THEORY OF MIND - NOT EMOTION RECOGNITION - MEDIATES THE RELATIONSHIP BETWEEN EXECUTIVE FUNCTIONS AND SOCIAL FUNCTIONING IN PATIENTS WITH SCHIZOPHRENIA

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SUMMARY

Background: *Dysfunction of social-cognitive abilities is one of the hallmark features of schizophrenia and is associated with neurocognition and social functioning. The Green and Nuechterlein model proposed that social cognition mediates the relationship between neurocognition and functional outcome. We tested this hypothesis in schizophrenia patients in the everyday clinical setting.*

Subjects and methods: *Social cognition, executive function and social functioning were assessed in a group of 43 patients with schizophrenia or schizoaffective disorder using a range of measures.*

Results: *Theory of mind was associated with executive functions and social functioning. Results of our mediation analysis suggested that the relationship between executive functions and social functioning was mediated by theory of mind. No relationships between emotion recognition and the domains of social functioning were found.*

Conclusions: *In line with prior research, zero-order associations were found between theory of mind and social functioning. Theory of mind was a mediator of the relationships between neurocognition and social functioning. Our results suggest that theory of mind should be a potential target of interventions to improve social functioning.*

Key words: *social cognition - theory of mind - emotion recognition – neurocognition - social functioning*

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INTRODUCTION

Schizophrenia is considered to be one of the most disabling disorders worldwide (Rössler et al. 2005). Although the clinical manifestations of schizophrenia are extremely diverse (Tandon et al. 2013), functional impairment is typical for almost all patients (Lay et al. 2000, Wiersma et al. 2000). Schizophrenia is also associated with lower quality of life when compare to people with physical disabilities (Palijan et al. 2017). Severe impairment of neurocognitive domains such as memory, attention, executive functions, and processing speed are severe and prevalent (Fioravanti et al. 2012, Heinrichs & Zakzanis 1998, Palmer et al. 1997, Reichenberg et al. 2009) and are found in most patients from very early stages of the disorder onwards, or even before the diagnosis has been established (Mesholam-Gately et al. 2009). An association between functional and neurocognitive impairment has been shown in cross-sectional (Green et al. 2000) and longitudinal studies Green et al. 2004). Neurocognitive deficits are considered a core feature of schizophrenia and are an important predictor of everyday psychosocial functioning of patients (Green et al. 2000).

The bulk of recent research has supported the theory that social cognitive deficits also play an important role as a predictor of social functioning (Couture et al. 2006, Fett et al. 2011). Social cognition is defined as a set of mental operations used for the processing of social information. These operations enable an individual to accurately perceive and understand inner and other dispositions and intentions (Brothers 2002). Although processing of socially relevant information relies on intact neurocognitive capabilities (such as executive functions, memory, and attention), recent empirical evidence show that social cognition and neurocognition are distinct domains (Mehta et al. 2013). Social cognition has traditionally been divided into four subdomains: theory of mind, emotion processing, social perception and attributional style (Green et al. 2008). Metaanalyses confirmed the existence of severe dysfunction in patients with schizophrenia in the domains of theory of mind (Bora et al. 2009, Sprong et al. 2007), emotion processing (Kohler et al. 2010), and social perception (Savla et al. 2013). Detailed empirical evidence for substantial differences in attributional styles has not yet been established (Savla et al. 2013). Impairment of social cognition in schizophrenia is related mainly to negative and disorganisation symptom clusters (Ventura et al. 2013).

Disturbance of social cognition in schizophrenia might be seen as the transformation and evolution of Bleuler's concept of autism, but it is not a specific scenario for schizophrenia, as it is applicable to different disorders such as child autism (Sasson et al. 2011), personality disorders (Beeney et al. 2015, Herpertz & Bertsch 2014), and bipolar disorder (Bora et al. 2016).

The importance of social cognition in schizophrenia research has been underlined by the recent NIMH SCOPE project (Pinkham et al. 2014, 2016), the primary aim of which was to improve the assessment of social cognition as one of the treatment outcomes in clinical trials in schizophrenia.

Green's model (Green & Nuechterlein 1999), in which social cognition mediates the relationship between neurocognition and social functioning, is supported by much evidence (Schmidt et al. 2011), also from the early stages of schizophrenia (Addington et al. 2006). If social cognition mediates this relationship, it should be an important target of interventions. A number of specialized training programs for remediation of social-cognitive deficits have been developed over the past few years (Combs et al. 2007, Moritz et al. 2013).

The aim of the present study was to investigate whether the theory of mind and emotion recognition mediate relationships between neurocognition and social functioning in patients with schizophrenia, with a focus on executive function.

SUBJECTS AND METHODS

Participants

Patients with a diagnosis of schizophrenia or schizoaffective disorder in a stable phase of treatment were enrolled. The diagnosis was based on ICD-10 criteria. Patients were assessed either before discharge from inpatient treatment or during attendance at our department's day-care centre. Patients with other types of psychotic disorder (organic, substance-induced, psychoreactive) and those unable or not willing to sign the informed consent form were excluded from the study. The study was approved by the institutional ethics committee of the University Hospital Bratislava, Slovakia.

Descriptive statistics for demographic variables and clinical characteristics are presented in Table 1. The mean age of patients was 38.2 years (SD 9.5). The sample consisted of 31 (72%) patients with schizophrenia and 12 (28%) patients with schizoaffective disorder. The median duration of illness was 8 years and the median of number of episodes was five.

Measures and Procedures

Clinical Global Impression – Schizophrenia (CGI-SCH)

The CGI-SCH (Haro et al. 2003) is a short rating scale based on the clinical impression during the week before assessment. The severity of positive, negative, cognitive and depressive symptoms, and overall severity, are measured on a seven-point Likert scale from (1) 'normal, not ill' to (7) 'among the most severely ill'. Only the severity subscale was used in this study and the questionnaire was administered by a trained psychiatrist.

Table 1. Demographic and clinical characteristics

Age (years, mean ± SD)	38.16 (9.45)
Sex (N, %)	
Male	26 (60%)
Female	17 (40%)
Education (N, %)	
Elementary	3 (7%)
High school	6 (14%)
High school with leaving examination	17 (40%)
University/College	17 (40%)
Partner status (N, %)	
Single	33 (77%)
Married	5 (12%)
Divorced	5 (12%)
Employment (N, %)	
Student	2 (5%)
Maternity leave	1 (2%)
Employed	7 (16%)
Unemployed	9 (21%)
Invalidity pension	24 (56%)
Diagnosis (N, %)	
Schizophrenia	31 (72%)
Schizoaffective disorder	12 (28%)
Duration of illness (mean ± SD)	11.33 (SD 9.12), Median 8
Number of hospitalizations (mean±SD)	5.44 (SD 4.12), Median 5
CGI-SCH (mean ± SD)	
Positive	2.79 (SD 1.46)
Negative	2.95 (SD 1.11)
Depressive	2.30 (SD 1.04)
Cognitive	2.79 (SD 1.06)
Severity	3.30 (SD 1.01)

CGI-SCH – Clinical Global Impression – Schizophrenia;
N – Frequency;   SD – Standard deviation

Hinting Task

This task consists of ten short vignettes (Corcoran et al. 1995). It measures the ability of subjects to infer the real intentions behind statements using indirect speech. A short story is read to participants and then questions about the intentions of the actor are asked. If the participant gives an incorrect answer, the next hint is presented. Each answer earns 0, 1 or 2 points, with a maximum score of 20. We used the raw score as the outcome for this task. Higher score on indicate better performance.

Emotion Recognition Task

This task comprised 48 stimuli. Eight actors (four male and four female) expressed six emotions: happiness, sadness, anger, disgust, fear, and surprise. The stimuli were selected from the Radbound Faces Database (Langner et al. 2010). The photographs were in color and taken full face on. The photographs were presented in a fixed random order on a 17-inch screen. Emotion labels were printed for participants on sheets of paper. No feedback on the correctness of answers was given, and the duration of the task was not limited. The percentage of correct answers was the outcome measure.

Computerized Wisconsin Card Sorting Test

The PEBL (Mueller & Piper 2014) computerized version of Wisconsin Card Sorting Test (WCST) was used (Fox et al. 2013). This task is well known for its ability to measure frontal lobe dysfunction and problem-solving abilities (Lezak et al. 2012). Only one pack of cards was used, so that participants sorted only 64 cards. The main outcome measures were the number of categories achieved and the number of perseverative errors.

Personal and Social Performance Scale

This scale measures four domains of social functioning, Social Activities, Social Relationships, Self-Care and Disturbing and Aggressive Behavior (Morosini et al. 2000). The total score is calculated based on the subscale scores. The total score (0–100) and domain scores were used in the statistical analyses. A higher total score indicates better functioning; lower domain scores indicate better functioning.

Statistical Analysis

R software was used for the data analysis. Data distributions were screened for normality violations. Due to the ordinal character of the data and some violations of normality, non-parametric rank correlation was used to assess relationships between variables.

The primary aim of the mediation model was to evaluate the magnitude of the indirect relationship while controlling for the direct effect of executive functions on social functioning. The lavaan (Rosseel et al. 2014) and MBESS packages (Kelley et al. 2016) were used for mediation analysis. Bootstrapped standard errors were calculated for path coefficients. The indirect effect was also tested using the bootstrapping procedure on 10,000 samples. The completely standardized indirect effect (Preacher & Kelley 2011) was used as a measure of effect size. Bootstrapping was used due to recent evidence favorizing this approach for mediation analysis (Preacher & Hayes 2008).

The score on the PSP scale (Domain score or Global score) was the dependent variable in the model, and the number of categories achieved in the WCST was the independent variable. The Hinting Task was included in the model as mediator.

RESULTS

Correlation analysis

Means, medians and standard deviations of variables are presented in Table 2. Zero-order correlations between variables are displayed in Table 3. We observed statistically significant negative correlations between theory of mind and all domains of social cognition (rs from -0.328 to -0.482). Emotion recognition was not associated with social functioning, but was moderately associated with categories achieved in the WCST (rs=0.403, p=0.007) and number of perseverative errors (rs=-0.523, p<0.001). The number of categories achieved in the WCST was associated with the overall PSP score and with the domain Social Activities. Strong intercorrelations between the PSP subscales were found.

Associations were also found between theory of mind and severity of cognitive symptoms (rs=-0.444. p=0.003) and overall severity (rs=-0.350. p=0.022). Emotion recognition was not significantly associated with symptoms domains (p>0.05). Better executive functions were associated with lower severity of positive (rs=-0.331. p=0.30) and depressive symptoms (rs=-0.308. p=0.044). Social functioning domains were more strongly associated with symptom domains than global level of functioning. Correlations are presented in the Table 4.

Table 2. Descriptive statistics

	M	SD	Md
Social Activities	2.42	0.96	2
Social Relationships	2.40	1.00	2
Self-Care	2.02	0.99	2
Disturbing and aggressive behavior	2.21	1.19	2
PSP – Global	57.70	16.27	63
WCST – Categories	1.70	1.44	1
WCST – Perseverative errors	15.60	8.76	13
Hinting Task	15.44	3.65	17
Emotion Recognition	73.93%	10.32%	75%

M – Mean; SD – Standards deviation; Md – Median; % - percentages of correct answers; PSP – Personal and Social Performance Scale; WCST – Wisconsin Card Sorting Test

Table 3. Correlation matrix between social cognition, neurocognition and functional outcome

	1	2	3	4	5	6	7	8	9
Social Activities	-								
Social Relationships	0.689***	-							
Self-Care	0.708***	0.724***	-						
Disturbing and Aggressive Behavior	0.291	0.382*	0.318*	-					
PSP - Global	-0.663***	-0.729***	-0.589***	-0.677***	-				
WCST - Categories	-0.332*	-0.243	-0.177	-0.192	0.306*	-			
WCST - Perseverative errors	0.293	0.256	0.159	0.226	-0.434**	-0.631***	-		
Hinting Task	-0.406**	-0.405**	-0.482**	-0.328*	0.419**	0.372*	-0.279	-	
Emotion Recognition	-0.071	-0.115	-0.016	0.001	0.128	0.403**	-0.523***	0.280	-

*p<0.05; **p<0.01, ***p<0.001; PSP – Personal and Social Performance Scale; WCST – Wisconsin Card Sorting Test

Table 4. Summarized zero-order correlation between symptom domains and other variables

	Social Activities	Social Relationships	Self-Care	Disturbing and aggressive behavior	PSP - Global	WCST – Categories	WCST – Perseverative errors	Hinting Task	Emotion Recognition
Positive	0.403**	0.188	0.289	-0.076	-0.123	-0.331*	0.226	-0.165	-0.123
Negative	0.291	0.150	0.205	-0.004	-0.122	-0.041	0.041	-0.174	0.118
Depressive	0.074	0.186	0.314*	-0.028	0.075	0.198	-0.308*	0.055	0.292
Cognitive	0.340*	0.135	0.249	0.139	-0.181	-0.157	0.111	-0.444**	-0.269
Severity	0.401**	0.261	0.428**	0.198	-0.291	-0.187	0.196	-0.350*	-0.115

*p<0.05; **p<0.01, ***p<0.001

Mediation analysis

Based on the correlation analysis, the PSP global score, subscale Social Activities, Hinting Task and Categories achieved in WCST were selected for further mediation analysis (see Figure 1). The Mediation model for emotion recognition was not tested due to the absence of associations with social functioning.
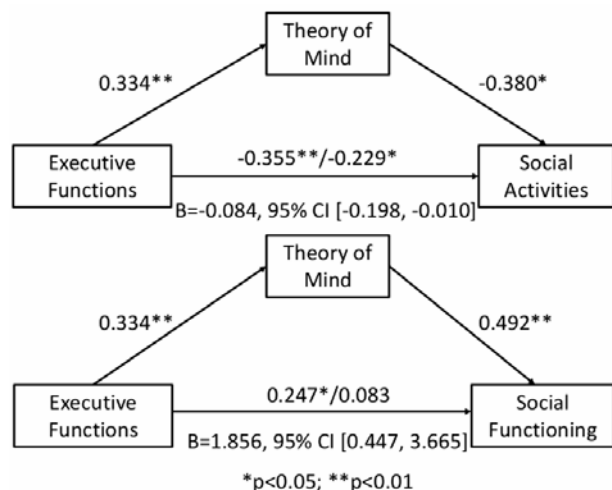
Figure 1. Mediation analysis
Upper mediation model indicates that theory of mind (measured by Hinting Task) mediates relationships between neurocognition (WCST – categories achieved) and social functioning (Personal and Social Performance Scale – subscale Social Activities). Lower mediation model indicates that theory of mind (measured by Hinting Task) mediates relationships between neurocognition (WCST – categories achieved) and global social functioning (Personal and Social Performance Scale – Overall score).

The results showed that executive functions are a significant predictor of theory of mind (β=0.334, p=0.004) and that theory of mind significantly predicted social activities (β=-0.380, p=0.012). Executive functions were a significant predictor of social activities (β=-0.355, p=0.006). After controlling for the mediator, executive functions were still a significant predictor (β=-0.229, p=0.05). The significance of the indirect effect was tested with a bootstrapping method on 10,000 samples. These results indicated a significant indirect effect (B=-0.084, 95% CI (-0.198, -0.010)). The standardized indirect effect was ES=-0.126, 95% CI (-0.262, -0.018).

In the second model, the global score in the PSP scale was selected as a dependent variable. The results showed that executive functions are a significant predictor of theory of mind (β=0.334, p=0.005) and that theory of mind significantly predicted social functioning (β=0.492, p=0.001). Executive functions were a significant predictor of social functioning (β=0.247, p=0.020). After controlling for the mediator, executive functions were no longer a significant predictor (β=0.083, p=0.453). The indirect effect was significant (B=1.856, 95% CI (0.447, 3.665)). The standardized indirect effect was ES=0.164 95% CI (0.041, 0.302).

DISCUSSION

In this study, we tested the hypothesis that social cognition - especially theory of mind and emotion recognition - mediates the relationship between executive functions and social functioning in patients with schizophrenia. Executive functions such as problem-solving skills and mental flexibility are important in guiding and modifying behavior during interpersonal interactions. Structural (Sawa & Snyder 2002, Wright et al. 2000) and functional changes (Davidson & Heinrichs 2003, Hill et al. 2004) in the frontal cortex which underlie this dysfunction are well documented in patients with schizophrenia. An association between executive functions and social functioning has been demonstrated (Green et al. 2000). Our results did not support associations between emotion recognition and social functioning. This result is contrary to metaanalyses recently conducted by Fett et al. (2011) which showed a moderate relationship between community functioning and emotion perception and processing. Emotion recognition stimulated by static facial expressions only partially reflects the dynamics of the real-world processing of social information, and the use of a more ecologically valid task might lead to different outcomes.

Recent evidence has highlighted the importance of using information from humans in the recognition of identity and perception of emotions (de Gelder 2006; Yovel & O'Toole 2016). Our results indicated significant associations with social functioning only for theory of mind. Particularly theory of mind is considered to be the strongest predictor of everyday functioning in the community (Fett et al. 2011). In our research, all relevant

domains of everyday functioning were associated with the ability to infer intentions from indirect utterances. Understanding intentions seems to be a more important aspect of functioning than emotion recognition. The Hinting Task apparently reflects higher-order social cognitive functions. Correct identification of expressed emotion may not be sufficient for successful social interaction, especially in situations where the meaning of this emotion is falsely interpreted due to biases in the attributional style or theory of mind deficit (Couture et al. 2006).

Recent evidence from the SCOPE project (Pinkham et al. 2016) has also supported the importance of theory of mind, measured by the Hinting Task and emotion recognition. The Bell-Lysaker emotion-recognition test (BLERT) (Bryson et al. 1997) is based on the presentation of dynamic video-clips including facial, vocal and upper body movement cues. It has been found, together with the Hinting Task, as the most important predictor of social functioning, more important even than neurocognition. It resembles the everyday situation much more than the static facial stimuli used in our study.

In line with recent evidence, we found a relationship between neurocognition and functional outcome. In an empirical review, Schmidt et al. (2011) concluded that a medium standardized effect size for mediation was ES=0.20, which is higher than we found. Based on our results, treating the social cognitive deficit might improve social functioning, as was demonstrated by Kurtz & Richardson (2012). Projects aiming to enhance social cognition by pharmacological treatments are under way at present. The findings of a small randomized clinical trial with application of oxytocin to enhance effectivity of social cognitive training have been published (Davis et al. 2014).

Limitations

The absence of relationships between emotion recognition and social functioning can be at least partially explained by lack of statistical power due to a small sample size. Future studies with longitudinal design are needed to test the temporal order of relationships, especially the role of theory of mind in mediation. The absence of a more detailed scale for symptom severity assessment limited the interpretation of our results. Strauss et al. (Strauss et al. 2013) found that patients with predominant avolition- apathy symptoms have a poorer functional outcome than patients with diminished expression. Only one measure of neurocognitive abilities was used in our study. Besides executive functions, other cognitive domains might significantly predict social functioning. Relationships between neurocognition and functional outcomes can be either direct (Green 1996) or mediated through functional capacity (Bowie et al. 2006, Galderisi et al. 2014). Also, other non-cognitive variables such as defeatist beliefs predict patient functioning (Grant & Beck 2009).

CONCLUSIONS

Despite its limitations, our study clearly supports the importance of theory of mind as a key mediator in the relationship between neurocognition and social functioning. Future research must focus on different mediation pathways and include more variables in the models tested. Beside interventions targeting symptoms and cognitive abilities, the complex treatment of patients with schizophrenia should include also remediation of social-cognitive domains to improve psychosocial functioning.

Contribution of individual authors:

Michal Hajdúk, Viera Kořínková, Anton Heretik & Ján Pečeňák designed the study. Michal Hajdúk, Dana Krajčovičová & Miroslava Zimányiová participated on the data collection. Michal Hajdúk conducted initial analysis and wrote initial draft. All authors critically reviewed the paper. All authors contributed to and have approved the final manuscript.

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