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Neurocognitive and social cognitive predictors of interpersonal skill in schizophrenia

Amy E. Pinkham, David L. Penn *

University of North Carolina-Chapel Hill, Department of Psychology, Davie Hall, CB#3270, Chapel Hill, NC 27599-3270, USA

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Abstract

Social dysfunction is among the major criteria for receiving a diagnosis of schizophrenia, and research indicates that the impairments in social functioning experienced by individuals with schizophrenia are strongly related to deficits in interpersonal skills. In turn, these deficits in interpersonal skills have been linked to impairments in general cognitive abilities and impairments in social cognition. This study explored the relationship between neurocognition, social cognition, and interpersonal skills in 49 outpatients with schizophrenia and 44 non-clinical control participants. Results indicate that individuals with schizophrenia demonstrated impaired performance across several domains of neurocognitive and social cognitive functioning as well as interpersonal skills. In addition, among the participants with schizophrenia, social cognition significantly contributed unique variance to interpersonal skill beyond that of neurocognition. This pattern was not observed in the non-clinical control sample. These findings have implications for the treatment of the disorder and represent an important step in understanding the role of social cognition in schizophrenia.

Keywords: Cognition; Social cognition; Social functioning

1. Introduction

Individuals with schizophrenia experience difficulties in multiple areas of social functioning including interpersonal relationships, work and personal achievement, finances, and self-care (Corrigan and Penn, 2001). These difficulties in social functioning have been linked to deficits in social/interpersonal skill. For instance, Bellack et al. (1990) reported that social dysfunction in schizophrenia may result from focal deficits in interpersonal skill rather than negative symptoms. In addition, several studies have demonstrated that individuals with schizophrenia show deficits in interpersonal skills compared with non-clinical controls (Fingeret et al., 1985; Donahoe et al., 1990; Mueser et al., 1991; Ikebuchi et al., 1999), and these deficits are not improved by medication alone (Bellack et al., 2004).

The identification of interpersonal skill deficits in individuals with schizophrenia has prompted an

* Corresponding author. Tel.: +1 919 843 7524; fax: +1 919 962 2537.

E-mail address: dpenn@email.unc.edu (D.L. Penn).

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examination of factors that may underlie poor social functioning. One area that has received considerable attention is that of neurocognition. In particular, deficits in memory, attention, and cognitive flexibility are related to difficulties in problem solving (Green et al., 2000; Hatashita-Wong et al., 2002), and deficits in executive functioning, memory, and verbal fluency are related to poorer community living skills (Bartels et al., 1997; Green et al., 2000). Finally, neurocognitive deficits are related to impairments in interpersonal skills (Penn et al., 1995). Overall, the findings suggest that neurocognition explains between 20% and 60% of the variance in the functional outcomes of individuals with schizophrenia (Green et al., 2000).

Although neurocognitive models have contributed to the understanding of social dysfunction in schizophrenia, they are not without limitations. First, even though neurocognition accounts for a significant amount of variance in social functioning, a fair amount of variance in social outcome remains unexplained (i.e., between 40% and 80%; Penn et al., 1997; Corrigan and Penn, 2001). Second, there may be other domains of cognition, more proximal to actual social behavior, than those assessed by traditional neurocognitive paradigms. One such domain is social cognition.

Social cognition refers to the cognitive processes involved in how individuals perceive, interpret, or process social information and include “the human ability and capacity to perceive the intentions and dispositions of others” (Brothers, 1990, p. 28). In schizophrenia research, early work exploring social cognition investigated emotion perception (Dougherty et al., 1974), theory of mind (ToM; Frith, 1992), attributional style (Kaney and Bentall, 1989; Bentall et al., 1991), and knowledge of social situations (Corrigan et al., 1990; Corrigan and Addis, 1995), and these domains remain the cornerstones of studies of social cognition in schizophrenia (reviewed in Penn et al., in press). Although neurocognition and social cognition are related in schizophrenia (Bryson et al., 1997; Kee et al., 1998; Lancaster et al., 2003), there is also evidence from both clinical and non-clinical samples that neural activation and neural pathways for neurocogniton and social cognition are separable (for reviews, see Adolphs, 2001; Pinkham et al., 2003). This dissociation suggests that these domains are not overlapping, and that social cognition may enhance our understanding of social dysfunction in schizophrenia.

There is growing evidence that social cognition may contribute variance beyond cognition to social functioning in schizophrenia (Corrigan and Toomey, 1995; Penn et al., 1996; Ihnen et al., 1998; Roncone et al., 2002; Brüne, 2005). However, previous work in this area has generally not examined social cognition as a multidimensional construct. As mentioned previously, social cognition includes a vast array of abilities (i.e., emotion perception, social knowledge, and ToM), and with one exception in which both emotion perception and ToM were explored (Brüne, 2005), studies that have examined social cognition have usually focused on only one of these abilities at a time. Because of this, it is difficult to determine which social cognitive factors are most strongly related to social functioning. Likewise, few studies have investigated whether the association between neurocognition and social cognition with social functioning differs across clinical and non-clinical samples. Such differences are worth examining because they may provide additional information about the nature of the disorder.

The primary purpose of this study was to examine the relationships between neurocognition, social cognition, and interpersonal skill in schizophrenia. Consistent with previous research, it was hypothesized that individuals with schizophrenia would show impairments in all social cognitive domains and would also be less interpersonally skilled than non-clinical controls. Second, it was hypothesized that social cognitive factors would contribute significant incremental variance, beyond that of neurocognition, to a model predicting interpersonal skill. Third, based on previous research from our laboratory (Penn et al., 1993), it was predicted that the patterns of overall variance accounted for by neurocognition and social cognition would differ between groups. Finally, the last goal, which was exploratory in nature, was to isolate the domain of social cognition that contributed the most variance to interpersonal skill.

2. Methods

2.1. Participants

Participants were individuals who had a diagnosis of a schizophrenia spectrum disorder ($n = 49$) and non-clinical healthy controls (n = 44). Individuals in the schizophrenia group were recruited from the Schizophrenia Treatment and Evaluation Program (STEP) at the University of North Carolina Neurosciences Hospital and had diagnoses that were confirmed via chart review, consultation with their primary physician, and when necessary, the Structured Clinical Interview for DSM-IV (SCID-P). Non-clinical control participants were recruited through campus mailings. To be included in the study, individuals could not have a history of neurological injury or meet current criteria for substance abuse or dependence. Additionally, the non-clinical controls could not meet past or present criteria for schizophrenia or schizoaffective disorder and could also not have any first-degree relatives with a psychotic or affective disorder.

The mean duration of illness for the group with schizophrenia was 10.4 years (standard deviation [S.D.] = 9.55); of the 49 participants, 35 individuals had a diagnosis of schizophrenia, 12 of schizoaffective disorder, and two of psychosis not otherwise specified. Severity of symptoms was assessed with the Positive and Negative Syndrome Scale (PANSS: Kay et al., 1992), which was administered by research assistants who had been trained to adequate reliability (ICC > 0.80 with a gold standard rater). All participants were experiencing minimal symptoms at the time of testing; positive symptom total: M = 15.27 (S.D. = 5.86); negative symptom total: M = 11.79 (S.D. = 4.146); and general symptom total: M = 29.02 (S.D. = 7.13). Additionally, 88% of the clinical group were taking atypical antipsychotic medications, 6% were on a combination of typical and atypical antipsychotics, and 2% were unmedicated. As based on Woods (2003), the mean chlorpromazine-equivalent dose for the medicated individuals was 352.65 mg/day (S.D. = 284.65). (Note: medication data were missing for two participants or 4% of the sample due to their participation in a current double-blind medication study.)

Chi-square tests and a multivariate analysis of variance (MANOVA) were conducted on the demographic variables (see Table 1). No significant differences were found between the two groups on gender (χ^2 = 1.268, P = 0.26) or ethnicity (χ^2 = 0.503, P = 0.778); however, the groups did significantly differ on the combined variables of age and years of education (Wilks' λ = 0.863, F(2, 88) = 6.977, P = 0.002). Univariate analyses revealed that the multivariate effect was driven by a significant difference between the groups in years of education (F(1, 89) = 12.563, P = 0.001) but that the groups did not significantly differ on age (F(1, 89) = 1.711, P = 0.194); the control group had completed more years of education than the group with schizophrenia.

Table 1
Demographic information

	Non-clinical (n = 44)		Schizophrenia (n = 49)	
	Mean	S.D.	Mean	S.D.
Gender (number)				
Male	20	n/a	28	n/a
Female	24	n/a	21	n/a
Ethnicity (number)				
African American	9	n/a	8	n/a
Caucasian	34	n/a	39	n/a
Other	1	n/a	2	n/a
Age	35.95	9.980	33.16	10.272
Years of education*	16.05	2.544	14.27	2.253

* Denotes a significant difference between groups on this variable.

2.2. Measures

2.2.1. Neurocognitive measures

Assessments of neurocognitive functioning included measures of overall intellectual ability, memory, and executive functioning. These areas of neurocognition were chosen based on previous findings showing that individuals with schizophrenia show impairments in each of these areas and that these areas are related to social functioning in schizophrenia. As reading ability can be considered a gross estimate of premorbid IQ (Dalby and Williams, 1986; Johnstone and Wilhelm, 1996; Griffin et al., 2002), an estimate of overall intellectual functioning was obtained with the reading scale on the Wide Range Achievement Test-III (WRAT-III; Wilkinson, 1993).

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph et al., 1998) was used to assess immediate memory, which is the ability to recall information immediately after it is presented and is assessed using a composite score from list learning and story recall tasks. Performance on the immediate memory scale of the RBANS is strongly correlated to performance on the Wechsler Memory Scale—Revised (α = 0.61 with verbal memory) and has been shown to be sensitive to the neurocognitive impairments found in schizophrenia.

Finally, Trails A and B were used to examine executive functioning (Reitan, 1958). Performance on each trial is indexed as the time taken to complete the task.

2.2.2. Social cognitive measures

In keeping with the conceptualization of social cognition as a multidimensional construct, three different domains were assessed. Each domain and corresponding measures are detailed below.

2.2.2.1. Emotion perception. Emotion perception was measured with the Face Emotion Identification Task and the Face Emotion Discrimination Task (FEIT and FEDT, respectively; Kerr and Neale, 1993). The FEIT comprises of 19 photographs of faces expressing one of six basic emotions (happy, sad, angry, afraid, surprised, and ashamed). The participant's task is to identify the emotion that is being expressed by each face. The FEDT is composed of 30 pairs of faces and requires the participant to determine if the two faces in each pair are displaying the same or different emotions. Performance on both tasks is indexed as the number of correct responses (0–19 for the FEIT and 0–30 for the FEDT), and reliability coefficients (Cronbach's alpha) for the FEIT and FEDT were 0.50 and 0.68, respectively, which, while below par, are consistent with previous research that has used these measures (Kerr and Neale, 1993; Mueser et al., 1996; Penn et al., 2000).

The Bell–Lysaker Emotion Recognition Task (BLERT; Bell et al., 1997) consists of 21 videotaped vignettes, each 10s long of the same actor speaking one of three standard monologues. For each vignette, the actor expresses one of seven emotions, which include happiness, sadness, fear, disgust, surprise, anger, or no emotion. After viewing each vignette, the participant is asked to identify the emotion that is being expressed; thus, possible scores range between 0 and 21. Previous research has shown that the test–retest reliability of the BLERT is 0.76, that stability of categorization over time is high (weighted $\kappa = 0.93$), and that it displays adequate discriminant validity. Reliability of the BLERT for this study was good (0.73).

2.2.2.2. Social knowledge. The Schema Component Sequencing Task was used to assess knowledge of social situations (SCST; Corrigan and Addis, 1995). The SCST consists of 12 sets of cards that describe social situations such as getting a job and going shopping. Each situation is divided into five or eight component actions, and each action is presented on a card. The cards for each situation are presented to the participant in a mixed-up order, and the participant's task is to arrange the cards in an order that makes sense. Performance is indexed as the average time to complete each set and the average number of correct juxtapositions, which ranges between 0 and 22. Previous research indicates that internal consistencies for short and long sequences are high, 0.75 and 0.86, respectively, and that the mean difficulty level for short and long sequences is identical at 0.85.

2.2.2.3. Theory of mind. Measures of ToM included the ToM vignettes (Corcoran, 2001) and the hinting task (Corcoran et al., 1995). The ToM vignettes include four stories, each of which describes an interaction among two or more characters. In each story, there is some degree of deception between the characters, and the participant's task is to make an inference about one character's belief state, thus requiring the participant to put him/herself into the place of the character. Performance is indexed as the number of items answered correctly, and scores range between 0 and 4. Reliability of the ToM vignettes for this study was 0.31. Given the low reliability of this measure, any findings that involve the ToM vignettes should be interpreted very cautiously.

The hinting task consists of 10 short stories that also involve an interaction between two characters, one of which drops a hint at the end of the story. The participant's task is to infer what the character really means by the hint. Participants are given a score of 0, 1, or 2 for each response, and performance on this task is indexed as the number of items correct (between 0 and 20). Reliability of the Hinting task for this study was 0.78.

2.2.2.4. Interpersonal skill. Interpersonal skill was assessed with the Conversation Probe role-play test (CP; Penn et al., 1994). In the CP, the participant is informed that he/she will be interacting with an unfamiliar individual (i.e., a research confederate) for 3 min and that the goal of the interaction is for the two individuals to get to know one another. The confederate is instructed to be pleasant, but to limit talking to no more than 50% of time. The role-play was videotaped and later rated by two independent coders on 9-point Likert scales; the raters were trained to satisfactory reliability with a gold-standard criterion (ICC > 0.70). Overall interpersonal skills, as well as the following component interpersonal skills, were rated: clarity (clear enunciation of speech), fluency (smoothness of verbal speech; absence of verbal interruptions), appropriate affect (appropriate communication of feeling through facial expression, use of gestures, and vocal tone), gaze (eye contact), and engagement (the extent to which the individual appears involved in the conversation).

A principal components factor analysis was conducted on these variables to determine the most comprehensive and parsimonious criterion variable(s) (and to reduce the number of interpersonal skill variables for subsequent analyses). The factor analysis yielded one primary factor that explained 70% of the variance in the data (Eigenvalue = 4.175) and was highly correlated ($\alpha = 0.92$) with the rating of overall interpersonal skill. Given the large association between the new factor and the rating of overall interpersonal skill, and the fact that a principal component analysis incorporates all variance, including error variance, the decision was made to use only the original rating of overall interpersonal skill as the dependent variable.

2.3. Procedure

Informed consent was obtained from all participants, and on average, the testing session lasted between 2 and 2.5 h for control subjects and 3 to 3.5 h for clinical subjects. The assessments were administered in a predetermined order, and all participants completed the study in a single session.

2.4. Data-analytic plan

MANOVAs were first conducted on the neurocognitive and social cognitive variables to examine group differences in these domains, and an ANOVA was conducted to assess differences in interpersonal skill across the groups. Next, to address the hypotheses that social cognition would account for a significant amount of the variance in the social functioning of individuals with schizophrenia beyond that of neurocognitive factors, and that the models would differ for each group, bivariate correlations were first computed between all variables of interest and overall ratings of interpersonal skill for each group. Variables that were significantly associated with interpersonal skill were then included in hierarchical regression analyses specific to each group; neurocognitive variables were entered into each model first, followed by social cognitive variables and then third factor variables such as demographic or clinical variables. This order of variables allows for an examination of the independent contribution of social cognition in the prediction of interpersonal skill while also considering the influence of demographic and symptom variables.

It should be noted that due to missing data for some of the participants, the sample size for each analysis varies slightly. The number of participants included in each analysis is detailed in the table for that particular analysis.

3. Results

3.1. Group comparisons

A one-way (group: non-clinical control versus schizophrenia) MANOVA was conducted on the neurocognitive variables. The multivariate group effect was significant (Wilk's $\lambda = 0.645$, $F(4,84) = 11.571$, $P < 0.001$), indicating that on these combined measures the control participants performed better than the group with schizophrenia. Univariate analyses revealed that the multivariate effect was driven by significant differences between the groups on RBANS immediate memory ($F(1,87) = 31.478$, $P < 0.001$), Trails A ($F(1,87) = 13.982$, $P < 0.001$), and Trails B ($F(1,87) = 14.735$, $P < 0.001$); non-clinical control participants had higher immediate memory scores and completed Trails A and B in less time than the participants with schizophrenia. The univariate effect for the WRAT was not statistically significant ($F(1,87) = 3.136$, $P = 0.08$).

For the social cognitive variables, a one-way (group: non-clinical control versus schizophrenia) MANOVA was again statistically significant (Wilk's

$\lambda = 0.728$, $F(7,84) = 4.475$, $P < 0.001$). Significant univariate group differences were observed on all tasks except for the FEIT ($F(1,90) = 3.353$, $P = 0.07$). Non-clinical participants performed better than individuals with schizophrenia on the two emotion perception measures, the BLERT and FEDT ($F(1,90) = 17.897$, $P < 0.001$ and $F(1,90) = 9.035$, $P = 0.003$, respectively), and on the social knowledge task, providing more correct responses ($F(1,90) = 10.716$, $P = 0.002$), and taking less time to complete the task ($F(1,90) = 10.904$, $P = 0.001$). Finally, the non-clinical control group performed better on both ToM tasks than the group with schizophrenia (Hinting: $F(1,90) = 8.717$, $P = 0.004$; ToM: $F(1,90) = 10.467$, $P = 0.002$).

A one-way (control versus schizophrenia) ANOVA conducted on the ratings of overall interpersonal skill was also statistically significant ($F(1,88) = 73.401$, $P < 0.001$); individuals with schizophrenia were rated as significantly less interpersonally skilled than control participants. These between-group results are summarized in Table 2.

Finally, given that the groups significantly differed on years of education, all MANOVAs and ANOVAs were repeated using education as a covariate. The results were generally unchanged, with the one exception being that the group difference observed on the Hinting task now approached statistical significance ($F(1,87) = 3.612$, $P = 0.061$).

3.2. Primary analyses

As a first step in our primary analyses, we computed the correlations between the neurocognitive and social cognitive variables (Table 3). As expected, the neurocognitive and social cognitive variables were significantly correlated with one another for both groups, with a mean correlation coefficient of 0.312 for controls and 0.234 for the group with schizophrenia. These findings suggest that neurocognition and social cognition are only modestly associated with one another and that a considerable portion of the variance remains unaccounted for between these two domains.

Next, to test the hypothesis that social cognition would uniquely predict a significant amount of the variance in interpersonal skill, bivariate correlations were computed among the neurocognitive and social cognitive factors and ratings of overall interpersonal skill for each group. Correlations between demographic variables and interpersonal skill were also calculated to determine if any "third variables" were related to interpersonal skill. Given the number of

Table 2
Descriptive statistics for cognition, social cognition, and interpersonal skill as a function of group

Measure	Non-clinical		Schizophrenia		ANOVA	
	Mean	S.D.	Mean	S.D.	*F*	*P*
Cognitive measures	(*n* = 41)		(*n* = 48)			
(Wilks' λ = 0.645, *F*(4, 84) = 11.571, *P* < 0.001)						
WRAT	107.73	10.74	103.29	12.615	3.136	0.080
RBANS—immediate memory	100.44	13.09	82.31	16.77	31.48	< 0.001*
Trails A	24.51	7.49	35.00	16.56	13.98	< 0.001*
Trails B	53.32	17.76	85.37	50.86	14.74	< 0.001*
Social cognition measures	(*n* = 43)		(*n* = 49)			
(Wilks' λ = 0.728 *F*(7, 84) = 4.475, *P* < 0.001)						
BLERT	17.63	2.31	14.94	3.561	17.90	< 0.001*
FEIT	13.42	2.185	12.43	2.894	3.353	0.070
FEDT	26.47	2.30	24.59	3.470	9.035	0.003*
SCST # correct	19.00	1.995	17.23	3.00	10.72	0.002*
SCST time	91.68	20.96	116.57	45.34	10.90	0.001*
Hinting	17.14	2.122	15.10	4.063	8.717	0.004*
ToM	3.58	0.626	3.06	0.876	10.47	0.002*
Interpersonal skill	(*n* = 41)		(*n* = 49)			
Overall interpersonal skill	7.81	0.740	5.98	1.19	73.40	< 0.001*

* Denotes a significant difference between groups.

Table 3
Correlations between cognitive and social cognitive variables for each group

	WRAT	IM	Trails A	Trails B	BLERT	FEIT	FEDT	SCST #	SCST time	Hinting
Control										
IM	0.281									
Trails A	−0.169	−0.207								
Trails B	−0.600**	−0.329*	0.474**							
BLERT	0.490**	0.247	−0.159	−0.435**						
FEIT	0.529**	0.414**	−0.276	−0.577**	0.293					
FEDT	0.350*	0.230	−0.038	−0.439**	0.476**	0.527**				
SCST #	0.371*	0.223	0.204	−0.384*	0.189	0.192	0.263			
SCST time	−0.418**	−0.514**	0.392*	0.547**	−0.387*	−0.525**	−0.222	−0.022		
Hinting	0.162	0.173	0.050	−0.023	−0.056	0.133	−0.180	0.181	−0.256	
ToM	0.187	0.400*	−0.275	−0.239	0.258	0.109	0.050	−0.117	−0.339*	0.098
Clinical										
Im	0.491**									
Trails A	−0.051	0.081								
Trails B	−0.325*	−0.342*	0.371*							
BLERT	0.471**	0.270	−0.086	−0.188						
FEIT	0.390**	0.280	−0.058	−0.186	0.373**					
FEDT	0.338*	0.398**	−0.065	−0.237	0.326*	0.658**				
SCST #	0.427*	0.298*	−0.134	−0.127	0.222	0.326*	0.393**			
SCST time	−0.312*	−0.199	0.336*	0.311*	−0.155	−0.306*	−0.103	−0.220		
Hinting	0.116	0.408**	−0.075	−0.060	0.221	0.300*	0.169	0.447**	−0.369**	
ToM	0.185	0.274	−0.169	−0.145	0.418**	0.442**	0.330*	−0.348*	−0.415**	0.412**

IM = Immediate memory.
* Denotes $P < 0.0588$.
** Denotes $P < 0.01$.

correlations computed, a more conservative P-value of 0.01 was applied to the results.

These correlations are summarized in Table 4, and in general, the results reveal different patterns of correlations for each group. For the non-clinical control group, no variables were significantly correlated to interpersonal skill at the 0.01 level.

For the schizophrenia group, better performance on the BLERT, the Hinting (ToM) task, and the ToM stories were all associated with greater interpersonal skill, along with faster completion of the social knowledge task and more correct sequences on that task. Finally, greater interpersonal skill was associated with having fewer negative symptoms.

It should be noted that at this point, no neurocognitive variables were significantly related to interpersonal skill in either group. Given this potential limitation to testing the hypothesized role of *both* neurocognitive and social cognitive variables in predicting social skill, we decided to include as predictor variables those bivariate correlates that were significant at the traditional P-value of 0.05.

For the control group, the neurocognitive factor, Trails B, significantly predicted approximately 10% of the variance in interpersonal skill (adjusted $R^2 = 0.105$; $F(1,37) = 5.464$, $P = 0.025$) (Table 5). The addition of the social cognitive predictor, the BLERT, did not significantly improve the model (R^2 change = 0.055; $F(1,36) = 2.437$, $P = 0.127$), but did slightly increase the total predictive ability of the model to approximately 14% (adjusted $R^2 = 0.139$). It is interesting to note that with the addition of the social cognitive predictor, performance on Trails B no longer remained a significant predictor ($b^* = -0.245$, $t(36) = -1.466$, $P = 0.151$, $sr^2 = 0.049$), indicating that neurocognition does not predict social skill above and beyond the other predictors in this model. The two-predictor model remained significant ($F(2,36) = 4.057$, $P = 0.026$). Likewise, including age did not significantly improve the model (R^2 change = 0.02; $F(1,35) = 0.880$, $P = 0.355$), and as neither the neurocognitive nor the social cognitive factor uniquely predicted interpersonal skill, entering age into the model did not alter these relationships. As before, the overall model remained

Table 4
Association of cognition, social cognition, demographics and symptoms with interpersonal skill

	Interpersonal skill	
	Control ($n=39$)	Clinical ($n=47$)
Cognition		
WRAT	0.092	0.362[a]
Immediate Memory	0.249	0.219
Trails A	−0.301	−0.193
Trails B	−0.359[a]	−0.346[a]
Social cognition		
BLERT	0.368[a]	0.380[b]
FEIT	0.086	0.320[a]
FEDT	−0.001	0.224
SCST # correct	−0.106	0.406[b]
SCST time	−0.228	−0.497[b]
Hinting	−0.054	0.387[b]
ToM	0.267	0.456[b]
Demographics		
Gender	$F=0.097$, $P=0.757$	$F=0.900$, $P=0.348$
Ethnicity	$F=0.490$, $P=0.617$	$F=0.424$, $P=0.657$
Age	−0.347[a]	−0.218
Education	0.208	0.371[a]
Symptoms		
Positive		−0.255
Negative		−0.486[b]
General		−0.332[a]

[a] $P<0.05$.
[b] $P<0.01$.

significant ($F(3,35)=2.989$, $P=0.044$) and accounted for 14% of the variance in interpersonal skill (adjusted $R^2=0.136$). Thus, it appears that in a non-clinical population, neurocognition predicts interpersonal skill, and social cognition does not add significant incremental variance to the model.

A different pattern emerged for the group with schizophrenia. The neurocognitive variables (i.e., performance on the WRAT and Trails B) were entered into the regression model first, and they significantly predicted approximately 15% of the variance in interpersonal skill (adjusted $R^2=0.153$; $F(2,44)=5.14$, $P=0.01$). This is comparable to the amount of variance that was accounted for by the neurocognitive predictors in control participants. The addition of the social cognitive factors (i.e., all variables with the exception of the FEDT) to the model contributed an additional 26% to the total variance (R^2 change$=0.255$), and the overall model remained statistically significant ($F(8,38)=3.797$, $P=0.002$). More importantly, the incremental gain in variance was also significant ($F(6,38)=2.904$, $P=0.02$) indicating that the social cognitive variables independently accounted for an additional 26% of the variance in interpersonal skill above and beyond that of the cognitive factors. Negative and general symptom factors on the PANSS were then added to the analysis, which increased the amount of variance predicted by the model to approximately 39% (adjusted $R^2=$

Table 5
Final regression models predicting overall interpersonal skill in each group

	R^2	Adjusted R^2	F	P	b^*	t	P	sr^2
Controls (n= 38)								
Trails B	0.204	0.136	2.989	0.044	−0.215	−1.263	0.215	0.036
BLERT					0.185	0.993	0.327	0.023
Age					−0.169	−0.938	0.355	0.020
Schizophrenia (n= 46)								
WRAT	0.543	0.400	3.786	0.001	0.008	0.044	0.965	0.000
Trails B					0.020	0.140	0.890	0.000
BLERT					0.053	0.346	0.731	0.002
FEIT					0.058	0.363	0.719	0.002
SCST # correct					0.134	0.894	0.377	0.010
SCST time					−0.370	−2.36	0.024	0.073
Hinting					−0.001	−0.004	0.997	0.000
ToM					0.051	0.323	0.748	0.001
Negative symptoms					−0.161	−1.113	0.273	0.016
General symptoms					−0.297	−2.015	0.052	0.053
Education					0.191	1.179	0.246	0.018

0.393). Although this incremental increase was not significant (R^2 change = 0.081; $F(2,36) = 3.070$, $P = 0.059$), the overall model remained so ($F(10,36) = 3.983$, $P = 0.001$). Finally, educational level was added to the model and was found to improve the predictive ability of the model by only 2% (R^2 change = 0.018), an increase that was not statistically significant ($F(1,35) = 1.391$, $P = 0.246$). Thus, the final model that included all four sets of predictors accounted for 40% of the variance in interpersonal skill (adjusted $R^2 = 0.400$; $F(11,35) = 3.786$, $P = 0.001$).

Examination of the individual regression coefficients from the final model revealed a main effect only for the social cognitive predictor of time to complete the social sequencing task ($b^* = -0.370$, $t(35) = -2.36$, $P = 0.024$), which accounted for approximately 7% of the variance in interpersonal skill when controlling for all other predictors; individuals who completed the task more quickly were rated as more interpersonally skilled. These results are summarized in Table 5.

4. Discussion

The primary purpose of this study was to examine the performance of individuals with schizophrenia on several neurocognitive and social cognitive domains and to determine how these domains relate to interpersonal skill. As hypothesized, individuals with schizophrenia displayed deficits in neurocognition, social cognition, and interpersonal skill compared with control participants. In addition, social cognitive factors accounted for a unique amount of variance in interpersonal skill above and beyond that of more general neurocognitive abilities in the group with schizophrenia alone. These findings are discussed in more detail below.

Group comparisons indicated that individuals with schizophrenia performed more poorly than non-clinical controls on measures of immediate memory and executive function but that their reading ability was comparable to that of control participants. Although counterintuitive, the finding of normal reading ability is not unprecedented. Reading ability is often used to obtain an estimate of premorbid intellectual ability (Dalby and Williams, 1986; Johnstone and Wilhelm, 1996; Griffin et al., 2002). Therefore, it is possible that these individuals were functioning at normative levels before they became ill and that their current deficits in immediate memory and executive function became more pronounced as their illness progressed.

The hypothesis that individuals with schizophrenia would be impaired on all domains of social cognition and in interpersonal skill was supported. Further, group differences in social cognition and interpersonal skill remained statistically significant after controlling for level of education (with the exception of ToM skills, as measured by the Hinting task, which approached statistical significance). As such, these findings suggest that social cognitive deficits may not be best characterized by one specific skill such as affect recognition or ToM, but by impairments that span the range of social cognitive skills.

The hypothesis that social cognition would contribute unique variance to interpersonal skill in schizophrenia beyond that of neurocognition was supported. Overall, performance on social cognitive tasks predicted almost twice the variance in interpersonal skill as neurocognitive factors did. In addition, when controlling for all other factors, no neurocognitive factors remained significant predictors of interpersonal skill. These results are on par with previous studies that found that neurocognition explains between 20% and 60% of the variance in functional outcome, although they were at the lower range in this study. These results are also consistent with previous research demonstrating that social cognition, and in particular ToM, significantly predicts social functioning in schizophrenia (Roncone et al., 2002; Brüne, 2005). Specifically, in Brüne (2005), ToM was found to account for 24% of the variance in severe problems in social behavior, and Roncone et al. (2002) reported that ToM accounted for 15% of the variance in social functioning. Differences in assessment batteries and statistical procedures make direct comparison with this study difficult, but in both previous studies ToM was also found to account for more variance than neurocognitive factors, which is consistent with the primary finding here. It should be noted however, that unlike these studies, ToM performance was not the most relevant predictor of interpersonal skill. This discrepancy could be due to the high correlations between ToM and the other social cognitive measures (Table 3) or to methodological differences, namely that our range of ToM tasks was not as extensive as those used by Brüne or subdivided into first- and second-order tasks as in Roncone and colleagues.

Moreover, these findings are also consistent with the argument presented by Fiddick et al. (2000) for "pre-emptive specificity," which states that "the human cognitive architecture should be designed so that more specialized inference systems pre-empt more general ones whenever the stimuli centrally fit the input conditions of the more specialized system" (p. 2), or more simply put, that a specialized system (such as social cognition) will be utilized when it is needed or when the stimuli demand it (i.e., a social situation). Applied here, this theory posits that during a social task, the social cognitive system should have a greater influence on behavior than the more general cognitive system.

For the control group, however, the pattern of variance differed from the schizophrenia group, which is consistent with previous findings (Penn et al., 1993; Toomey et al., 1997). Here, the addition of the social cognitive factors did not significantly improve the model. Drawing again upon the Fiddick et al. (2000) model of pre-emptive specificity, it is possible that for the control participants, who presumably engage in numerous social interactions, simple interpersonal skill assessments (like the task used in the present study) may not be difficult or specific enough to require recruitment of a specialized system (i.e., social cognitive processing). Thus, for these individuals, "normal" neurocognition is sufficient for adequate performance of the social task. It is possible that for healthy individuals, social cognitive skills may not relate to social functioning until social tasks become more complex (e.g., figuring out how to say something that will not hurt someone's feelings). However, for individuals with schizophrenia, who often struggle in social interactions, the interpersonal skill task may have been intrinsically taxing and therefore, more likely to require the involvement of the specialized social cognitive system.

The results also showed that of the social cognitive predictors included in the model for the schizophrenia group, time to complete the social knowledge task explained the greatest variance in interpersonal skill and remained a significant predictor of interpersonal skill above and beyond all other predictors in the final model. We have reported similar findings with a comparable measure in previous research carried out in inpatients (Penn et al., 1996). In this earlier study, multiple regression analyses revealed that time to complete a social sequencing task similar to the one used in the present study significantly predicted irritability on the ward. Importantly, in this analysis, the neurocognitive variable, errors on a card-sorting task, did not remain in the final regression model. These findings, therefore, extend the functional significance of performance on the social knowledge task to outpatients and to interpersonal skill during actual interactions, and suggest that the predictive relationship between social cognition and social functioning may remain stable across illness severity. It also raises some interesting questions about why social knowledge was found to be a better predictor of interpersonal skill than the other neurocognitive and social cognitive abilities. It is possible that social knowledge provides the basic foundation of social interactions; to interact effectively, one needs to know the rules that govern social settings. Indirect support for this conclusion is garnered by the non-significant association between social sequencing speed and immediate memory, and its modest association with executive processing on Trails A and B (Table 3), which suggests that this task is assessing something other than mere information-processing speed or immediate memory. However, this assertion is speculative and needs to be evaluated more rigorously in future research.

If social cognitive impairments play a larger role in the interpersonal skill deficits of individuals with schizophrenia than general neurocognitive impairments, then it may be beneficial to target social cognitive skills as a means of providing greater "traction" for psychosocial treatment programs (e.g., Penn and Combs, 2001; Frommann et al., 2003). Of course, the findings from this study are correlational and cross-sectional, so their implications for actual treatment planning and implementation need to be placed in context. However, they do have heuristic value in stimulating hypotheses about how improving social cognition may lead to more comprehensive treatments for schizophrenia.

This study suffers from some limitations that should be addressed in future work. First, the reliability of the ToM vignettes was rather low, and thus results pertaining to this task should be interpreted cautiously.

Second, for our sample size, a large number of variables were entered into the regression equation for the clinical participants, which may have artificially inflated the fit of our overall model. Although we reported adjusted R^2 statistics, which account for the number of variables entered, future work should use a larger sample size, so as to remove the possibility of any Type I error. Third, the neurocognitive battery was admittedly narrow and omitted a number of the neurocognitive tasks traditionally used in schizophrenia research (e.g., Wisconsin Card Sorting task; Backward Masking; Span of Apprehension). This may explain why the predictive power of neurocognition reported here was comparatively low, and a larger battery might result in different patterns of correlations and greater predictive power that should be explored further. Similarly, the patterns of prediction reported here may vary with a more comprehensive assessment of social functioning. Our assessment of interpersonal skill was brief and conducted in a laboratory setting which may not directly translate to everyday social performance. It is possible that the addition of other indices of social functioning such as community activities, recreation, or work achievement would better elucidate the relationships between social cognition and social functioning in schizophrenia. Thus, replication of these findings with a more comprehensive cognitive and social functioning battery is essential. Finally, future studies should also consider the use of statistical procedures such as structural equation modeling that could better clarify the interrelationships between each of these cognitive domains and social functioning.

In closing, individuals with schizophrenia are indeed impaired in social cognition and interpersonal skill as compared with healthy individuals, and it appears that in schizophrenia, social cognition predicts variance in interpersonal skill that cannot be accounted for by neurocognitive abilities. These findings are an important step in understanding the role of social cognition in schizophrenia.

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