Psychiatry Research 242 (2016) 150–156

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Social cognition in schizophrenia: Factor structure of emotion processing and theory of mind

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ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form
12 April 2016
Accepted 25 May 2016
Available online 31 May 2016

Keywords:
Emotion processing
Theory of mind
Social cognitive skill
Confirmatory factor analysis (CFA)

ABSTRACT

Factor analytic studies examining social cognition in schizophrenia have yielded inconsistent results most likely due to the varying number and quality of measures. With the recent conclusion of Phase 3 of the Social Cognition Psychometric Evaluation (SCOPE) Study, the most psychometrically sound measures of social cognition have been identified. Therefore, the aims of the present study were to: 1) examine the factor structure of social cognition in schizophrenia through the utilization of psychometrically sound measures, 2) examine the stability of the factor structure across two study visits, 3) compare the factor structure of social cognition in schizophrenia to that in healthy controls, and 4) examine the relationship between the factors and relevant outcome measures including social functioning and symptoms. Results supported a one-factor model for the patient and healthy control samples at both visits. This single factor was significantly associated with negative symptoms in the schizophrenia sample and with social functioning in both groups at both study visits.

1. Introduction

Social cognition is a significant research target in schizophrenia due to its relationship with functional outcomes (Couture et al., 2006; Fett et al., 2011; Green and Leitman, 2008). Moreover, social cognitive interventions improve specific social cognitive skills, negative symptoms, and social functioning (Kurtz and Richardson, 2011; Lindenmayer et al., 2013; Roberts et al., 2014). However, despite the associations between social cognition and real world functioning in schizophrenia, research and treatment progress has been impeded by inconsistencies in construct definition and measurement (Pinkham et al., 2013). Previous research has utilized varying definitions and measures of social cognition in this population, leading to challenges in comparing results across studies (Green et al., 2005). Further, most existing measures of social cognition have unsatisfactory or unknown psychometric properties (Pinkham et al., 2015; Yager and Ehmann, 2006), thus precluding a valid understanding of its underlying factor structure.

The majority of existing factor analytic studies have established social cognition as distinct from related constructs such as neurocognition (Allen et al., 2007; Hoe et al., 2012; Mehta et al., 2013; Nuechterlein et al., 2004; Sergi et al., 2007; Van Hooren et al., 2008) and metacognition (Lysaker et al., 2013). In addition, the factor structure of social cognition in schizophrenia has yielded two-factor (Buck et al., 2016; Ziv et al., 2011), three-factor (Mancuso et al., 2011; Mehta et al., 2014), and four-factor solutions (Bell et al., 2009). Due to the differing conceptualizations of social cognition and a wide array of measures with unknown psychometric properties utilized in previous work, the genuine factor structure remains unknown. Fortunately, the recent conclusion of phase 3 of the Social Cognition Psychometric Evaluation (SCOPE) study offers a valuable opportunity to examine the factor structure of social cognition in schizophrenia using only the most psychometrically sound measures.

The SCOPE Study seeks to address the problem of inconsistent definition and measurement of social cognition by identifying the most widely used measures, systematically evaluating the psychometric properties, and validating a gold-standard battery for assessing these domains (Pinkham et al., 2013). Phases 1 and 2 of the project utilized expert surveys and the RAND Appropriateness

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http://dx.doi.org/10.1016/j.psychres.2016.05.034
0165-1781/

Method of consensus development to select the best existing measures based on current knowledge of their psychometric properties and their potential for use in clinical trials. Despite varying views on the number of domains comprising social cognition, eight measures of social cognition covering four domains (emotion processing, social perception, theory of mind/mental state attribution, and attributional style/bias) and one "novel" category were identified in the SCOPE study (Pinkham et al., 2013). The novel category included measures that "showed promise but were not widely used in schizophrenia" (Pinkham et al., 2013, p. 821).

In phase 3, large samples of individuals with schizophrenia and healthy controls completed the measures to assess the psychometric properties (e.g. reliability and validity) of each task (Pinkham et al., 2015). As a result of SCOPE Phase 3, the most widely used measures of all four domains of social cognition have been examined and the most psychometrically sound have been identified. Specifically, five measures of social cognition (described in the methods section) from the emotion processing and theory of mind domains were selected. Given that measures from the additional two social cognition domains (social perception and attributional style) did not exhibit sufficient reliability and validity in Phase 3, they will not be included in the present study. Further, the subsequent phase of SCOPE (currently in progress) is focused on identifying and testing different measures of these domains to establish a complete gold-standard battery of social cognition measures.

In this article, we report the results of a confirmatory factor analysis of social cognition in individuals with schizophrenia using the 5 most psychometrically sound measures identified in SCOPE Phase 3. This study has the potential to significantly impact the field in four important ways: 1) examine the factor structure of social cognition in schizophrenia through the utilization of psychometrically sound measures, 2) examine the stability of the factor structure through its examination at two visits, 3) compare the factor structure of social cognition in schizophrenia to that in healthy controls, and 4) examine the relationship between the factors and relevant outcome measures including social functioning and symptoms Tabless 1 and 2.

Table 1
Demographic and Clinical Characteristics.

	SZ Sample ($n=179$)	HC Sample ($n=104$)
Male, % (n)[*]	65 (117)	47 (49)
Race, % (n)		
Caucasian	42 (76)	41 (43)
African American	53 (94)	53 (55)
Native American	1 (1)	0 (0)
Asian	2 (4)	4 (4)
Other	2 (4)	2 (2)
Ethnicity, % (n)		
Hispanic	21 (37)	20 (21)
Non-Hispanic	79 (142)	80 (83)
Age (years), M (SD)	42.11 (12.32)	39.20 (13.70)
Years of Education, M (SD)[*]	12.70 (2.14)	13.43 (1.66)
Diagnosis, % (n)		
Schizophrenia	54 (96)	–
Schizoaffective Disorder	46 (83)	

Note. SZ = Schizophrenia; HC=Healthy Control.
[*] $p < 0.01$.

Table 2
Descriptive data of social cognitive, neurocognitive, and social functioning measures.

	SZ Sample M (SD)	HC Sample M (SD)
Social Cognitive Measures (T_1)[a]	$n=179$	$n=104$
BLERT	13.17 (3.88)	15.75 (2.88)
ER-40	29.55 (5.40)	32.80 (3.54)
Eyes	20.15 (5.46)	23.55 (4.62)
Hinting	13.59 (3.87)	16.82 (2.05)
TASIT	44.43 (7.64)	51.48 (5.62)
Social Cognitive Measures (T_2)[b]	$n=171$	$n=98$
BLERT	13.91 (3.99)	16.12 (2.96)
ER-40	30.42 (4.95)	33.13 (3.41)
Eyes	20.66 (5.85)	23.55 (5.34)
Hinting	14.22 (3.69)	17.44 (1.49)
TASIT	42.92 (6.36)	48.21 (6.58)
Neurocognitive Measures[c]	$n=178$	$n=104$
Trails A	41.06 (18.78)	30.72 (12.10)
Coding	42.18 (11.78)	53.99 (14.00)
HVLT	20.27 (5.37)	24.85 (4.45)
LNS	11.37 (4.07)	13.85 (3.85)
AF	18.44 (5.12)	21.98 (6.36)
Social Functioning Measures[d]	$n=178$	$n=103$
UPSA-B	69.95 (14.36)	-
SSPA	4.11 (0.534)	4.52 (0.440)
SLOF	3.91 (0.570)	4.62 (0.440)

Note. SZ=Schizophrenia; HC=Healthy Control; T_1=Time 1; T_2=Time 2; BLERT=Bell Lysaker Emotion Recognition Task; ER-40=Penn Emotion Recognition Task; Eyes=Reading the Mind in the Eyes Test; Hinting=Hinting Task; TASIT=The Awareness of Social Inferences Test, Part III; LNS=Letter Number Span, AF=Animal Fluency; UPSA-B=UCSD Performance-Based Skills Assessment, Brief; SSPA=Social Skills Performance Assessment; SLOF=Specific Levels of Functioning Scale.
[a] T_1 Hinting data was missing for 1 SZ subject and 2 HC subjects.
[b] T_2 Hinting data was missing for 1 HC subject and T_2 TASIT data was missing for 1 SZ subject.
[c] HVLT data was missing for 2 SZ subjects and LNS data was missing for 1 SZ subject.
[d] SSPA and SLOF data were missing for 1 SZ subject.

2. Method

2.1. Subjects

The study took place at two sites, Southern Methodist University (SMU) and the University of Miami Miller School of Medicine (UM). Patients at the SMU site were recruited from Metrocare Services, a non-profit mental health services provider organization in Dallas County, TX, and other area clinics. UM patient recruitment occurred at the Miami VA Medical Center and the Jackson Memorial Hospital-University of Miami Medical Center. At both sites, healthy controls (n=104) were recruited via community advertisements.

To be eligible, patients (n=179) required a DSM-IV diagnosis of schizophrenia or schizoaffective disorder as confirmed by clinical interview with the MINI (Sheehan et al., 1998) and SCID Psychosis Module (First, Spitzer, Gibbon, and Williams, 2002). Patients could not have any hospitalizations within the last two months and had to be on a stable medication regimen for a minimum of six weeks with no dose changes for a minimum of two weeks. Healthy controls (n=104) were screened for history of psychopathology to ensure they did not meet criteria for any major DSM-IV Axis I or II disorders. Exclusion criteria for both groups included: 1) presence or history of pervasive developmental disorder or mental retardation (defined as IQ < 70) by DSM-IV criteria, 2) presence or history of medical or neurological disorders that may affect brain function (e.g. seizures, CNS tumors, or loss of consciousness for 15 min or more), 3) presence of sensory limitation including visual (e.g. blindness, glaucoma, vision uncorrectable to 20/40) or hearing impairments that interfere with assessment, 4) no proficiency in English, 5) substance abuse in the past month, and 6) substance dependence not in remission for the past six months.

2.2. Measures

Since the present study examined the five most psychometrically sound social cognition measures as determined in phase 3 of SCOPE (Pinkham et al., 2015), only these measures are described in full detail next. See Pinkham et al., (2015) for a full description of the methods and procedure.

2.2.1. Social cognition measures

2.2.1.1. Emotion processing. Bell Lysaker Emotion Recognition Task (BLERT; Bryson et al., 1997). The BLERT measures the ability to correctly identify seven emotional states: happiness, sadness, fear, disgust, surprise, anger, or no emotion. Subjects view 21 10-second video clips of a male actor, providing dynamic facial, vocal-tonal, and upper-body movement cues. After viewing each video, subjects identify the expressed emotion. Total scores indicated the number of correctly identified emotions (ranging from 0 to 21).

Penn Emotion Recognition Task (ER-40; Kohler et al., 2003). The ER-40 includes 40 color photographs of static faces expressing 4 basic emotions (i.e. happiness, sadness, anger, or fear) and neutral expressions. Stimuli are balanced for poser's gender, age, and ethnicity, and for each emotion category, 4 high-intensity and 4 low-intensity expressions are included. Subjects view one image at a time and choose the correct emotion label for each face; total scores are the total number correct (ranging from 0 to 40).

2.2.1.2. Theory of mind/mental state attribution. Reading the Mind in the Eyes Test (Eyes Test; Baron-Cohen et al., 2001). The Eyes test measures the capacity to discriminate the mental state of others from expressions in the eye region of the face. Subjects view 36 photos of the eye region of different faces and choose the most accurate descriptor word for the thought/feeling that is portrayed. Four possible options are presented with each photo, and a glossary of mental state terms is provided for reference. Scores represent the overall number correct (ranging from 0 to 36).

The Awareness of Social Inferences Test, Part III (TASIT; McDonald et al., 2003). The TASIT assesses detection of lies and sarcasm. Subjects watch short videos of everyday social interactions and answer four standard questions per video that probe understanding of the intentions, beliefs, and meanings of the speakers and their exchanges. Total scores index performance (ranging from 0 to 64).

Hinting Task (Corcoran et al., 1995). The Hinting Task examines the ability of individuals to infer the true intent of indirect speech. In the present study, passages are read aloud by the experimenter, and subjects are asked what the character truly meant. If the first response provided is inaccurate, a second hint is provided, allowing subjects to earn partial credit for that passage. Performance is indexed as overall number correct (ranging from 0 to 20).

2.2.2. Neurocognitive measures

A subset of the MATRICS Consensus Cognitive Battery (Nuechterlein et al., 2008) was used to assess speed of processing (Trail Making Test, Part A; Symbol Coding; and Category Fluency: Animal Naming), working memory (Letter-Number Span), and verbal learning (HVLT-R).

2.2.3. Functional outcome measures

UCSD Performance-Based Skills Assessment, Brief (UPSA-B; Mausbach et al., 2007). The UPSA-B is a widely used measure of functional capacity that assesses financial and communication skills required for community living. In the present study, the UPSA-B was only administered to SZ subjects due to anticipated ceiling effects if administered to HC subjects. Total scores could range from 0 to 100.

Social Skills Performance Assessment (SSPA; Patterson et al., 2001). Social skill was assessed with the SSPA, a role-play measure in which subjects are asked to initiate and maintain a conversation in two social situations: meeting a new neighbor and negotiating with a landlord to fix a leak. Role-plays are audiotaped and coded by an expert rater blind to diagnosis on the following variables: interest, fluency, clarity, focus, overall abilities, and social appropriateness. The landlord role-play is also coded for negotiation ability and persistence. The mean total score across both role-plays is used as the dependent measure (ranging from 1 to 5).

Specific Level of Functioning Scale (SLOF; Schneider and Struening, 1983). Functional outcomes were assessed via the 31-item version of the SLOF, which is both a self-report and an informant-rated measure of social functioning (interpersonal relationships and social acceptability) and community living skills (participation in activities and work skills). SZ subjects had informants complete the SLOF and HC subjects completed the self-report version. Informants were identified by the SZ subjects and were high contact clinicians, family members, or close friends. Ratings for each item are made on a 1–5 point scale (in both the self report and informant report versions) with higher scores indicating better functioning, and average scores across all items (ranging from 1 to 5) provide the total outcome index.

2.3. Procedures

All subjects completed two study visits: baseline and a retest assessment completed 2–4 weeks after the initial visit (mean interval = 17.29 days) to allow for examination of test-retest reliability in the SCOPE study (Pinkham et al., 2015). Further, this interval provides a strong test of practice effects while also limiting the possibility of performance differences due to clinical change (Pinkham et al., 2015). At visit 1, all subjects provided informed consent and completed the social cognition, neurocognition, and functional outcome measures. The order of these task blocks was counterbalanced, and within the social cognition battery, the order of individual tasks was counterbalanced as well. For patients, visit 1 also included diagnostic assessment and an evaluation of symptom severity using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987). Diagnostic and symptom raters were trained to reliability (i.e. intraclass correlation >0.80) using the established procedures at each site. At visit 2, symptom severity was reassessed in the patients, and all subjects repeated the social cognitive measures in the same order as their first visit. For TASIT, an alternative form (TASIT-B) was administered to all subjects at visit 2; however alternative forms were not available for any other social cognitive task, so these were identical to visit 1. Visit durations were approximately 3.5–4.5 h for visit 1 and 3 h for visit 2.

2.4. Statistical analyses

We hypothesized a single-factor model as all measures included in this study assess domains of emotion processing and theory of mind. Further, previous research found a separation between social cognitive skill (i.e. performance indexed as correct or incorrect) and social cognitive biases (e.g. attributional style) and thus would suggest that the measures utilized in the current study would comprise a skill-based domain (Buck et al., 2016, Mancuso et al., 2011; Van Hooren et al., 2008). For these reasons, we conducted a series of confirmatory factor analyses (e.g., Raykov and Marcoulides, 2006) based on this unidimensionality model.

These analyses are based on application of a robust version of the popular full information maximum likelihood (FIML) method, i.e., of robust ML, in the presence of missing data, with appropriate auxiliary variables (AVs; e.g., Enders, 2010). FIML is used to negate the impact of missing data in the analyzed dataset. Further, although the present study did not have excessive missing data, FIML was the chosen approach so as to be as comprehensive as possible. This FIML approach is characterized by 5 main features (e.g., Little and Rubin, 2002): (1) no subject is omitted or dropped from the (pertinent) data set while analyzing it; and (2) no missing value is imputed. Rather, (3) all data are used from all studied subjects who are of relevance for the corresponding of the analyses. In addition, (4) for each of the following analyses, appropriate auxiliary variables (AVs) are used, in order to counteract - to the extent possible - potential violations of the assumption of missing at random (MAR) that underlies FIML (The same assumption is basic also for contemporary utilizations of multiple imputation with widely available software; cf. Raykov, 2005). The AVs used are chosen following the widely adopted recommendation to be measures that are related as closely as possible to the dependent variables with missing values (e.g., Enders, 2010). Lastly, as mentioned above, (5) the use of robust FIML allows one to deal with likely violations of normality on the dependent variables in the pertinent analyses of the 5 social cognition measures.

3. Results

3.1. Pooling across sites

We first examined whether the two study sites, SMU and Miami, could be pooled – both at each assessment occasion and within each of the 2 groups of the study, healthy controls (HC) and individuals with schizophrenia (SZ). Pooling across sites allows for greater sample sizes within groups and thus increased statistical power for the latent structure examination.

To examine if the 2 sites could be pooled within group (i.e., within the HC and SZ groups), a total of 4 analyses were conducted: (i) at time 1 for the HC group; (ii) at time 1 for the SZ group; (iii) at time 2 for the HC group; and (iv) at time 2 for the SZ group. For each of these 4 analyses, we sought to determine if data could be pooled across site and considered as a single group in the ensuing latent structure analyses. To this end, we examined whether the 5 variable means and associated covariance matrices for the 2 sites were the same, for each of the 4 occasions and group combinations.

For SZ at time 1, the associated goodness of fit indices were as follows: chi-square =19.815, degrees of freedom (df)=15, root mean square error of approximation (RMSEA)=.060, with a 90%-confidence interval (95%-CI) being (.0,.123). These results can be considered indicative of the tested hypothesis of similarity being plausible (e.g., Hu and Bentler, 1999), and thus that the data from the patients at time 1 could be pooled into a SZ group across the two sites. Similarly, for SZ at time 2 the fit indices were as follows (95%-CI for RMSEA following index): chi-square=13.195, df=15, RMSEA=0 (.0,.088). These findings indicate that the two sites can be pooled into a SZ group also at time 2.

For healthy controls, the fit indices were as follows: at time 1, chi-square =18.932, df =15, RMSEA=.071 (.0,.157); and at time 2, chi-square=28.906, df=15, RMSEA=.134 (.056,.206). This set of results similarly indicates that there is insufficient evidence to warrant rejection of the hypothesis of same means and covariance matrices and thus, that data across the two sites could be pooled, at each time, into a healthy control group. Therefore, the remainder of this paper is based on pooling the SMU and Miami sites both at time 1 and time 2, within each of the 2 groups of the study, HC and SZ.

Table 3
One-factor Model of Social Cognition for Both Groups at Time 1.

	SZ		HC	
Measure	**Factor loading**	**R^2**	**Factor loading**	**R^2**
BLERT	1.000	0.528*	1.000	0.422*
ER-40	1.209	0.429*	1.209	0.332*
Eyes	1.403	0.533*	1.403	0.328*
Hinting	0.217	0.319*	0.775	0.037
TASIT	2.168	0.591*	2.168	0.470*

Note. BLERT=Bell Lysaker Emotion Recognition Task; ER-40=Penn Emotion Recognition Task; Eyes=Reading the Mind in the Eyes Test; Hinting=Hinting Task; TASIT=The Awareness of Social Inferences Test, Part III. Factor loadings are unstandardized.

* $p < 0.001$.

3.2. Confirmatory factor analysis (CFA)

The CFA analyses examine a single-factor model that also incorporates measurement invariance (MI).[1] MI can be treated as the assumption of measuring the same construct (e.g., Millsap, 2011) in the HC and SZ groups at time 1 and at time 2. The pertinent single-factor model is found to be associated with the following fit indices at time 1 for the HC and SZ groups: chi-square=30.150, df=16, RMSEA=.079 (.033,.122). Similarly, at time 2, the same two-group model is associated with the following fit indices: chi-square=30.355, df=16, RMSEA=.079 (.034,.122). To achieve this tenable fit, it was necessary to release the loading and intercept of the Hinting measure from the cross-group constraint at time 1 as well as at time 2. Further, this was necessary given that the loadings and intercepts of all measures except for the Hinting Task are the same in both groups (See Tabless 3 and 4). However, the Hinting Task is still present within the one-factor model; but functions differently in both groups from the other measures, as evidenced by the different loadings and intercepts.

The mean of the common factor evaluated by the social cognition measures, referred to as social cognitive ability (SCA), was significantly lower in the SZ group at both visits. Specifically, at time 1 the latent SCA group mean difference (HC mean minus SZ mean) was estimated at 2.772, with a standard error (SE)=.340, t-value=8.165, and p-value (p)=.000 (e.g., Raykov and Marcoulides, 2010). At time 2, this difference was estimated at 2.383, SE=.366, t-value=6.504, p=.000. In addition, at time 1, the latent SCA variance was estimated (standard error in parentheses) at 3.247 (.696) in the HC group, while it was estimated at 7.908 (1.339) in the SZ group; at time 2 the SCA variance was estimated at 4.555 (1.136) in the HC group, and at 8.309 (1.449) in the SZ group. A comparison of the 95%-confidence intervals for these latent variances within visit suggested that SCA variance was considerably higher in the SZ group than in the HC group at each visit (e.g., Raykov and Marcoulides, 2006; this comparison is not used here in the form of a formal statistical test). These findings

[1] A 2-factor model was tested with one factor comprising BLERT and ER-40 and the other comprising Hinting, TASIT, and Eyes. The null hypothesis H_0: "In the 2-factor model, the correlation between the 2 latent factors is equal to 1" was tested for SZ and HC samples at each time point. Note that under this hypothesis, the 2 latent factors 'collapse' into a single factor (e.g., Raykov et al., 2015). In the HC group, we fail to reject the null hypothesis at Time 1 (p=.195) and Time 2 (p=.500). In the SZ group, the null hypothesis is formally rejected at Time 1 (p=.006) and Time 2 (p=.007); however, the estimated correlation (denoted Rho below) between the 2 latent factors was 'practically' 1 (standard errors in parentheses): *Time 1*: estimated rho =.868 (.057); *Time 2*: estimated rho=.882 (.050). As a result, the 2 factors in the SZ group may be treated as practically indistinguishable. Overall, the results indicate that at each assessment occasion (Time 1 and Time 2) and in each group (HC and SZ), the 2 latent factors are either effectively identical or practically indistinguishable.

Table 4
One-factor Model of Social Cognition for Both Groups at Time 2.

	SZ		HC	
Measure	**Factor loading**	**R^2**	**Factor loading**	**R^2**
BLERT	1.000	0.523*	1.000	0.527*
ER-40	1.223	0.520*	1.223	0.572*
Eyes	1.518	0.562*	1.518	0.420*
Hinting	0.681	0.282*	0.028	0.002
TASIT	1.561	0.469*	1.561	0.235*

Note. BLERT=Bell Lysaker Emotion Recognition Task; ER-40=Penn Emotion Recognition Task; Eyes=Reading the Mind in the Eyes Test; Hinting=Hinting Task; TASIT=The Awareness of Social Inferences Test, Part III. Factor loadings are unstandardized.
* $p < 0.001$.

indicate that at each visit, while HC group was on average higher on SCA, individual differences for the schizophrenia sample were greater. In other words, healthy controls were more internally similar in their SCA than patients were on their SCA ability at each assessment occasion.

3.3. *Stability of social cognition and relationships with symptoms and social functioning*

To examine the stability of the social cognition construct for HC and SZ over time as well as its relationships with symptoms and social functioning measures, the single factor model was fitted to the data from both visits in each of the groups whereby measurement invariance over time was postulated, i.e., the assumption that the same SC construct was measured at both assessments was incorporated (Millsap, 2011). Specifically, the unidimensional model was postulated at each assessment in each group, while the SC constructs at time 1 and time 2 were correlated with each other as well as with the symptoms and social functioning measures.

In SZ, this model with covariates was found plausible: chi-square=179.173, df=109, RMSEA=.060 (.044,.075). There was a slight increase in mean SCA at time 2 relative to time 1: mean SCA difference was estimated at.348 (.129), p=.007. The degree of inter-individual differences on SCA was however stable over time, with the two latent variances being estimated at 8.358 (1.426) and 7.981 (1.389) at the two consecutive visits, respectively, indicating essentially identical extent of patient SCA differences at both assessment occasions.[2]

The correlations of SCA at time 1 and time 2, as well as with symptoms and social functioning in the SZ group are presented in Table 5. SCA was significantly associated with negative symptoms at time 1 and time 2 indicating that better social cognitive ability is related to lower negative symptoms. The relationship between SCA and positive and general symptoms was in the expected direction; however, neither was statistically significant. All three of the social functioning measures (UPSA-B, SSPA, & SLOF) were significantly associated with SCA at both visits, demonstrating that greater social cognitive ability is related to better social functioning outcomes (See Table 5).

Similarly, in the HC group, the above two-assessment model with covariates was found plausible: chi-square=71.241, df=52, RMSEA=.060 (.014,.092).[3] Stability was indicated by identical SCA means and variances. Additionally, SCA was significantly associated with SSPA and SLOF at both visits, suggesting that better social cognitive ability is related to greater social functioning (See Table 6).

Table 5
Bivariate correlations among social cognitive ability factor (sca), symptoms, and social functioning in schizophrenia sample at Time 1 and Time 2.

	SCA Factor Time 1	**SCA Factor Time 2**
Time 1 Symptom variables		
PANSS Positive symptoms	−0.047	0.052
PANSS negative symptoms	−0.398***	−0.347***
PANSS General symptoms	−0.152	−0.057
Time 2 Symptom variables		
PANSS Positive symptoms	−0.088	−0.076
PANSS Negative symptoms	−0.344***	−0.353***
PANSS General symptoms	−0.100	−0.127
Social functioning variables		
UPSA-B	0.554***	0.556***
SSPA	0.425***	0.397***
SLOF	0.275***	0.334***

Note. PANSS=Positive and Negative Syndrome Scale; UPSA-B=UCSD Performance-Based Skills Assessment, Brief; SSPA=Social Skills Performance Assessment; SLOF=Specific Levels of Functioning Scale. (Partial) measurement invariance holds over time (see main text).
* $p < 0.05$, ** $p < 0.01$,
*** $p < 0.001$.

Table 6.
Bivariate Correlations between Social Cognitive Ability Factor (SCA) and Social functioning in healthy control sample at Time 1 and Time 2.

	SCA factor Time 1	**SCA factor Time 2**
SSPA	0.407**	0.410**
SLOF	0.303*	0.270*

Note. UPSA-B=UCSD Performance-Based Skills Assessment, Brief; SSPA=Social Skills Performance Assessment; SLOF=Specific Levels of Functioning Scale. (Partial) measurement invariance holds over time.
*** $p < 0.001$.
* $p < 0.05$,
** $p < 0.01$,

4. Discussion

The primary purpose of this study was to ascertain the factor structure of social cognition using the most psychometrically sound measures recently established in the SCOPE study (Pinkham et al., 2015). Additionally, this study sought to examine the stability of the factor structure through its examination at two visits and to examine the relationship between the factors and social functioning and symptom measures.

Results of confirmatory factor analysis support a one-factor model of SCA for both individuals with schizophrenia and healthy controls. On the surface, results from the present study are

[2] The ratio of the SC variance at time 1 to that variance at time 2 was estimated at 1.047 (.105), with a 95%-confidence interval (.860, 1.274) that includes 1 (e.g., Raykov and Marcoulides, 2014). Hence, the null hypothesis of stability in latent variance can be retained.

[3] When fitting the model, to achieve tenable fit we relaxed the constraint of time invariant intercept of the Tasit measure, which was estimated at a significantly lower value at time 2. This result indicates a slight decrease in 'difficulty' in this measure in the healthy control group (Raykov and Marcoulides, 2011), which could be interpreted as a consequence of practice effects.
The ratio of the SC variance at time 1 to that variance at time 2 was estimated at.735 (.103), with a 95%-confidence interval (.558,.967) that includes 1 (e.g., Raykov and Marcoulides, 2014). Therefore, the null hypothesis of stability in latent variance can similarly be retained.

inconsistent with previous work finding two-factor (Ziv et al., 2011), three-factor (Mancuso et al., 2011; Mehta et al., 2014), and four-factor solutions (Bell et al., 2009). However, direct comparisons between previous studies and the present study should consider variability in the number, type, and quality of measures utilized. The current study only included measures of emotion processing and theory of mind, whereas others have also included attributional bias and social perception tasks. Specifically, the measures included in the present study all assess one's ability to correctly or incorrectly identify the mental content of others. Several previous factor analytic studies yielding multiple factor solutions have found a clear delineation between attributions and skills-based domains of social cognition (Buck et al., 2016, Mancuso et al., 2011; Van Hooren et al., 2008), which may clarify our lack of a multiple factor solution. Considering this literature, our results appear consistent with previous research, as our analysis lacks measures of social cognitive bias, and our one-factor model may be conceptually similar to the lower level social cue detection factor (Mancuso et al., 2011) and social cognitive skills factor (Buck et al., 2016) found in previous work. Our results are also consistent with Lysaker et al. (2013) who found that the BLERT, Hinting, and Eyes formed one factor.

Given that the current study included only skills-based measures and that these loaded onto a single factor, this work provides support for a distinct skills-based domain of social cognition. However, it should be noted that the Hinting Task did not load well onto the single factor, especially in the HC group suggesting that this measure may function differently in the two samples. Moreover, modest ceiling effects of this task were present when used in HCs (Pinkham et al., 2015) and as a result, may provide some explanation for its poor loading onto the single factor. Nonetheless, because this study was the first to use only the most psychometrically sound measures of social cognition (Pinkham et al., 2015), our results suggest that emotion processing and theory of mind, when measured using valid and reliable tools, may represent one broad domain of social cognition (e.g. social cognitive skill). The inclusion of attributional bias and social perception measures may result in one or more additional factors of social cognition in schizophrenia (Bell et al., 2009; Mancuso et al., 2011; Mehta et al., 2014; Ziv et al., 2011). Yet, it is difficult to hypothesize the specific overall factor structure at this time given that it has not been assessed using psychometrically sound measures.

The one-factor model of social cognition was found to be plausible at time 1 and time 2, suggesting stability of the latent structure associated with this construct over time. This finding extends previous research examining social cognition's factor structure at one single time point. The stability of social cognition suggests that the effects of time (over the course of 2–4 weeks) did not substantially influence the underlying factor structure of social cognition in individuals with schizophrenia or healthy controls. Knowledge of this stability has implications for interpretation of results observed during short-term treatment studies that are aimed at identifying meaningful changes in social cognition. In addition, SZ subjects were more variable in their performance on social cognitive tasks than HC subjects, which may suggest the existence of multiple subgroups within the SZ sample. Such subgroups could represent endophenotypes that may be important for understanding the dimensional nature of mental illness. Taken together, these findings may provide valuable future directions for treatment research that extend beyond the traditional categorical view of mental illness.

Consistent with previous factor analytic research, results from correlational analyses between SCA and symptoms and social functioning indicate that superior social cognition was related to lower levels of negative symptoms (Lysaker et al., 2013; Mehta et al., 2014) and improved social functioning (Allen et al., 2007; Mancuso et al., 2011) in individuals with schizophrenia. Moreover, our results are consistent with strong research support for positive associations between emotion processing and theory of mind domains and community functioning (Couture et al., 2006; Fett, et al., 2011). Further, the relevance of social cognition in daily functioning may extend beyond the clinical sample, as the social cognition skills of healthy controls were also related to social functioning. In both groups, these relationships were essentially identical at both visits providing support for the stability of SCA, at least as measured in this study, as a one-factor construct as well as its relationship with outcomes.

Several limitations should be considered when interpreting the results of the current study. First, the assessment battery only included measures of two of the four primary SCOPE domains of social cognition (Pinkham et al., 2013; emotion processing and theory of mind/mental state attribution) because psychometrically sound measures of attributional style/bias and social perception were not identified in Phase 3 of the SCOPE study (Pinkham et al., 2015). As a result, the present study does not provide information related to social perception or social cognitive bias. The impact of including these domains on our current factor structure is unknown. Second, the schizophrenia sample included relatively stable outpatients and may not generalize to individuals with more severe symptoms or those receiving inpatient treatment. Third, because the single factor solely encompasses domains of social cognition that can be evaluated as correct or incorrect (e.g. correctly identifying an emotion), interpretations of the relationship between social cognition and social functioning are limited. Future work is needed to examine not only an individual's ability to correctly identify mental states of others but also the ability to synthesize social information into the kinds of complex representations needed for effective participation in the community. Finally, the confirmatory factor analyses reported are based on large-sample statistical theory, and thus before a replication study is conducted caution is advised in generalizing the above results.

In summary, this is the first study to examine the factor analytic structure of social cognition using the most psychometrically sound measures (Pinkham et al., 2015). A single factor that is consistent with the construct of social cognitive ability was found in both individuals with schizophrenia and healthy controls. This factor was stable over time and showed strong correlations to functional outcomes. As only two social cognitive domains were included here, the factor analysis should be replicated once measures from the two remaining domains of social cognition (attributional style/bias and social perception) have been established. Despite only examining these two domains of social cognition, the results suggest that emotion processing and theory of mind may be valuable treatment targets given the relationship between the single factor and symptoms and social functioning. Future research should consider examining the factor structure of social cognition in first episode psychosis as well as in different racial and ethnic groups. A more accurate understanding of the factor structure of social cognition in these groups can inform the development and evaluation of appropriate treatments. Finally, the results of the present study represent a valuable first step in establishing the factor structure of social cognition in schizophrenia using psychometrically sound measures and should be replicated upon completion of the next phase of SCOPE.

Conflicts of interest

none.

Acknowledgments

We would like to thank all of the individuals who participated in this study and the following individuals for their assistance with data collection and management: Isis Nelson-Graham (SMU), Kelsey Ludwig (UNC), Gabriela Vargas (UM), and Belinda Robertson (UM).

The SCOPE study was supported by the National Institute of Mental Health at the National Institutes of Health (R01 MH093432 to P. D. H., D. L. P., and A. E. P.).

References

Allen, D.N., Strauss, G.P., Donohue, B., van Kammen, D.P., 2007. Factor analytic support for social cognition as a separable cognitive domain in schizophrenia. Schizophr. Res. 93 (1), 325–333.
Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., Plumb, I., 2001. The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. J. Child. Psychol. Psychiatry 42 (2), 241–251.
Bell, M., Tsang, H.W., Greig, T.C., Bryson, G.J., 2009. Neurocognition, social cognition, perceived social discomfort, and vocational outcomes in schizophrenia. Schizophr. Bull. 35 (4), 738–747.
Bryson, G., Bell, M., Lysaker, P., 1997. Affect recognition in schizophrenia: A function of global impairment or a specific cognitive deficit. Psychiatry Res. 71 (2), 105–113.
Buck, B., Healey, K., Gagen, E., Roberts, D., Penn, D.L., 2016. Social cognition in schizophrenia: Factor structure, clinical and functional correlates. JMH 1 (8). http://dx.doi.org/10.3109/09638237.2015.1124397.
Corcoran, R., Mercer, G., Frith, C.D., 1995. Schizophrenia, symptomatology and social inference: Investigating "theory of mind" in people with schizophrenia. Schizophr. Res. 17 (1), 5–13.
Couture, S.M., Penn, D.L., Roberts, D.L., 2006. The functional significance of social cognition in schizophrenia: A review. Schizophr. Bull. 32 (1), S44–S63.
Enders, C.K., 2010. Applied Missing Data Analysis. Guilford., New York.
Fett, A.K.J., Viechtbauer, W., Penn, D.L., van Os, J., Krabbendam, L., 2011. The relationship between neurocognition and social cognition with functional outcomes in schizophrenia: A meta-analysis. Neurosci. Biobehav Rev. 35 (3), 573–588.
First, M.B., Spitzer, R.L., Gibbon, M., Williams, J.B.W., 2002. Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient EditionWith Psychotic Screen (SCID-I/P W/ PSY Screen). Biometrics Research, New York State Psychiatric Institute., New York.
Green, M.F., Olivier, B., Crawley, J.N., Penn, D.L., Silverstein, S., 2005. Social cognition in schizophrenia: Recommendations from the measurement and treatment research to improve cognition in schizophrenia new approaches conference. Schizophr. Bull. 31 (4), 882–887.
Green, M.F., Leitman, D.I., 2008. Social cognition in schizophrenia. Schizophr. Bull. 34 (4), 670–672.
Hoe, M., Nakagami, E., Green, M.F., Brekke, J.S., 2012. The causal relationships between neurocognition, social cognition and functional outcome over time in schizophrenia: A latent difference score approach. Psychol. Med. 42 (11), 2287–2299.
Hu, L.-T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct. Equ. Model. 6, 1–55.
Kay, S.R., Flszbein, A., Opfer, L.A., 1987. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr. Bull. 13 (2), 261.
Kohler, C.G., Turner, T.H., Bilker, W.B., Brensinger, C.M., Siegel, S.J., Kanes, S.J., Gur, R. E., Gur, R.C., 2003. Facial emotion recognition in schizophrenia: intensity effects and error pattern. Am. J. Psychiatry 160 (10), 1768–1774.
Kurtz, M.M., Richardson, C.L., 2011. Social cognitive training for schizophrenia: A meta-analytic investigation of controlled research. Schizophr. Bull., sbr036
Lindenmayer, J.P., McGurk, S.R., Khan, A., Kaushik, S., Thanju, A., Hoffman, L., Valdez, G., Wance, D., Herrmann, E., 2013. Improving social cognition in schizophrenia: A pilot intervention combining computerized social cognition training with cognitive remediation. Schizophr. Bull. p. sbs1, 20.
Little, R.J., Rubin, D.B., 2002. Statistical Analysis with Missing Data. Wiley., New York.
Lysaker, P.H., Gumley, A., Luedtke, B., Buck, K.D., Ringer, J.M., Olesek, K., Kukla, M., Leonhardt, B.L., Popolo, R., Dimaggio, G., 2013. Social cognition and metacognition in schizophrenia: Evidence of their independence and linkage with outcomes. Acta Psychiatr. Scand. 127 (3), 239–247.
Mancuso, F., Horan, W.P., Kern, R.S., Green, M.F., 2011. Social cognition in psychosis: Multidimensional structure, clinical correlates, and relationship with functional outcome. Schizophr. Res. 125 (2), 143–151.
Mausbach, B.T., Harvey, P.D., Goldman, S.R., Jeste, D.V., Patterson, T.L., 2007. Development of a brief scale of everyday functioning in persons with serious mental illness. Schizophr. Bull. 33 (6), 1364–1372.
McDonald, S., Flanagan, S., Rollins, J., Kinch, J., 2003. TASIT: A new clinical tool for assessing social perception after traumatic brain injury. J. Head Trauma Rehabil. 18 (3), 219–238.
Mehta, U.M., Thirthalli, J., Bhagyavathi, H.D., Kumar, J.K., Subbakrishna, D.K., Gangadhar, B.N., Eack, S.M., Keshavan, M.S., 2014. Similar and contrasting dimensions of social cognition in schizophrenia and healthy subjects. Schizophr. Res. 157 (1), 70–77.
Mehta, U.M., Thirthalli, J., Subbakrishna, D.K., Gangadhar, B.N., Eack, S.M., Keshavan, M.S., 2013. Social and neuro-cognition as distinct cognitive factors in schizophrenia: A systematic review. Schizophr. Res. 148 (1), 3–11.
Millsap, R.E., 2011. Statistical approaches to Measurement invariance. Routledge,.
Nuechterlein, K.H., Barch, D.M., Gold, J.M., Goldberg, T.E., Green, M.F., Heaton, R.K., 2004. Identification of separable cognitive factors in schizophrenia. Schizophr. Res. 72 (1), 29–39.
Nuechterlein, K.H., Green, M.F., Kern, R.S., Baade, L.E., Barch, D.M., Cohen, J.D., Essock, S., Fenton, W.S., Frese III, F.J., Gold, J.M., Goldberg, T., 2008. The MATRICS Consensus Cognitive Battery, part 1: Test selection, reliability, and validity. Am. J. Psychiatry.
Patterson, T.L., Moscona, S., McKibbin, C.L., Davidson, K., Jeste, D.V., 2001. Social skills performance assessment among older patients with schizophrenia. Schizophr. Res. 48 (2), 351–360.
Pinkham, A.E., Penn, D.L., Green, M.F., Buck, B., Healey, K., Harvey, P.D., 2013. The social cognition psychometric evaluation study: Results of the expert survey and RAND panel. Schizophr. Bull. 40 (4), 813–823.
Pinkham, A.E., Penn, D.L., Green, M.F., Harvey, P.D., 2015. Social cognition psychometric evaluation: Results of the initial psychometric study. Schizophr. Bull., 56.
Raykov, T., 2005. Analysis of longitudinal data with missing values via covariance structure modeling using full-information maximum likelihood. Struct. Eq. Model. 12, 331–341.
Raykov, T., Marcoulides, G.A., 2006. A First Course in Structural equation modeling. Erlbaum., Mahwah, NJ.
Raykov, T., Marcoulides, G.A., 2010. Group comparisons in the presence of missing data using latent variable modeling techniques. Struct. Equ. Model. 17, 135–149.
Raykov, T., Marcoulides, G.A., 2011. Introduction to Psychometric Theory. Taylor & Francis., New York.
Raykov, T., Marcoulides, G.A., 2014. Identifying useful auxiliary variables for incomplete data analyses: A note on a group difference examination approach. Educ. Psychol. Meas. 74, 537–550.
Raykov, T., Marcoulides, G.A., Tong, B., 2015. Do two or more multicomponent instruments measure the same construct? Testing construct congruence using latent variable modeling. Educ. Psychol. Meas.
Roberts, D.L., Combs, D.R., Willoughby, M., Mintz, J., Gibson, C., Rupp, B., Penn, D.L., 2014. A randomized, controlled trial of Social Cognition and Interaction Training (SCIT) for outpatients with schizophrenia spectrum disorders. Br. J. Clin. Psychol. 53 (3), 281–298.
Schneider, L.C., Struening, E.L., 1983. SLOF: A behavioral rating scale for assessing the mentally ill. In. Social Work Research and Abstracts Vol. 19. Oxford University Press,, pp. 9–21.
Sergi, M.J., Rassovsky, Y., Widmark, C., Reist, C., Erhart, S., Braff, D.L., Marder, S.R., Green, M.F., 2007. Social cognition in schizophrenia: Relationships with neurocognition and negative symptoms. Schizophr. Res. 90 (1), 316–324.
Sheehan, D.V., Lecrubier, Y., Sheehan, K.H., Amorim, P., Janavs, J., Weiller, E., , Hergueta, T., Baker, R., Dunbar, G.C., 1998, The Mini-International Neuropsychiatric Interview (MINI): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. J. Clin. Psychiatry.
Van Hooren, S., Versmissen, D., Janssen, I., Myin-Germeys, I., à, Campo, J., Mengelers, R., Van Os, J., Krabbendam, L., 2008. Social cognition and neurocognition as independent domains in psychosis. Schizophr. Res. 103 (1), 257–265.
Yager, J.A., Ehmann, T.S., 2006. Untangling social function and social cognition: A review of concepts and measurement. Psychiatry 69 (1), 47–68.
Ziv, I., Leiser, D., Levine, J., 2011. Social cognition in schizophrenia: Cognitive and affective factors. Cogn. Neuropsychiatry 16 (1), 71–91.