 (*0.286*)	0.229 (*0.490*)*	0.338 (*0.358*)
ToMseq−t								−0.295 (*−0.213*)	−0.513* (*−0.299*)	0.289a	−0.127 (*0.094*)	−0.102 (*−0.223*)	−0.135 (*−0.238*)	−0.319 (*−0.019*)	−0.125 (*0.006*)	−0.235 (*0.090*)
ToMquest									0.841** (*0.894*)**	0.068[a]	0.370 (*−0.021*)	−0.086 (*0.729*)**	0.194 (*0.723*)*	0.108 (*0.776*)**	0.051 (*0.825*)**	0.226 (*0.821*)**
ToMtot										−0.068[a]	0.312 (*−0.111*)	0.088 (*0.648*)**	0.295 (*0.801*)**	0.140 (*0.714*)**	0.175 (*0.847*)**	0.328 (*0.782*)**
Hap											0.362[a]	−0.128[a]	0.399[a]	−0.020[a]	0.161[a]	0.358[a]
Sad												0.136 (*0.259*)	0.063 (*0.000*)	0.113 (*−0.059*)	0.094 (*0.119*)	0.529** (*0.314*)
Fear													0.162 (*0.653*)**	0.449* (*0.513*)*	0.035 (*0.591*)*	0.602** (*0.788*)**
Surpr														0.207 (*0.839*)**	0.319 (*0.806*)**	0.612** (*0.882*)**
Disg															0.304 (*0.839*)**	0.673** (*0.861*)**
Anger																0.517* (*0.906*)**
ERtot																

[a] At least one variable is constant.
* Correlation is significant at the 0.05 level (two-tailed).
** Correlation is significant at the 0.01 level (two-tailed).

Table 4
Correlations of patients' behavioral measures with executive functioning, social perception, and social cognition

	Age at onset	Duration of illness	MWT	WCSTerr	WCSTpers	KST	ZMT	ToMseq	ToMseq-t
Age at onset		−0.031	−0.350	0.081	0.057	−0.490*	−0.190	−0.371	0.030
Duration of illness			−0.309	0.168	0.224	−0.371	−0.342	−0.489*	0.489*
MWT				−0.196	−0.346	0.453*	0.463*	0.488*	−0.097
WCSTerr					0.075	−0.174	−0.221	−0.213	0.373
WCSTpers						−0.515*	−0.639**	−0.374	0.307
KST							0.558**	0.544**	−0.256
ZMT								0.444*	−0.483*
ToMseq									−0.569**
ToMseq-t									
ToMquest									
ToMtot									
ERtot									
PANSSpos									
PANSSneg									
PANSSgen									
PANSStot									
BSM									
BSS									
SBS									

* Correlation is significant at the 0.05 level (two-tailed).
** Correlation is significant at the 0.01 level (two-tailed).

Most remarkably, ToMtot remained in all backwards-stepwise regression models as a highly significant predictor independent of which two of the four nonsocial cognitive measures (WCSTerr, WCSTpers, Key Search Test, and Zoo Map Test) were fitted into the equation.

(2) To examine the relationship of social cognition to patients' actual social behavior, a linear regression analysis with BSS as dependent variable and ToMquest, duration of illness, and MWT as independent variables was performed. The linear regression equation revealed an R^2 value of 0.433 (adjusted R^2 value as a more conservative estimate was 0.343), indicating that, conservatively estimated, at least one third of the variance of the BSS score could be accounted for by these three variables [$F(3,21)=4.833$, $P=0.012$]. In a stepwise regression using the same constellation, ToMquest and duration of illness remained in the model as significant predictors of BSS [$F(2,21)=7.067$, $P=0.005$], while MWT was excluded. The R^2 was 0.414 (with the adjusted $R^2=0.355$ even greater than in the model that included 'crystallized' IQ); hence, again, over one third of the amount of variance could be accounted for by patients' performance on the ToM questionnaire and their duration of illness. Notably, in the stepwise model, ToMquest was entered first [$F(1,21)=7.970$, $P=0.01$], where R^2 was 0.275 (adjusted $R^2=0.241$). Thus, ToMquest alone explained a quarter of the variance. In the second step, duration of illness added another 14% (R^2 change was 0.139) of variance. Since ToMtot and duration of illness did not significantly correlate ($r=-0.284$, $P=0.094$,

Table 5
Backwards-stepwise logistic regression equation predicting the odds of being a patient

Predictor(s)	Model			Nagelkerke R^2	Percentage correctly predicted	
	χ^2	*df*	*P*		Schizophrenia	Control
WCSTpers, Zoo Map Test, ToMtot, ERtot	34.103	4	<0.001	0.757	91.3	94.4
WCSTpers, ToMtot, ERtot	33.892	3	<0.001	0.754	91.3	94.4
WCSTpers, ToMtot	32.669	2	<0.001	0.736	82.6	94.4

ToMquest	ToMtot	ERtot	PANSSpos	PANSSneg	PANSSgen	PANSStot	BSM	BSS	SBS
−0.568**	−0.506*	−0.100	−0.290	−0.059	−0.082	−0.068	0.309	0.396	0.112
−0.284	−0.454*	−0.323	0.144	0.309	0.113	0.250	0.502*	0.506*	0.384
0.473*	0.540**	0.305	−0.047	−0.064	0.005	−0.050	−0.278	−0.434*	−0.113
0.059	−0.114	−0.274	0.070	−0.055	−0.186	−0.131	−0.042	−0.154	−0.074
−0.232	−0.354	−0.492*	−0.098	00.231	0.038	0.092	−0.209	−0.190	−0.300
0.535**	0.605**	0.204	0.149	−0.457*	−0.223	−0.284	−0.178	−0.237	−0.125
0.431*	0.492*	0.656**	−0.259	−0.364	−0.281	−0.399	−0.045	−0.022	−0.082
0.578**	0.928**	0.338	−0.086	−0.216	−0.117	−0.120	−0.261	−0.308	−0.188
−0.295	−0.513*	−0.235	−0.158	0.070	−0.006	−0.006	−0.073	−0.165	0.081
	0.841**	0.226	0.092	−0.274	−0.085	−0.168	−0.421*	−0.524*	−0.264
		0.328	−0.015	−0.268	−0.116	−0.156	−0.366	−0.444*	−0.245
			−0.345	−0.124	−0.109	−0.192	−0.086	−0.082	−0.005
				0.406	0.437*	0.575**	0.208	0.132	0.289
					0.837**	0.905**	0.292	0.214	0.574**
						0.928**	0.326	0.217	0.704**
							0.372	0.262	0.678**
								0.928**	0.787**
									0.642**

n.s.), they made independent contributions to the prediction of patients' amount of severe social behavioral problems (Table 6).

4. Discussion

This study investigated 'crystallized' verbal intelligence, executive functioning, and social perception and cognition in patients diagnosed with schizophrenia. Special emphasis was put on the relation of these cognitive functions to psychopathology and the actual social behavior of patients with schizophrenia. All three predictions were confirmed. As expected and demonstrated in a number of previous studies, patients with schizophrenia were impaired relative to healthy control subjects on all tasks involving executive functioning, emotion recognition, and ability to appreciate the mental states of others (Evans et al., 1997; Poole et al., 2000; Pickup and Frith, 2001; Brüne, in press).

Table 6
Stepwise linear regression equation predicting severe social behavioral problems (BSS) in schizophrenic patients

Predictor(s)	Model			R^2	Adjusted R^2	R^2 change
	F	*df*	*P*			
ToMquest	7.970	1	0.01	0.275	0.241	
ToMquest, duration of illness	7.067	2	0.005	0.414	0.355	0.139
ToMquest, duration of illness, 'crystallized' IQ	4.833	3	0.012	0.433	0.343	0.019

4.1. Social perception and cognition

As expected and in line with the findings of Frith and Corcoran (1996), for example, patients had greater difficulty in answering ToM questions with increasing level of 'intentionality' or 'higher-order' belief questions. Apart from patients' understanding of reciprocity and first-order questions, they performed more poorly on every other ToM task such as second-order and third-order false belief questions, recognition of deception, and recognition of cheating detection. These impairments could not be accounted for by attention deficits alone, since patients did not perform more poorly on the reality questions. Patients were significantly slower than controls in sorting the ToM picture stories, a deficit that was unrelated to any measure of psychopathology. The difference in sequencing time was, however, nonsignificant when executive functioning was accounted for. This could suggest that patients' slowness was partly associated with their impaired understanding of the social interaction depicted in the stories, and with executive functioning, which is in line with previous studies (Mazza et al., 2001).

In contrast to a previous study (Brüne, 2003a), differences in ToM performance between patients and healthy controls were independent of 'crystallized' IQ. This deserves further discussion. Firstly, the samples differed; in the first study, only patients with disorganized schizophrenia were included (Brüne, 2003a,b), whereas in the present study, patients were recruited regardless of subtype. Secondly, while we used a single 'prototype' ToM picture story in the previous study, we now applied a test battery of six different ToM cartoons, which might have increased statistical power. Thirdly, since IQ was a confounding factor in the first study, we now sought to parallel the patient and the control group for 'crystallized' IQ. In the present study, a subgroup of patients with normal IQ and largely intact executive functioning still performed significantly more poorly than controls on the ToM tasks.

The relationship of IQ with ToM skills has been debated in different psychiatric disorders. In patients with autism, IQ has been found to predict ToM and emotion recognition abilities in children (Buitelaar et al., 1999), but IQ was independent of ToM performance in adults with high-functioning autism (Baron-Cohen et al., 1997). In adults with schizophrenia, Doody et al. (1998) reported that patients with comorbid learning disabilities performed more poorly on ToM tasks than schizophrenic subjects without lower premorbid IQ, indicating that IQ may contribute to ToM story comprehension in addition to the underlying psychotic process. The recent study of Greig et al. (2004) revealed that IQ moderately correlated with ToM performance in patients with schizophrenia, but in contrast to the severity of thought disorder and verbal memory, IQ did not predict ToM performance in patients. Likewise, in nonclinical subjects, general intelligence does not contribute to distinguishing between those with high schizotypy scores and ToM impairments (here, understanding of irony) from low-schizotypal individuals without such impairments (Langdon and Coltheart, 2004). In sum, to some extent, the problem of how IQ interferes with ToM performance remains unresolved, in part, because the IQ and ToM tests used in the available studies vary considerably.

In the present study, correlation matrices also revealed strong associations of ToM performance and executive functioning. Therefore, to further investigate the putative specificity of the ToM impairment in schizophrenia, a logistical regression analysis was carried out. Consistent with previous findings (Langdon et al., 2001; Pickup and Frith, 2001), whichever two of the four executive variables were fitted into the backwards-stepwise model, ToM performance remained in the equation as the most powerful predictor of the odds of being a patient. The number of perseverative errors in the computerized WCST also remained significant, but did not correlate with ToM performance in the patient group, suggesting independent contributions to distinguishing patients from controls.

In addition, the duration of illness had a fairly strong negative impact on ToM performance, which is consistent with previous studies (Drury et al., 1998; Sarfati et al., 2000; Brüne, 2003a), but was unrelated to emotion recognition abilities. Previous studies have shown inconsistent associations of the chronicity of the disorder with emotion recognition deficits; some found a relationship (e.g., Bellack et al., 1996), whereas others did not (Salem et al., 1996).

Patients also performed more poorly on the emotion recognition tasks except for appreciating 'happiness,' and for identifying 'fear' or 'sadness' when IQ and executive functioning were taken into account. Emotion recognition in general also significantly distinguished between patients and controls as a zero-order predictor but was slightly less powerful than patients' ToM abilities. However, it is noteworthy that both social perception and social cognition accounted for at least as much of the variance differentiating patients with schizophrenia from healthy controls as nonsocial measures of executive functioning (Penn et al., 1997; Pinkham et al., 2003). In the patient group, emotion recognition and ToM abilities were unrelated and independent of each other. This finding could tentatively be interpreted in a way as supporting Frith and Frith's (1999, 2001) neurocognitive model of social interaction. It is conceivable that the disparate neural networks underlying 'behavior reading' and ToM are independently affected in schizophrenia, leading to a mosaic pattern of defective or preserved social perceptual and cognitive capacities.

4.2. Social behavior

Another important issue of the study was to investigate the relationship of nonsocial and social cognitive skills with patients' actual social behavior (Brüne, 2001). Most remarkably, no association could be found between executive functioning and psychopathology as measured using the PANSS (Kay et al., 1989), or social behavioral problems as assessed using the SBS (Wykes and Sturt, 1986).

In accordance with many other studies, a significant relation of emotion recognition with psychopathology or social behavioral problems in schizophrenia could not be determined (e.g., Cramer et al., 1989; Toomey et al., 2002). Whereas Bellack et al. (1990) found an association of impaired social skills with the presence of negative symptoms in schizophrenic patients, the study of Mueser et al. (1996) revealed only a weak correlation of social perceptual skills and social competence in schizophrenia. Ihnen et al. (1998) were unable to confirm an association of social perception and social skills in a sample of outpatients with schizophrenia. These studies therefore suggest that patients with chronic schizophrenia and predominant 'deficit syndrome' are possibly more prone to exhibit reduced social competence than remitted or less chronically ill patients. This would be consistent with the finding of the present study that at least severe social behavioral symptoms were linked to the patients' duration of illness.

Most interestingly, however, patients' performance on the ToM questionnaire was the most significant predictor of severe social behavioral abnormalities independent of the duration of illness, whereas 'crystallized' verbal intelligence only weakly contributed to the amount of variance accounting for severe social behavioral symptoms in schizophrenic patients. This study, therefore, suggests that schizophrenic patients' ToM is crucially linked to their social behavioral competence. This particular association of social cognitive capacities and actual social behavioral skills in schizophrenia has similarly been found in the study of Roncone et al. (2002). In their study, however, the duration of illness contributed most to the amount of variance (27%), and ToM performance added another 15% of the amount of variance, which is the reverse of what the present study revealed.

Consistent with these findings, yet in a more general vein, Cutting and Murphy (1990) found patients with schizophrenia impaired in their ability to appropriately react in hypothetical social scenarios, and in the study of Corcoran and Frith (1996), schizophrenic patients violated basic conversational rules such as quantity, quality, and relevance of speech as well as tact and politeness. Likewise, Sullivan and Allen (1999) and, more recently, Mazza et al. (2003) described schizophrenic patients as being impaired in tasks involving strategic social reasoning. Taken together, all these studies point into the same direction that *intact* social cognition is, as clinical intuition suggests, indispensable for appropriate social functioning.

As a methodological aspect of this study, it is worth mentioning my overall impression that the nurses who scored the patients' actual social behavior tended to underrate the severity of social behavioral problems, perhaps simply because they were used to the 'oddities' or 'habits' of individual patients. This could explain why the statistical association between social cognition and social behavior in schizophrenia was, in fact, not as strong as expected, and was therefore not reflected in an association with milder social behavioral problems or the total score on the SBS. Future studies ought to address this possibility by training staff in using standardized ratings such as the SBS. A further shortcoming of this study was that the schizophrenic patients were treated as a single group without further subtyping of the sample. As previous studies have shown and in accordance with Frith's (1992) framework, there are differences in ToM performance and differences to be expected in emotion recognition abilities between patients with pronounced behavioral positive or negative symptoms, paranoid patients, remitted patients, and patients who primarily experience 'passivity' symptoms (Frith, 1992). However, due to the relatively small sample size, subtyping would have led to a decrease of discriminative power and therefore simply made no statistical sense. Other shortcomings of the present study were that the patient and control groups were not matched for sex, and any putative effect of medication was not examined, although a previous study did not find evidence for a medication effect on ToM performance (Sarfati et al., 1999).

To my knowledge, this is the first study to examine the association of emotion recognition deficits, ToM impairments, and executive dysfunctions in schizophrenia with patients' actual social behavioral abnormalities. As hypothesized (Penn et al., 1997), it could be demonstrated that impaired social perception and social cognition in schizophrenia contribute more to the understanding of deviant social behavior than disturbed executive functioning, as none of the executive functioning tests correlated with any of the social behavioral scores.

Moreover, within the 'social module,' patients' social perception and social cognition may be affected independently. Future studies in larger samples ought to address to what extent impairments in social and nonsocial cognition reflect different subtypes of schizophrenia, whether such deficits are related to sex or medication and whether patients may benefit from differential cognitive behavioral treatment regimes that take into account the social domain (Sarfati et al., 2000).

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