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Emotion perception and learning potential: Mediators between neurocognition and social problem-solving in schizophrenia?

ANJA VASKINN,[1,2] KJETIL SUNDET,[3] SVEIN FRIIS,[1,2] CARMEN SIMONSEN,[2,3] ASTRID B. BIRKENAES,[1,2] HALLDORA JÓNSDÓTTIR,[1,2] PETTER ANDREAS RINGEN,[1,2] AND OLE A. ANDREASSEN[1,2]

[1]Institute of Psychiatry, University of Oslo, Oslo, Norway
[2]Division of Psychiatry, Ullevål University Hospital, Oslo, Norway
[3]Institute of Psychology, University of Oslo, Oslo, Norway

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Abstract

Social cognition and learning potential have been proposed as mediating variables between neurocognition and functional outcome in schizophrenia. The present study examined this relation in a schizophrenia group ($N = 26$) with normal IQ. Neurocognition was measured with a composite score from tests of verbal learning, psychomotor speed, and executive functioning. Functional outcome was defined as social problem-solving skills and assessed with a role-play test. Social cognition was indexed by tests of visual and auditory emotion perception; and learning potential by estimating a gain score using a triple administration of the WCST. Neurocognition was confirmed to be a strong predictor of social problem-solving, and emotion perception was related to both neurocognition and social problem-solving. When controlling for emotion perception, the association between neurocognition and social problem-solving was weakened, implying a mediating role of emotion perception. Learning potential was not significantly related to neurocognition or social problem-solving, and thus not found to mediate the studied relation. In conclusion, our study indicates that emotion perception is a mediator between neurocognition and functional outcome as assessed with a social problem-solving task and thus a key factor in understanding functional outcome of schizophrenia. (*JINS*, 2008, *14*, 279–288.)

Keywords: Neuropsychology, Cognition, Social cognition, Psychosis, Interpersonal skills, Mediation

INTRODUCTION

Compromised neurocognition is a hallmark characteristic of schizophrenia with deficits seen on a range of the standard tests in use (Heinrichs & Zakzanis, 1998). Most people with the diagnosis are affected, including individuals with high or normal current IQ who nevertheless may show signs of a decline from a higher premorbid level if assessed adequately (Wilk et al., 2005). In addition, healthy relatives of persons with schizophrenia present evidence of neurocognitive deficits (Snitz et al., 2006). Thus, cognitive impairment is central to schizophrenia, and it has been claimed to represent a core dysfunction of the disorder (Elvevag & Goldberg, 2000).

Neurocognition is an important predictor of functional outcome in schizophrenia, which encompasses a range of different skills such as community functioning, social problem-solving and psychosocial skill acquisition (Green, 1996; Green et al., 2000). Neurocognition has been shown to be related to social skills as assessed with role-play tests in the laboratory (Addington & Addington, 1999), to community functioning rated from semi-structured interviews (Velligan et al., 2000), and to direct assessment of independent living skills (grocery shopping) in real-life (Rempfer et al., 2003). Some of these skills are purely instrumental (cooking, grooming, paying one's bills), whereas others have a strong social component (engaging in role-plays with another person).

Correspondence and reprint requests to: Anja Vaskinn, Division of Psychiatry, Psychosis Research Section–TOP, Ullevål University Hospital, Building 49, 0407 Oslo, Norway. E-mail: anja.vaskinn@medisin.uio.no

Because of its significance for functional outcome, neurocognition is considered an important treatment target. This is evidenced in the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) initiative (Green et al., 2004), where the goal is to develop new drugs specifically targeting cognitive dysfunction by using a standardized neuropsychological test battery in drug trials. However, far from all of the variance in functional outcome can be explained by neurocognition, and other predictors may exist, such as social cognition (Couture et al., 2006). Hence, social cognition has been included as one of the domains to be investigated in the MATRICS program (Green et al., 2005). Social cognition includes various functions, such as social perception (the ability to understand social situations and the rules that govern them), emotion perception (the capacity to decode emotional expressions in other people), theory of mind (ToM; the capability to infer what another person knows or experiences) and attributional style (how a person explains the causes of events in that person's life). A recent review showed that social cognition defined in all four manners seems to be related to different aspects of functional outcome (Couture et al., 2006). Among these, emotion perception has been examined most thoroughly with the bulk of the evidence showing that people diagnosed with schizophrenia in general perform poorer than healthy controls (Kohler & Brennan, 2004; Mandal et al., 1998).

Social cognition and learning potential have been proposed as possible mediators of the relationship between neurocognition and functional outcome (Green et al., 2000). Several recent studies have found social cognition to be involved in the relation between neurocognition and functional outcome (Addington et al., 2006a; Pinkham & Penn, 2006; Sergi et al., 2006). Although it could be hypothesized that the direction of the relation is uncertain, both theory and empirical data support a model where social cognition is the mediating variable between neurocognition and functional outcome. The recognition of emotional expressions in other people probably depends on neurocognitive abilities such as working memory, visual scanning, speech and face perception, and not the other way around (see for example, Sergi et al., 2006). The suggested model aims at investigating to what extent emotional processing and learning potential mediate input from cognitive modules. Identifying mediators will help us understand the mechanisms in which neurocognition impacts the everyday life of individuals with schizophrenia. These mechanisms can be targeted in clinical interventions, aiming at improving the lives of affected individuals.

Learning potential refers to a person's ability to benefit from additional help and training. This approach focuses on how well a person can perform given the best of circumstances. It grew out of criticisms raised against traditional intelligence classifications, which may be unfair to those who have not had the chance to acquire the skills necessary for performing well on such tests. Examples are children of lower social economic status or of an ethnic minority group (Hamers & Resing, 1993). From this it followed that if these children were to be assessed in another way, better and truer scores of their cognitive capacity would be achieved. This was done through learning potential assessment, where one is interested in what the child can achieve under optimal conditions, not what they already know (IQ-testing). The dynamic learning potential approach has been extended to the schizophrenia field through the idea that a low degree of learning potential will indicate less ability to benefit from rehabilitation. The method to assess learning potential in schizophrenia has most commonly been a 64-card test-train-test version of the Wisconsin Card Sorting Test (Heaton et al., 1993). Because learning potential is assessed with a neuropsychological test, some overlap is expected with other neuropsychological tests, such as learning scores. But learning potential is not the same as learning, since learning potential assessments consider both the baseline before training as well as the degree of improvement after training (learning). Thus, a person who has a high baseline score will have less learning potential because less improvement can be achieved with an initial high score. The most important difference between learning scores from regular neuropsychological tests and learning potential assessments is that the latter is dynamic and seeks to identify to which degree the individual can benefit from help and hints given. So far studies on learning potential in schizophrenia have focused mostly on methodological issues and on how to best assess and validate subgroups (Vaskinn et al, in press), but some have shown that learning potential predicts problem-solving skills (Wiedl, 1999) and the ability to learn simple work skills (Sergi et al., 2005).

To our knowledge, no one has yet investigated the relationship between learning potential and interpersonal problem-solving skills, and there are few studies on how emotion perception relates to social problem-solving skills (e.g., Addington et al., 2006b). Additionally, studies have not focused on schizophrenia with normal IQ. Research on samples with normal IQ makes it possible to focus on what the specific problems of schizophrenia might be, because they have fewer deficits when compared to healthy samples, but still fulfill the diagnostic criteria. The purpose of this study is to examine the hypothesis that emotion perception and learning potential mediate between neurocognition and social problem-solving in schizophrenia participants with normal IQ.

METHOD

Participants

Twenty-six individuals with a DSM-IV diagnosis of schizophrenia were consecutively included in the current substudy upon recruitment to the Norwegian Study Thematic Organized Psychosis Research (TOP) from psychiatric departments at Ullevål University Hospital in Oslo. The TOP study is a large translational research study investigating a number of clinical and biological characteristics of schizophrenia and bipolar disorder. In addition to information on clinical and neurocognitive features, genetic status as well as functional and structural MRI data are collected. The TOP study is approved by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate and is completed in accordance with the Helsinki Declaration. Diagnoses were confirmed by the Structured Clinical Interview for DSM-IV Axis I disorders (First et al., 1995), which was administered by trained and reliable psychiatrists ($\kappa = 0.77$). Participants with a history of traumatic brain injury, neurological disease, and IQ below 70 were excluded. Current IQ was measured with the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999), and premorbid IQ was assessed with a research version of the National Adult Reading Test (NART; Vaskinn & Sundet, 2001). All participants were prescribed antipsychotic medication with a mean dose in chlorpromazine equivalents of 390 mg/day. One person used a first generation antipsychotic medication as monotherapy, whereas 12 used a second generation antipsychotic medication as the only drug. The rest were using different combinations of first and second generation antipsychotic medication, antidepressants or antiepileptic drugs. One person received anticholinergic medication.

Measures of Clinical Characteristics and Social Functioning

Psychopathology was assessed with the Positive and Negative Syndrome Scale; PANSS (Kay et al., 1987). Global functioning was measured with the Global Assessment of Functioning; GAF (split-version; Pedersen et al., 2007). The interrater reliability of the raters (trained psychiatrists) was satisfactory, corresponding to an intraclass coefficient ($ICC_{(1,1)}$; Shrout & Fleiss, 1979) of 0.85 (95% CI: 0.76–0.92) for GAF-f, and 0.86 (95% CI: 0.77–0.92) for GAF-s; of 0.76 (95% CI: 0.58–0.92) for PANSS negative symptoms, 0.82 (95% CI: 0.66–0.94) for PANSS positive symptoms, and 0.73 (95% CI: 0.54–0.90) for PANSS general symptoms. We used the Social Functioning Scale (SFS; Birchwood et al., 1990) to assess level of social functioning. It is a seven-scale self-report questionnaire covering social interaction, participation in community activities, independent living and work functioning. The SFS was developed for individuals diagnosed with schizophrenia and has been standardized with a mean of 100 and a standard deviation of 15 for each of the seven scales. Means and standard deviations for clinical and demographic variables and social functioning are shown in Table 1. This sample is relatively well-functioning with only moderate symptom load and IQ

Table 1. Sample characteristics ($N = 26$)

Variables (measures)			
Demographics			
Gender (males/females)	17/9		
	M	*SD*	Range
Age	32.3	9.3	22–55
Education (years)	13.0	2.4	9–20
WASI IQ	107.5	11.6	87–132
NART (errors–maximum 50)	16.2	7.3	2–33
Clinical characteristics			
Total psychopathology (PANSS–total score)	55.0	11.1	30–76
Positive symptoms (PANSS–positive scale)	11.7	3.9	7–21
Negative symptoms (PANSS–negative scale)	15.4	5.5	7–28
Level of functioning (GAF-f)	49.0	9.3	30–67
Level of symptoms (GAF-s)	47.5	10.9	29–78
Illness duration (years)	6.7	5.3	0–24
Social functioning (SFS)			
Withdrawal/social engagement	106.1	10.6	90.5–124.5
Interpersonal communication	118.2	16.7	96–145
Independence–performance	108.6	8.6	85.5–127
Independence–competence	117.7	7.1	97.5–131
Recreation	112.9	12.2	93.5–140
Prosocial	113.5	14.7	65–133
Employment/occupation	108.4	9.3	81.5–122.5

PANSS = Positive and Negative Syndrome Scale; GAF = Global Assessment of Functioning; WASI = Wechsler Abbreviated Scale of Intelligence; NART = National Adult Reading Test (Norwegian research version); SFS = Social Functioning Scale

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scores within the normal range, and level of social functioning as expected or better. However, few were competitively employed or able to follow academic studies, either full or part time. According to previous Norwegian research (Birkenaes et al., 2006) these characteristics are fairly representative for younger participants with schizophrenia volunteering to participate in a demanding study such as ours.

Measures of Neurocognition

A comprehensive neuropsychological test battery was administered. Test instruments for the TOP battery was selected prior to the MATRICS initiative, but include measures from mainly the same neurocognitive domains: Digit Symbol (WAIS-III, Wechsler, 1997), Semantic Fluency (D-KEFS, Delis et al., 2001), and Grooved Pegboard (Matthews & Kløve, 1964) from the domain *Speed of Processing*; Continuous Performance Test (CPT-II, Conners & MHS Staff, 2000) from *Attention/Vigilance*; Digit Span Forwards and Backwards (WAIS-III, Wechsler, 1997) and Color-Word Interference Test (D-KEFS, Delis et al., 2001) from *Working Memory* (and *Executive Function*); California Verbal Learning Test (CVLT-II, Delis et al., 2000) from *Verbal Learning*; Continuous Visual Memory Test (CVMT, Trahan & Larrabee, 1998) from *Visual learning*; Matrix Reasoning (WASI, Psychological Corporation, 1999) from *Reasoning and Problem Solving*; and Face/Voice Emotion Identification and Discrimination Test (Kerr & Neale, 1993) from *Social Cognition*. The latter measure is our mediating variable and will be described in the next paragraph. Reducing the more than 10 neuropsychological test measures into valid components by factor analysis could not be performed because of the low sample size. Instead we chose to focus on the four measures that were significantly related to social problem-solving: Digit Symbol (Pearson's $r = .55$, $p < .01$), Semantic Fluency (Pearson's $r = .49$, $p < .05$), Inhibition/Switching (Pearson's $r = -.48$, $p < .05$), and CVLT-II, Total List A learning (Pearson's $r = .39$, $p < .05$). The sample performed relatively well on all these measures (see Table 2); within one standard deviation below the normative mean, but slightly below what is expected from their WASI IQ score (107.5). These measures were found suitable for data reduction by principal components analysis (Bartlett's test was significant, $p < .001$, and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.77). All four tests loaded significantly on the first factor, which accounted for 70.3% of the variance. Based on the factor loadings, a z-transformed composite score was computed (see Table 2). The resulting index had good internal consistency (Cronbach's $\alpha = .86$) and constitutes our measure of neurocognition.

Measures of Social Cognition

Emotion perception was selected as the chosen domain within social cognition because of its leading role in schizophrenia research (Kohler & Martin, 2006) and because a Norwegian adaptation of the Face/Voice Emotion Identification and Discrimination Test (Kerr & Neale, 1993) already has been shown sensitive to impaired emotion perception in schizophrenia (Vaskinn et al., 2007). It consists of visual (facial pictures) and auditory (tape-recorded sentences) stimuli where the subject is asked first to identify the expressed emotion from a given set of six alternatives and then to judge whether two presented stimuli carry the same or different emotional messages. These four measures of emotion perception were reduced by principal component factor analyses (Bartlett test was significant, $p < .001$, and the Kaiser-Meyer-Olkin measure = .66) with all four tests loading on one factor that accounted for 57.3% of the variance. A z-transformed composite score was computed from the factor loadings (see Table 2). The resulting emotion perception index had good internal consistency (Cronbach's α = 0.75) and is our measure of social cognition.

Measure of Learning Potential

Learning potential was assessed with a 64-card test-train-test version of the WCST. Thus, the test is administered 3

Table 2. Means and standard deviations for measures of neurocognition and emotion perception in participants with schizophrenia; and factor loads from separate principal component analyses of measures of neurocognition and emotion perception

Variables (measures)	*M* (*SD*)	Range	Factor load
Neurocognition			
Psychomotor speed (Digit Symbol; SS)	7.2 (2.1)	4–14	0.93
Semantic fluency (Animals & Boys' Names; SS)	10.6 (4.3)	3–19	0.87
Executive control (Inhibition/Switching; SS)	8.8 (3.4)	1–15	0.71
Verbal learning (CVLT-II; T-score)	50.2 (10.7)	30–71	0.83
Emotion perception			
Visual emotion identification (maximum 19)	12.9 (2.5)	8–18	0.79
Visual emotion discrimination (maximum 30)	25.4 (2.3)	20–29	0.55
Auditory emotion identification (maximum 21)	16.3 (2.8)	11–21	0.78
Auditory emotion discrimination (maximum 22)	17.5 (2.9)	9–22	0.87

SS = Scaled score
*N = 25 due to missing data

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times (T1, T2, and T3) with instructions described by Green et al. (1992) given during the training administration (T2). The person receives information on the sorting rules ("There are three ways to match the cards: you can match the card by color, by the number of objects on the card, or by shape") and gets continuous feedback during the training. After each correct answer, the person is told why it was right ("That's right, we are matching to color"), and after each wrong answer the alternatives ("That was wrong, so we are not matching to the number of objects, we must be matching to color or shape"). After 10 consecutively correctly sorted cards, the participant is informed of the rule change ("After you get 10 correct in a row, the rule changes; you are no longer matching to color, you must be matching to the number of objects or to the shape"). We calculated gain scores as proposed by Sergi et al. (2005) (i.e., by dividing actual gain by potential gain). The following formula was used: Gain score = (post-training performance–pre-training performance)/(58 − pre-training performance). Sorting 58 cards correctly was considered perfect performance, since six errors are expected because of the maximum six rule-changes that can occur on a 64-card WCST version. The significant differences between T1 performance and T3 performance on the WCST (correct responses; paired samples *t*-test; $t = -3.14$, $p = .04$, $df = 24$) imply that the training intervention was effective and that improvement took place (see Table 3).

Measure of Functional Outcome

Functional outcome was assessed with the Assessment of Interpersonal Problem Solving Skills (AIPSS; Donahoe et al., 1990), a social problem-solving task. In this test, participants are exposed to 13 videotaped social situations of which 10 present a problem where one person prevents another person from reaching a desired goal. The participant is probed for receiving, processing, and sending skills. *Receiving Skills* is based on the person's answer to the question of whether there is an interpersonal problem in the situation and the explanation of what this problem is. *Processing Skills* is the subject's response to what he would do to solve the problem. *Sending Skills* is scored from the participant's role-play with the test administrator, where he is told to solve the situation. The person is evaluated for verbal and nonverbal skills and of how likely it is that he will solve the problem. Percentage correct responses are computed for each of the three AIPSS skills.

Table 3. Performance on the Wisconsin Card Sorting Test in participants with schizophrenia ($N = 25$)

	M	*SD*	Range
WCST			
T1 Correct responses	48.8	8.0	24–57
T2 Correct responses	60.1	2.8	52–64
T3 Correct responses	54.7	6.2	39–64
Gain score	0.38	1.22	−3.00–2.50

The AIPSS has been translated to Swedish with good psychometric properties (Stålberg et al., 2008). We used the Swedish version, but added dubbed-over Norwegian voices. In order to check the reliability of the Norwegian version we had one Swedish expert, who was blind to the subject's group status, rate 10 videotaped recordings and compared the subject's scores with that of the Norwegian administrator (AV). According to the AIPSS manual, two raters are in agreement if their ratings are within 0.5 points of one another. This was the case for 99% of the scored items, whereas the corresponding number for total agreement was 88%. In addition, an intraclass correlation coefficient (Shrout & Fleiss, 1979) was calculated. It corresponded to a value of $ICC_{(3,1)} = 0.96$ ($p < .001$, CI: 0.95–0.96). In this study, we investigate AIPSS *Sending Skills* as functional outcome, where the mean score was 47.1% (SD = 13.3) correct items.

Statistical Analyses

The Statistical Package for the Social Sciences (SPSS for Windows, version 14.0; SPSS Inc., Chicago, IL, USA) was used. The first step when examining mediation consisted of several analyses using Pearson's *r* for bivariate correlations. The associations between social problem-solving and its hypothesized predictor variables; neurocognition, emotion perception, and learning potential, as well as background variables, such as symptom level, demographic information and social functioning were analyzed.

We followed the method described by Baron & Kenny (1986) to determine whether emotion perception and learning potential mediated between neurocognition and social problem-solving. A mediating effect is said to be present if the following three conditions are fulfilled: (1) the independent variable (neurocognition) is related to the mediator (emotion perception or learning potential), (2) the mediator (emotion perception or learning potential) is related to the dependent variable (social problem-solving), and (3) a previously significant relationship between the independent variable (neurocognition) and the dependent variable (social problem-solving) is no longer significant, or at least greatly reduced, when the mediator (emotion perception or learning potential) is controlled.

Specifically, condition one and two were analyzed by computing zero-order correlations (Pearson's *r*) between the investigated set of variables as described in the paragraph above. Condition three was analyzed by three regression analyses. In Model I the predictive power of the independent variable (neurocognition) on the dependent variable (social problem-solving) was investigated. In Model II the mediating effect of emotion perception on the relation between neurocognition and social problem solving was analyzed by conducting a stepwise hierarchical regression analysis. Emotion perception was entered in the first block and neurocognition in the second block. In Model III the same procedure was performed in order to analyze the medi-

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Table 4. Pearson's correlations between clinical and demographic characteristics, social funtioning and social problem-solving skills in participants with schizophrenia

Variables (measures)	AIPSS Sending Skills
Demographics	
Gender	0.42*
Age	−0.36
Education	−0.03
WASI IQ	−0.03
NART errors	−0.15
Clinical characteristics	
Total psychopathology (PANSS–total score)	−0.11
Positive symptoms (PANSS–positive scale)	−0.12
Negative symptoms (PANSS–negative scale)	−0.20
Level of functioning (GAF-f)	0.04
Level of symptoms (GAF-s)	−0.04
Illness duration	−0.22
Social functioning (SFS)	
Withdrawal/social engagement	0.24
Interpersonal communication	0.08
Independence–performance	0.10
Independence–competence	−0.14
Recreation	0.26
Prosocial	−0.10
Employment/occupation	0.24

$^{*}p < .05$

ating effect of learning potential on the relation between neurocognition and social problem-solving. Learning potential was entered in the first block, neurocognition in the second. Standard statistics are reported (R, R^2, adjusted R^2, increase in R^2 (ΔR^2), and significance testing of the model (F-values)), followed by partial r, standardized regression weights (β) and significance testing of each effect (t-tests). Comparing the partial correlations (or standardized regression weights, β) from Model II (and Model III) with those from Model I, the mediating effect of emotion perception (or learning potential) on the effect of neurocognition on social problem-solving, can be shown. A reduction in the correlation (or regression weight) of neurocognition on social problem-solving when controlling for emotion perception (or learning potential), gives an estimate of the size of the mediating effect.

RESULTS

Correlations between AIPSS *Sending Skills* and demographic, clinical and social function variables are presented in Table 4. AIPSS *Sending Skills* was not significantly related to any of the clinical characteristics, nor to any of the self-reported social functioning measures. Among the demographic variables, a significant association with gender and a trendwise association with age were found. Women and younger participants performed better than men and older participants.

Table 5. Pearson's correlations between study variables

	AIPSS	Neurocognition	Emotion perception
Neurocognition	0.57**	—	—
Emotion perception	0.50**	0.67**	—
Learning potential	0.29	0.32	0.31

$^{**}p < .01$

The mediating effect was studied by analyzing whether the three conditions specified earlier were fulfilled. In Table 5 the zero-order correlations between the study variables are shown. Conditions one and two were fulfilled for emotion perception being a mediating variable through its significant relation to both the independent (neurocognition: $r = .67$, $p < .001$) and the dependent variable (social problem-solving, $r = .50$, $p < .001$). Conditions one and two were only partly met for learning potential as a mediator. Neither the relation to the independent (neurocognition, $r = 0.32$, $p = .06$), nor to the dependent variable (social problem-solving, $r = .29$, $p = .06$) were significant. However, because both correlations equaled a medium effect size (Cohen, 1988), and the lack of statistical significance may be explained by the small sample size, we decided not to exclude learning potential in the condition three analyses.

Condition three was examined by three regression analyses (see Table 6). In Model I the previously reported significant relation between neurocognition and social problem solving ($r = .57$) was restated by showing that its effect amounted to 30% explained variance with a standardized regression weight of $\beta = 0.57$. In Model II the effect of emotion perception on social problem-solving was restated in step 1 with 22% explained variance. In step 2, the net effect of neurocognition on social problem-solving when controlling for the mediating variable was shown as a non-significant partial correlation of .37 and standardized regression weight of $\beta = .43$. Both Model I and Model II were highly significant and explained approximately the same amount of variance in social problem-solving (Adjusted R^2: .30 *vs*. .29). In Model II, however, the effect of neurocognition was reduced from a significant ($p = .002$) to an insignificant contribution ($p = .071$). For learning potential the same change did not occur. Whereas both models (I and III) significantly explained approximately the same amount of variance in social problem-solving (Adjusted R^2: .30 *vs*. .27), no major change in the effect of neurocognition on social problem-solving occurred when controlling for the mediating effect of learning potential ($p = .002$ *vs*. $p = .009$).

DISCUSSION

To the best of our knowledge this is the first study to simultaneously investigate the mediating role of both emotion

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Table 6. Regression analyses showing the effect of neurocognition on social problem-solving before and after controlling for the two proposed mediators (emotion perception and learning potential)

	Social problem-solving: AIPSS Sending Skills								
	Explained variance					Partial effects			
	R	R^2	Adj. R^2	ΔR^2	F (*df*)	Partial *r*	β	*t*	*p*
Model I					11.6 (1,24)				
Neurocognition	0.57	0.33	0.297	0.33	$p = 0.002$	0.57	0.57	3.40	0.002
Model II					6.2 (2,23)				
1. Emotion perception	0.50	0.25	0.216	0.25	$p = 0.007$	0.19	0.21	0.91	0.372
2. Neurocognition	0.59	0.35	0.292	0.10		0.37	0.43	1.89	0.071
*Model III**					5.4 (2,22)				
1. Learning potential	0.29	0.08	0.042	0.08	$p = 0.012$	0.13	0.12	0.62	0.537
2. Neurocognition	0.57	0.33	0.269	0.25		0.53	0.53	2.86	0.009

**N* = 25 due to missing data

perception and learning potential between neurocognition and social problem-solving skills in schizophrenia. We found that a neurocognitive factor, based on four neuropsychological tests, predicted the ability to role-play the solution to an interpersonal problem. Thus, our study confirmed that neurocognition is an important contributor to social problem-solving skills, with about 30% of the variance explained. The neuropsychological tests comprising our neurocognitive composite score and the social problem-solving test require similar skills. The need for rapid processing of stimuli and the ability to change strategies depending on the surroundings is involved both in a social role-play situation, as well as in the solving of these neuropsychological tests. If trying to solve a challenging social situation by one approach is not successful, the smart thing to do is to try another. A similar type of flexibility is involved in the successful solving of a set shifting executive test. Our measure of social cognition, a composite score based on four emotion perception measures, also predicted social problem-solving, and neurocognition predicted emotion perception.

The main finding of our study was a weakened association between neurocognition and social problem-solving when emotion perception was controlled for. Although establishing causal effects is difficult in a cross-sectional design, our results imply that emotion perception may be seen as a partial mediator of the relationship between neurocognition and social problem-solving, and that neurocognition has both direct and indirect effects on social problem-solving. Because it appears less likely from a theoretical standpoint that neurocognition is a mediator between emotion perception and social problem-solving, this issue was not studied.

Although we were not able to show that emotion perception eliminated the previously significant relationship between neurocognition and interpersonal skills, which is the formal requirement for total mediation (Baron & Kenny, 1986), our results are in line with the emerging literature on this matter. Several studies have examined this relationship, using different measures and statistical methods. Using methods similar to the one in our study, Addington and colleagues have found that facial affect recognition was a partial mediator between neurocognition and social functioning (quality of life) in psychosis (2006b), and that social perception mediated between neurocognition and interpersonal role-playing skills (2006a). Using path analysis, Brekke et al. (2005) found support for biosocial pathways to functional outcome, that is, the influence of neurocognition on functional outcome (work, social functioning, and independent living) was mostly indirect through emotion perception, social support, and social competence. Using structural equation modeling, Sergi et al. (2006) showed that social perception was a mediator between neurocognition and social functioning, whereas Vauth et al. (2004) found social perception to have a stronger influence on work-related skills than neurocognition had, but social perception could, to a large degree, be explained by neurocognition. Thus, there is growing evidence that social cognition is a mediator between neurocognition and functional outcome. This has led to a search for new clinical interventions, and there are currently several efforts to incorporate training of social cognitive deficits in therapeutic approaches. Combs et al. (2007) recently reported improvement in social cognition and self-reported social relationships in an inpatient sample of individuals diagnosed with schizophrenia spectrum disorders after participation in a social cognitive training program.

For learning potential the picture is somewhat different from that of emotion perception. Contrary to our hypothesis, learning potential did not significantly predict social problem-solving skills and was not shown to mediate the relation between neurocognition and social problem-solving. Earlier studies have found learning potential to predict non-social problem-solving skills (Wiedl, 1999) and readiness for psychosocial rehabilitation (Fiszdon et al., 2006), phenomena that can both be considered as functional outcomes. These outcome measures are less socially demanding

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than performance on a role-play test dealing with problematic interpersonal situations, thus constituting functional outcome of a different nature. Our outcome measure is one of social functioning, and it can be speculated that the reason we did not find learning potential to be related to AIPSS performance, is that it is closer to non-social than to social functional outcome. Measures of non-social functional outcome were not included in the current study, but future studies should look into this. Following the same argument, it is not surprising that emotion perception, a social cognitive measure, showed stronger potential as a mediator, given the social nature of our outcome variable.

The sample showed gender effects for social problem-solving skills. Women performed better than men, an effect that we also found in an earlier study on auditory emotion perception in the same sample (Vaskinn et al., 2007), with females outperforming males. Thus, our results support the finding that schizophrenia strikes harder in men than in women (Leung & Chue, 2000), and future studies should investigate how gender influences the relation between neurocognition and social problem-solving. We found no significant associations between social functioning and social problem-solving, both measures of functional level. This could be because of the fact that these measures differ in terms of scoring procedures. The AIPSS is scored by an expert watching a videotaped role-play, whereas the SFS is a self-report measure. People diagnosed with schizophrenia have poor insight (Aleman et al., 2006), and it is possible that the current sample overrated their own level of social functioning on the SFS.

The participants in our study, mostly outpatients, comprise a reliably diagnosed schizophrenia group with moderate symptom load and normal intellectual functioning. The present group performed slightly better than individuals diagnosed with schizophrenia in most previous studies. The TOP schizophrenia sample ($N = 110$) reported on in a previous study from our group (Vaskinn et al., in press), represents the largest group of people with schizophrenia studied at that time with neurocognitive measures in Norway. Their WASI IQ was 104.6 ($SD = 14.0$), which is not substantially different from the present sample's IQ of 107.5 ($SD = 11.6$). Although it is likely that the more affected individuals refused to partake in a demanding study such as ours, we are lead to believe that acquiring a mean WASI IQ of slightly above 100 is typical for participants diagnosed with schizophrenia of mostly outpatient status volunteering for research. In spite of the normal IQ, we still found that the well-established relation between neurocognition and functional outcome was mediated by emotion perception, albeit not by learning potential. We thus conclude that also in well-functioning participants with schizophrenia emotion perception impacts on how well participants solve social problems. Learning potential seems not to, although it is unclear whether samples with greater memory problems than our group show different associations between neurocognition, learning potential, and functional outcome.

Our study has several limitations. First, our sample is small with reduced statistical power as a result. This may explain the lack of statistical significant associations between learning potential and other measures. The sample size also reduces the number of variables that can be reliably investigated and prevented us from building more complicated regression models. Also, the effect of neurocognition on social problem-solving still approached significance after controlling for emotion perception ($p = .071$), although it was reduced. With a larger sample size, the same effect would be significant, and emotion perception can only be claimed to be a partial mediator. Finally, we have restricted our analyses to AIPSS *Sending skills*, but acknowledge the need to examine other outcome measures.

In conclusion, our study indicates that emotion perception partially mediates the relationship between neurocognition and functional outcome as assessed with a social problem-solving task. Learning potential seems to have less potential as a mediating variable between neurocognition and social aspects of functional outcome.

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REFERENCES

Addington, J. & Addington, D. (1999). Neurocognitive and social functioning in schizophrenia. *Schizophrenia Bulletin*, *25*, 173–182.

Addington, J., Saeedi, H., & Addington, D. (2006a). Influence of social perception and social knowledge on cognitive and social functioning in early psychosis. *British Journal of Psychiatry*, *189*, 373–378.

Addington, J., Saeedi, H., & Addington, D. (2006b). Facial affect recognition: A mediator between cognitive and social functioning in psychosis? *Schizophrenia Research*, *32*, 171–181.

Aleman, A., Agrawal, N., Morgan, K.D., & David, A.S. (2006). Insight in psychosis and neuropsychological function. *British Journal of Psychiatry*, *189*, 204–212.

Baron, R.M. & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.

Birchwood, M., Smith, J., Cochrane, R., Wetton, S., & Copestake, S. (1990). The social functioning scale: The development and validation of a new scale of social adjustment for use in family intervention programs with schizophrenic patients. *British Journal of Psychiatry*, *157*, 853–859.

Birkenaes, A.B., Søgaard, A.J., Engh, J.A., Jonsdottir, H., Ringen, P.A., Vaskinn, A., Friis, S., Sundet, K., Opjordsmoen, S.,

& Andreassen, O.A. (2006). Sociodemographic characteristics and cardiovascular risk factors in patients with severe mental disorders compared with the general population. *Journal of Clinical Psychiatry*, *67*, 425–433.

Brekke, J., Kay, D.D., Lee, K.S., & Green, M.F. (2005). Biosocial pathways to functional outcome in schizophrenia. *Schizophrenia Research*, *80*, 213–225.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Combs, D.R., Adams, S.D., Penn, D.L., Roberts, D., Tiegreen, J., & Stern, P. (2007). Social cognition and interaction training (SCIT) for inpatients with schizophrenia spectrum disorders: Preliminary findings. *Schizophrenia Research*, *91*, 112–116.

Conners, C.K. & MHS Staff (2000). *Conners' Continuous Performance Test (CPT II). Computer program for Windows. Technical guide and software manual*. North Tonawanda, NY: Multi-Health Systems Inc.

Couture, S.M., Penn, D.L., & Roberts, D.L. (2006). The functional significance of social cognition in schizophrenia: A review. *Schizophrenia Bulletin*, *32*, S44–S63.

Delis, D., Kaplan, E., & Kramer, J.K. (2001). *Delis-Kaplan Executive Function System. Examiner's Manual*. San Antonio, TX: The Psychological Corporation.

Delis, D., Kramer, J.H., Kaplan, E., & Ober, B.A. (2000). *CVLT-II. California Verbal Learning Test. Manual. Second Edition. Adult Version*. San Antonio, TX: The Psychological Corporation.

Donahoe, C.P., Carter, M.J., Bloem, W.D., Hirsch, G.L., Laasi, N., & Wallace, C.J. (1990). Assessment of interpersonal problem-solving skills. *Psychiatry*, *53*, 329–339.

Elvevag, B. & Goldberg, T.E. (2000). Cognitive impairment in schizophrenia is the core of the disorder. *Critical Reviews in Neurobiology*, *14*, 1–21.

First, M., Spitzer, R., Gobbon, M., & Williams, J. (1995). *Structured clinical interview for DSM-IV Axis I disorders, patient edition (SCID-P), version 2*. New York: New York State Psychiatric Institute, Biometrics Research.

Fiszdon, J.M., McClough, J.F., Silverstein, S.M., Bell, M.D., Jaramillo, J.R., & Smith, T.E. (2006). Learning potential as a predictor of readiness for psychosocial rehabilitation in schizophrenia. *Psychiatry Research*, *143*, 159–166.

Green, M.F. (1996). What are the functional consequences of neurocognitive deficits in schizophrenia? *American Journal of Psychiatry*, *153*, 321–330.

Green, M.F., Kern, R.S., Braff, D.L., & Mintz, J. (2000). Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the "right stuff"? *Schizophrenia Bulletin*, *26*, 119–136.

Green, M.F., Nuechterlein, K.H., Gold, J.M., Barch, D.M., Cohen, J., Essock, S., Fenton, W.S, Frese, F., Goldberg, T.E., & Heaton, R.K. (2004). Approaching a consensus cognitive battery for clinical trials in schizophrenia: The NIMH-MATRICS conference to select cognitive domains and test criteria. *Biological Psychiatry*, *56*, 301–307.

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. *Schizophrenia Bulletin*, *31*, 882–887.

Green, M.F., Satz, P., Ganzell, L.S., & Vaclav, J.F. (1992). Wisconsin Card Sorting Test performance in schizophrenia: Remediation of a stubborn deficit. *American Journal of Psychiatry*, *149*, 62–67.

Hamers, J.H.M. & Resing, W.C.M. (1993). Learning potential assessment. In J.H.M. Hamers, K. Sijtsma, & A.J.J.M. Ruijssenaars (Eds.). *Learning Potential Assessment. Theoretical, methodological and practical issues*. Amsterdam: Swets & Zeitlinger.

Heaton, R.K., Chelune, G.J., Talley, J., Kay, G.G., & Curtiss, G. (1993). *Wisconsin Card Sorting Test Manual*. Odessa, FL: Psychological Assessment Resources.

Heinrichs, R.W. & Zakzanis, K.K. (1998). Neurocognitive deficit in schizophrenia: A quantitative review of the evidence. *Neuropsychology*, *12*, 426–445.

Kay, S.R., Fiszbein, A., & Opler, L.A. (1987). The Positive and Negative Syndrome Scale (PANSS) for Schizophrenia. *Schizophrenia Bulletin*, *13*, 261–276.

Kerr, S.L. & Neale, J.M. (1993). Emotion perception in schizophrenia—specific deficit or further evidence of generalized poor performance. *Journal of Abnormal Psychology*, *102*, 312–318.

Kohler, C.G. & Brennan, A.R. (2004). Recognition of facial emotions in schizophrenia. *Current Opinion in Psychiatry*, *17*, 81–86.

Kohler, C.G. & Martin, E.A. (2006). Emotional processing in schizophrenia. *Cognitive Neuropsychiatry*, *11*, 250–271.

Leung, A. & Chue, P. (2000). Sex differences in schizophrenia: A review of the literature. *Acta Psychiatrica Scandinavica*, *101*, 3–38.

Mandal, M.K., Pandey, R., & Prasad, A.B. (1998). Facial expressions of emotions and schizophrenia: A review. *Schizophrenia Bulletin*, *24*, 399–412.

Matthews, C.G. & Kløve, H. (1964). *Instruction manual for the Adult Neuropsychology Test Battery*. Madison, WI: University of Wisconsin Medical School.

Pedersen, G., Hagtvet, K.A., & Karterud, S. (2007). Generalizability studies of the Global Assessment of Functioning-Split version. *Comprehensive Psychiatry*, *48*, 88–94.

Pinkham, A.E. & Penn, D.L. (2006). Neurocognitive and social cognitive predictors of interpersonal skill in schizophrenia. *Psychiatry Research*, *143*, 167–178.

Psychological Corporation (1999). *WASI. Wechsler Abbreviated Scale of Intelligence Manual*. San Antonio, TX: The Psychological Corporation.

Rempfer, M.V., Hamera, E.K., Brown, C.E., & Cromwell, R.L. (2003). The relations between cognition and the independent living skill of shopping in people with schizophrenia. *Psychiatry Research*, *117*, 103–112.

Sergi, M.J., Kern, R.S., Mintz, J., & Green, M.F. (2005). Learning potential and the prediction of work skill acquisition in schizophrenia. *Schizophrenia Bulletin*, *31*, 67–72.

Sergi, M.J., Rassovsky, Y., Nuechterlein, K., & Green, M.F. (2006). Social perception as a mediator of the influence of early visual processing on functional status in schizophrenia. *American Journal of Psychiatry*, *163*, 448–454.

Shrout, P.E. & Fleiss, J.L. (1979). Intraclass correlations—uses in assessing rater reliability. *Psychological Bulletin*, *86*, 420–428.

Snitz, B.E., MacDonald, A.W., & Carter, C.S. (2006). Cognitive deficits in unaffected first-degree relatives of schizophrenia patients: A meta-analytic review of putative endophenotypes. *Schizophrenia Bulletin*, *32*, 179–194.

Stålberg, G., Lichtenstein, P., Sandin, S., & Hultman, C.M. (2008). Video-based assessment of interpersonal problem-solving skills in patients with schizophrenia, their siblings and non-psychiatric controls. *Scandinavian Journal of Psychology*, *49*, 77–82.

Trahan, D.E. & Larrabee, G.J. (1998). *Continuous Visual Memory Test. Professional Manual*. Odessa, Florida: Psychological Assessment Resources.

Vaskinn, A. & Sundet, K. (2001). Estimating premorbid IQ: A Norwegian version of National Adult Reading Test. (Article in Norwegian, abstract in English). *Journal of the Norwegian Psychological Association*, *38*, 1133–1140.

Vaskinn, A., Sundet, K., Friis, S., Simonsen, C., Birkenæs, A.B., Engh, J.A., Jónsdóttir, H., Ringen, P.A., Opjordsmoen, S., & Andreassen, O.A. (2007). The effect of gender on emotion perception in schizophrenia and bipolar disorder. *Acta Psychiatrica Scandinavica*, *116*, 263–270.

Vaskinn, A., Sundet, K., Friis, S., Ueland, T., Simonsen, C., Birkenaes, A.B., Engh, J.A., Opjordsmoen, S., & Andreassen, O.A. (in press). Can learning potential in schizophrenia be assessed with the standard CVLT-II? An exploratory study. *Scandinavian Journal of Psychology*.

Vauth, R., Rüsch, N., Wirtz, M., & Corrigan, P.W. (2004). Does social cognition influence the relation between neurocognitive deficits and vocational functioning in schizophrenia? *Psychiatry Research*, *128*, 155–165.

Velligan, D.I., Bow-Thomas, C.C., Mahurin, R.K., Miller, A.L., & Halgunseth, L.C. (2000). Do specific neurocognitive deficits predict specific domains of community function in schizophrenia? *Journal of Nervous and Mental Disease*, *188*, 518–524.

Wechsler, D. (1997). *WAIS-III Manual*. San Antonio, TX: The Psychological Corporation.

Wiedl, K.H. (1999). Rehab Rounds: Cognitive modifiability as a measure of readiness for rehabilitation. *Psychiatric Services*, *50*, 1411–1419.

Wilk, C.M., Gold, J.M., McMahon, R.P., Humber, K., Iannone, V.N., & Buchanan, R.W. (2005). No, it is not possible to be schizophrenic yet neuropsychologically normal. *Neuropsychology*, *19*, 778–786.