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Structural Neurobiological Correlates of Mayer-Salovey-Caruso Emotional Intelligence Test Performance in Early Course Schizophrenia

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Abstract

Objective—The Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) is a key measure of social cognition in schizophrenia that has good psychometric properties and is recommended by the MATRICS committee. As a way to further investigate the validity of the MSCEIT, this study sought to examine the neurobiological correlates of MSCEIT performance in patients with early course schizophrenia.

Methods—A total of 51 patients diagnosed with early course, stabilized schizophrenia or schizoaffective disorder completed structural magnetic resonance imaging (MRI) scans and the MSCEIT. Investigation of the associations between MSCEIT performance and gray matter morphology was examined by conducting voxel-based morphometry (VBM) analyses across hypothesized social-cognitive regions of interest using automated anatomical labeling in Statistical Parametric Mapping Software, version 5 (SPM5). All VBM analyses utilized general linear models examining gray matter density partitioned images, adjusting for demographic and illness-related confounds. VBM results were then followed up with confirmatory volumetric analyses.

Results—Patients with poorer overall and Facilitating, Understanding, and Managing Emotions subscale performances on the MSCEIT showed significantly reduced gray matter density in the left parahippocampal gyrus. Additionally, attenuated performance on the Facilitating and Managing Emotions subscales was significantly associated with reduced right posterior cingulate gray matter density. All associations observed between MSCEIT performance and gray matter density were supported with confirmatory gray matter volumetric analyses, with the exception of the association between the right posterior cingulate and the facilitation of emotions.

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Contributors

Ms. Jessica A. Wojtalik and Dr. Shaun M. Eack conducted the analyses and wrote the initial draft of this manuscript. Dr. Matcheri S. Keshavan provided critical feedback and revisions. All authors contributed to and have approved the final manuscript.

Conflict of Interest

In the past year, Dr. Shaun M. Eack has received consulting fees from Abbott Laboratories and Dr. Matcheri S. Keshavan has received Glaxo Smith Kline and Sunovion grants for studies of cognitive remediation.

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Conclusion—These findings provide additional evidence for the MSCEIT as a valid social-cognitive measure by elucidating its correlates with neurobiological structures commonly implicated in emotion processing. These findings provide additional biological evidence supporting the use of the MSCEIT in cognitive enhancing clinical trials in schizophrenia.

Keywords

Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT); social cognition; structural MRI; neurobiological correlates; schizophrenia

1. Introduction

Cognitive impairment in schizophrenia is now considered a central characteristic of the disorder (Heinrichs and Zakzanis, 1998; Keefe and Fenton, 2007), with recent evidence recognizing the particularly important contribution of social-cognitive impairments on functional outcomes (Couture et al., 2006; Green and Horan, 2010; Vauth et al., 2004). Despite recognition of the centrality of social-cognitive deficits in schizophrenia, the availability of tools for the assessment of social cognition in the disorder has been limited (Green et al., 2004). The Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT; Mayer et al., 2003) has emerged as a promising measure of social cognition in schizophrenia. Indeed, the National Institute of Mental Health's (NIMH) committee on Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) has recommended that the MSCEIT be the key measure for assessing social-cognitive outcomes in clinical trials of cognitive enhancers in schizophrenia (Green et al., 2005). Additionally, previous investigations of the MSCEIT have demonstrated strong psychometric properties for assessing the emotional components of social cognition in the disorder (Eack et al., 2010; Kee et al., 2009; Nuechterlein et al., 2008), and has also documented the sensitivity of the MSCEIT for detecting social-cognitive treatment effects (Eack et al., 2007), underscoring its potential utility for use in clinical trials.

A critical component to the continued validation of the MSCEIT is the identification of the neural underpinnings that subserve performance on the test. Indeed, a myriad of evidence has indicated an increasingly clear neurobiological basis for social cognition and emotion processing in healthy control samples (Adolphs, 2001; Amodio and Frith, 2006; Lieberman, 2007; Maddock et al., 2003; Saxe, 2006), with schizophrenia patients displaying impairments in similar brain regions. Such structural and functional abnormalities include regions of the prefrontal cortex (e.g., orbitofrontal cortex and ventrolateral prefrontal cortex), the insula, the medial-temporal lobe (e.g., amygdala, hippocampus, parahippocampal gyrus, and fusiform gyrus), the cuneus, and the cingulate gyrus (Benedetti et al., 2009; Pinkham et al., 2008; Pinkham et al., 2003; Yamada et al., 2007). Therefore, the success of the MSCEIT to detect social-cognitive impairments in schizophrenia could depend on associations between poorer performance on the measure and increased structural abnormalities in these social-cognitive brain regions.

To our knowledge, no study has identified the neurobiological correlates of MSCEIT performance or its association with structural deficits in schizophrenia using brain morphometry. Hooker et al. (2012) observed a post social-cognitive training increase in postcentral gyrus functioning using fMRI that predicted improved MSCEIT performance on the Perceiving Emotions subscale. Deficits in management of emotions measured by the MSCEIT have also been linked to 5-HT_{2A} gene variation in schizophrenia patients (Lo et al., 2010). In an effort to further investigate the validity of the MSCEIT for assessing social cognition in schizophrenia, we examined the neural correlates between performance on the MSCEIT and gray matter morphology in a sample of patients in the early course of the

disorder. We hypothesized that patients with greater performance impairments on the MSCEIT would have lower gray matter densities in fronto-temporal brain regions previously associated with social-cognitive deficits in schizophrenia (Pinkham et al., 2003; Yamada et al., 2007).

2. Methods

2.1. Participants

Participation in this study included 51 stabilized, early-course outpatients with a diagnosis of schizophrenia ($n=34$) or schizoaffective disorder ($n=17$) confirmed by the Structural Clinical Interview for the DSM-IV (First, Spitzer, Gibbon, & Williams, 2002). The early course of schizophrenia was defined by the onset of first, untreated psychotic symptoms within the past 8 years. Eligibility criteria for the study included a diagnosis of schizophrenia, schizoaffective disorder, or schizophreniform disorder; emergence of first psychotic symptoms within the past 8 years (including duration of untreated illness); an IQ 80; a two month duration free of drug and alcohol abuse prior to study enrollment; and social and cognitive disability assessed using the Cognitive Style and Social Cognition Eligibility Interview (Hogarty et al., 2004).

The participants in this study were young and early in the course of their illness with an average age of 25.87 ($SD=6.13$) and an illness duration of 3.28 ($SD=2.21$) years. All participants were taking an antipsychotic medication. The average chlorpromazine equivalent (CPZ) was 403.36 ($SD=311.97$). Majority of the participants were taking an atypical antipsychotic ($n=45$; 88%), 1 prescribed a typical antipsychotic (2%), and 5 taking both an atypical and typical antipsychotic medication (10%). The majority of patients were male ($n=34$; 67%) and Caucasian ($n=35$, 68%). At the time of this research, 37 (72.5%) participants were college educated, while only 14 (27.5%) were employed. Participants in the study were part of a larger randomized-controlled trial of Cognitive Enhancement Therapy (Eack et al., 2009).

2.2. Procedure

Participants were recruited from Western Psychiatric Institute and Clinic and other community clinics in Pittsburgh, PA. Utilizing video-taped interviews of participants, consensus conferences were implemented to determine eligibility for study participation. Those patients meeting inclusion criteria were then assessed with the MSCEIT and measures of brain morphology described above. All patients provided written informed consent prior to participation, and the study protocol was reviewed annually by the University of Pittsburgh Institutional Review Board.

2.3. Measures

2.3.1 Social Cognition—The MSCEIT (Mayer et al., 2003) is a computer-administered, performance-based measure of emotion processing and management, which is recommended by the NIMH-MATRICES committee for assessing social cognition in schizophrenia (Nuechterlein et al., 2008). The MSCEIT consists of 141-items assessing the four branches of emotional intelligence presented by Mayer and Salovey (1997). Scores for the four subscales and overall performances are based on a scale of a large normative sample with a mean of 100 ($SD=15$). A higher score indicates a better emotional intelligence quotient. The subscale branches include an individual's ability to accurately perceive, understand, and manage emotions and to utilize emotions to facilitate thinking. The ability to perceive emotions is assessed by identifying emotions in pictures of human faces and scenery. The understanding of emotions is assessed by identifying how emotions are combined to produce other emotions. The management of emotions is measured by

recognizing how emotions change with intensity and identifying correct strategies to regulate one's own and others emotions in certain social situations. The ability to use emotions to facilitate thinking is assessed by matching emotions with sensations and judging which emotions are required to facilitate thoughts and behaviors (Mayer et al., 2003). The MSCEIT has been previously shown to have good reliability and adequate discriminate construct and concurrent validity for assessing the emotional components of social cognition in patients with schizophrenia (Eack et al., 2010; Nuechterlein et al., 2008).

2.3.2. Brain Morphology—Assessments of brain morphology were conducted using structural magnetic resonance imaging (MRI) with a 3-T Signa whole body scanner and head coil (GE Medical Systems, Milwaukee, WI). Whole brain volume was acquired in 124 1.5 mm-thick contiguous coronal slices with spoiled gradient recalled acquisition in steady state pulse sequence (TE = 5 ms, TR = 25 ms, acquisition matrix = 256×192 , FOV = 24 cm). A masters-level imaging research assistant examined the images manually for quality and motion. Images were then normalized to standard Montreal Neurological Institute (MNI) space and segmented using the unified segmentation algorithm to produce unmodulated gray matter partitioned images (Ashburner and Friston, 2005) based on templates of adults brains in Statistical Parametric Mapping Software, version 5 (SPM5) (Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK). To provide the best balance between minimal intersubject variability and maximal analytic sensitivity, the unmodulated, segmented images were smoothed using a 12 mm Gaussian Kernel and radio frequency inhomogeneity artifacts were corrected using a bias correction algorithm built into the segmentation procedure. Prior to analysis, the Wake Forest University PickAtlas toolbox for SPM5 (Maldjian et al., 2003) was used to define image masks for region of interest (ROI) analyses of gray matter regions that have been previously implicated in social cognition (Adolphs, 2001; Taylor et al., 2012). Regional definitions were delineated by Tzourio-Mazoyer and colleagues (2002), and included the orbitofrontal cortex, posterior cingulate cortex, fusiform gyrus, amygdala, hippocampus, parahippocampal gyrus, and cuneus.

2.4. Data analysis

Analyses began with a series of ROI voxel-based morphometry (VBM) analyses employing general linear models executed in SPM5 utilizing the normalized, unmodulated segmented, and smoothed images described above. Results of MSCEIT-related brain morphology will reflect gray matter density since these images are *not* modulated by their Jacobian determinants. Because the MSCEIT is based on a four factor model of emotional intelligence (Mayer and Salovey, 1997), five individual multiple regression designs were implemented for each of the MSCEIT subscales scores (e.g., Perceiving, Facilitating, Understanding, and Managing Emotions) and total scores. All the above analyses controlled for possible confounding effects of age, gender, and illness length. Correction for multiple inference testing was handled with Monte Carlo simulations produced with AlphaSim (Ward, 2000), which indicated a combined voxel-extent threshold of 59 contiguous voxels and an α threshold of .001 was sufficient to keep the study-wise Type 1 error rate at .047 across all VBM analyses. To increase confidence in our VBM findings of associations between gray matter density and MSCEIT performance, subsequent confirmatory volumetric analyses were completed in SPSSv.19 using partial correlation analyses adjusting for age, gender, illness length, and total intracranial volume. This was accomplished by extracting gray matter volumes from segmented images modulated by their Jacobian determinants obtained during image normalization. These images included regions displaying significant associations with MSCEIT performance from the VBM analyses. Results from these volumetric analyses represent gray matter volume instead of density because extracted volumes were obtained from modulated images. Total intracranial volume

was included to control for the effects of different brain sizes as Jacobian modulated images were used (unmodulated images used above in VBM) in these volumetric analyses, which reflect absolute vs. relative levels of gray matter volume that are affected by variations in brain size. In order to conserve power we only retained confounding variables showing a significant relationship with MSCEIT performance and/or brain morphology. Although antipsychotic medication was considered as a potential confounding variable, CPZ dosage was not correlated with either MSCEIT performance (e.g., total and subscale) or brain morphology, and thus not included in analyses.

3. Results

3.1. MSCEIT Behavioral Performance

Table 1 presents MSCEIT overall and subscale performance scores from the sample of early course schizophrenia patients studied in this investigation compared to the normative sample mean of 100 (Mayer et al., 2003). Early course schizophrenia patients displayed significant performance impairments on the MSCEIT overall and the Perceiving, Facilitating, Understanding, and Managing Emotions subscales. The largest domain of impairment was on the Managing Emotions subscale.

3.2. VBM Results of Gray Matter Density ROIs Associated with Impaired MSCEIT Performance

Investigation of the neural substrates of impaired MSCEIT performance revealed that patients with poorer overall performance on the MSCEIT showed significant reductions in gray matter density in the left parahippocampal gyrus (see Table 2 for VBM results). A similar relationship was observed with regard to the individual subscale measures of the MSCEIT. Lower gray matter density in the left parahippocampal gyrus was consistently related to poorer performance on the Facilitating, Understanding, and Managing Emotions subscales. Additionally, gray matter density reduction in the right posterior cingulate was implicated in poorer performance on the Facilitating and Managing Emotions subscales (see Figure 1). No associations were observed between the Perceiving Emotions subscale and lower gray matter density, and no negative associations were found between performance on the MSCEIT (overall and subscale) and gray matter morphology.

3.3. Volumetric Confirmatory Support for the Neurobiological Correlates of Impaired MSCEIT Performance

Confirmatory support was observed for the associations between reduced gray matter volume in the left parahippocampal gyrus and overall MSCEIT performance ($pr = 0.31$, $p = 0.033$), as well as performance on the Understanding ($pr = 0.34$, $r = 0.017$), Managing ($pr = 0.31$, $p = 0.034$), and Facilitating ($pr = 0.41$, $p = 0.004$) Emotions subscales. Finally, reduced gray matter volume in the right posterior cingulate was also associated with emotion management ($pr = 0.34$, $p = 0.019$; see Figure 2), but not emotion facilitation ($pr = 0.24$, $p = 0.103$). Taken together, these findings provide additional evidence for important brain regions implicated in social cognition that are associated with poorer MSCEIT performance in early course schizophrenia.

4. Discussion

Social-cognitive impairments in schizophrenia are broad and place significant burden on functional recovery (Couture et al., 2006; Green and Horan, 2010). Despite precedence given to the understanding and amelioration of social-cognitive impairment in schizophrenia, assessment tools for the elucidation of specific deficits in social cognition have been limited (Green et al., 2004). The NIMH MATRICS committee has recently

recommended the MSCEIT as the key measure of social cognition in clinical trials of cognitive enhancers for schizophrenia (Green et al., 2005). Indeed, several investigations have underscored the value of utilizing the MSCEIT in clinical trials with demonstration of good psychometric properties (Eack et al., 2010; Kee et al., 2009; Nuechterlein et al., 2008) and sensitivity to longitudinal treatment effects (Eack et al., 2007). As a critical next step in the validation of this promising measure, this study examined the neurobiological correlates between MSCEIT performance and gray matter morphology in early course patients with schizophrenia.

Results indicated significant relationships between impaired performance on the MSCEIT and gray matter density reductions in both the left parahippocampal gyrus and the right posterior cingulate. Specifically, attenuated overall and subscale (e.g., Facilitating, Understanding, and Managing Emotions) performance was significantly associated with lower gray matter density in the left parahippocampal gyrus. In addition, attenuated performance on the subscale measures of Facilitating and Managing Emotions was significantly related to right posterior cingulate gray matter density reduction. All associations between impaired MSCEIT performance and lower gray matter density were supported with confirmatory volumetric correlations, with the exception for the right posterior cingulate and the facilitation of emotions. No relationships were observed between performance on the Perceiving Emotions subscale and gray matter morphology.

In healthy control individuals, regions such as the ventromedial prefrontal cortex, insula, cuneus, and the cingulate cortex play an important role in performance on measures of emotional intelligence (Koven et al., 2011; Takeuchi et al., 2011). Regarding the MSCEIT specifically in healthy controls, left insula gray matter volume has been shown to be related to overall MSCEIT performance (Kilgore et al., 2012). Schizophrenia patients have deficits in similar brain regions related to impaired social cognitive functioning (Pinkham et al., 2003). While our results are not entirely consistent with the above findings of global social cognition, both the parahippocampal gyrus (Lane et al., 1997) and the posterior cingulate (Maddock et al., 2003) have been indicated in emotional processing studies of healthy participants. Indeed, parahippocampal gyrus hyperactivation abnormalities have been shown to be related to emotional misattributions in schizophrenia when compared to controls (Surguladze et al., 2006). Also, associations between hypoactivation abnormalities in the posterior cingulate and theory of mind deficits have been observed in schizophrenia (Walter et al., 2009). The results from this investigation also demonstrate some consistencies (e.g., parahippocampal gyrus) with recent meta-analytic evidence from functional neuroimaging examinations of emotion processing in schizophrenia patients (Taylor et al., 2012). Finally, although lateral effects are difficult to interpret in this initial investigation of the neural correlates subserving MSCEIT performance, observation of lower right posterior cingulate gray matter is consistent with findings showing emotional processing deficits are similar in schizophrenia patients and patients with right hemispheric brain damage (Mitchell and Crow, 2005; Kucharska-Pietura, 2006). The observation of reduced gray matter in the left parahippocampal gyrus and right posterior cingulate may represent impairments in processing of positive and negative emotional stimuli during MSCEIT performance. According to the valence model of emotional processing, regions of the right hemisphere are important for processing of negative emotion while left hemispheric regions are important for positive emotional processing (Adolphs et al., 2001; Demaree et al., 2005; Shamay-Tsoory et al., 2008), both of which have shown impairment in patients with schizophrenia (Gur et al., 2002; Kohler et al., 2004; Loughland et al., 2002). Taken together, these findings continue to support the validity of the MSCEIT for assessing the emotional components of social-cognitive impairments in patients with schizophrenia by demonstrating associations between impaired performance on the test and abnormalities in known emotion processing-associated brain regions. Additionally, the associations between brain morphology in social-

cognitive networks and performance on the Managing Emotions subscale provide further support for the decision of the MATRICS committee to recommend this particular subscale for the assessment of social cognition in schizophrenia (Green et al., 2005).

Although the observation of neurobiological correlates of MSCEIT performance provides additional evidence for the validity of the MSCEIT to assess social cognition in schizophrenia, a number of limitations should be considered in the interpretation of these findings. This study is characterized by a moderate sample size ($N = 51$), the absence of a matched healthy control group, and its cross-sectional nature. These limitations precluded our ability to make strong inferences about the associations between MSCEIT performance and gray matter morphology, as well as detection of smaller relations between MSCEIT performance and gray matter reductions. Also, the inclusion of early course patients may have inhibited findings of possibly more robust brain abnormalities related to poorer MSCEIT scores. Social cognitive dysfunction including emotion processing, however, has been shown to be stable from prodrome to chronic phases of the illness and is an important factor in early intervention (Horan et al., 2011). Despite these limitations, these findings give important biological evidence to the MSCEIT as a valid measure of social cognition and add to the growing body of literature supporting its use in clinical trials of cognitive enhancement interventions in patients with schizophrenia (Hogarty et al., 2004; Eack et al., 2007; 2009).

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Abbreviations

MSCEIT	Mayer-Salovey-Caruso Emotional Intelligence Test
MRI	Magnetic resonance imaging
NIMH	National Institute of Mental Health
MATRICES	Measurement and Treatment Research to Improve Cognition in Schizophrenia
CPZ	Chlorpromazine equivalent
MNI	Montreal Neurological Institute
SPM5	Statistical Parametric Mapping Software, version 5
ROI	Region of interest
VBM	Voxel-based morphometry

References

- Adolphs R. The neurobiology of social cognition. *Curr Opin Neurol.* 2001; 11:231–239.
- Adolphs R, Jansari A, Tranel D. Hemispheric perception of emotional valence from facial expressions. *Neuropsychology.* 2001; 15(4):516–524. [PubMed: 11761041]

- Amodio DM, Frith CD. Meeting of minds: The medial frontal cortex and social cognition. *Nat Rev Neurosci.* 2006; 7:268–277. [PubMed: 16552413]
- Ashburner J, Friston KJ. Unified segmentation. *Neuroimage.* 2005; 26:839–851. [PubMed: 15955494]
- Benedetti F, Bernasconi A, Bosia M, Cavallaro R, Dallspezia S, Falini A, Poletti S, Radaelli D, Riccaboni R, Scotti G, Smeraldi E. Functional and structural brain correlates of theory of mind and empathy deficits in schizophrenia. *Schizophr Res.* 2009; 114:154–160. [PubMed: 19632816]
- Couture SM, Penn DL, Roberts DL. The functional significance of social cognition in schizophrenia: A review. *Schizophr Bull.* 2006; 32(S1):S44–S63. [PubMed: 16916889]
- Demaree HA, Everhart DE, Youngstrom EA, Harrison DW. Brain lateralization of emotional processing: historical roots and a future incorporating “dominance”. *Behav Cogn Neurosci.* 2005; 4(1):3–20.
- Eack SM, Greeno CG, Pogue-Geile MF, Newhill CE, Hogarty GE, Keshavan MS. Assessing social-cognitive deficits in schizophrenia with the Mayer-Salovey-Caruso Emotional Intelligence Test. *Schizophr Bull.* 2010; 36(2):370–380. [PubMed: 18648021]
- Eack SM, Greenwald DP, Hogarty SS, Cooley SJ, DiBarry AL, Montrose DM, Keshavan MS. Cognitive enhancement therapy for early-course schizophrenia: Effects of a two-year randomized controlled trial. *Psychiatr Serv.* 2009; 60(11):1468–1476. [PubMed: 19880464]
- Eack SM, Hogarty GE, Greenwald DP, Hogarty SS, Keshavan MS. Cognitive enhancement therapy improves emotional intelligence in early course schizophrenia: preliminary effects. *Schizophr Res.* 2007; 89:308–311. [PubMed: 17055227]
- First, MB.; Spitzer, RL.; Gibbon, M.; Williams, JBW. Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition. Biometrics Research, New York State Psychiatric Institute; New York, NY: 2002.
- Green MF, Horan WP. Social cognition in schizophrenia. *Curr Dir Psychol Sci.* 2010; 19(4):243–248.
- Green MF, Nuechterlein KH, Gold JM, Barch DM, Cohen J, Essock S, Fenton WS, Frese F, Goldberg TE, Heaton RK, Keefe RS, Kern RS, Kraemer H, Stover E, Weinberger DR, Zalcman S, Marder SR. Approaching a consensus cognitive battery for clinical trials in schizophrenia: The NIMH-MATRICES conference to select cognitive domains and test criteria. *Biol Psychiatry.* 2004; 56(5): 301–307. [PubMed: 15336511]
- Green MF, Olivier B, Crawley JN, Penn DL, Silverstein S. Social cognition in schizophrenia: recommendations from the measurement and treatment research to improve cognition in schizophrenia new approaches conference. *Schizophr Bull.* 2005; 31(4):882–887. [PubMed: 16135561]
- Gur RE, McGrath C, Chan RM, Schroeder L, Turner T, Turetsky BI, Kohler C, Alsop D, Maldjian J, Gur RC. An fMRI study of facial emotion processing in patients with schizophrenia. *Am J Psychiatry.* 2002; 159:1992–1999. [PubMed: 12450947]
- Heinrichs RW, Zakzanis KK. Neurocognitive deficit in schizophrenia: a quantitative review of the evidence. *Neuropsychology.* 1998; 12(3):426–445. [PubMed: 9673998]
- Hogarty GE, Flesher S, Ulrich R, Carter M, Greenwald D, Pogue-Geile M, Keshavan M, Cooley S, DiBarry AL, Garrett A, Parepally H, Zoretich R. Cognitive enhancement therapy for schizophrenia: Effects of a 2-year randomized trial on cognition and behavior. *Arch Gen Psychiatry.* 2004; 61(9):866–876. [PubMed: 15351765]
- Hooker CI, Bruce L, Fisher M, Verosky SC, Miyakawa A, Vinogradov S. Neural activity during emotion recognition after combined cognitive plus social cognitive training in schizophrenia. *Schizophr Res.* 2012; 139:53–59. [PubMed: 22695257]
- Horan WP, Green MF, Degroot M, Fiske A, Helleman G, Kee K, Kern RS, Lee J, Sergi MJ, Subtnik KL, Sugar CA, Ventura J, Nuechterlein KH. Social cognition in schizophrenia, part 2: 12-month stability and prediction of functional outcome in first-episode patients. *Schizophr Bull.* 2011 [Epub ahead of print].
- Kee KS, Horan WP, Salovey P, Kern RS, Sergi MJ, Fiske AP, Lee J, Subotnik KL, Nuechterlein K, Sugar CA, Green MF. Emotional intelligence in schizophrenia. *Schizophr Res.* 2009; 107:61–68. [PubMed: 18805674]
- Keefe RSE, Fenton WS. How should *DSM-V* criteria for schizophrenia include cognitive impairment? *Schizophr Bull.* 2007; 33(4):912–920. [PubMed: 17567627]

- Kilgore WD, Weber M, Schwab ZJ, DelDonno SR, Kipman M, Weiner MR, Rauch SL. Gray matter correlates of trait and ability models of emotional intelligence. *Neuroreport*. 2012; 23(9):551–555. [PubMed: 22546702]
- Kohler CG, Brennan AR. Recognition of facial emotions in schizophrenia. *Curr Opin Psychiatry*. 2004; 17:81–86.
- Koven NS, Roth RM, Garlinghouse MA, Flashman LA, Saykin AJ. Regional gray matter correlates of perceived emotional intelligence. *Soc Cogn Affect Neurosci*. 2011; 6(5):582–590. [PubMed: 20934987]
- Kucharska-Pietura K. Disorder emotional processing in schizophrenia and one-sided brain damage. *Prog Brain Res*. 2006; 156:467–479. [PubMed: 17015097]
- Lane RD, Reiman EM, Bradley MM, Lang PJ, Ahern GL, Davidson RJ, Schwartz GE. Neuroanatomical correlates of pleasant and unpleasant emotion. *Neuropsychologia*. 1997; 35(11):1437–1444. [PubMed: 9352521]
- Lieberman MD. Social cognitive neuroscience: a review of core processes. *Annu Rev Psychol*. 2007; 58:259–289. [PubMed: 17002553]
- Lo CH, Tsai GE, Liao CH, Wang MY, Chang JP, Tsuang HC, Lane HY. Emotional management and 5-HT_{2A} receptor gene variability in patients with schizophrenia. *Biol Psychol*. 2010; 83(2):79–83. [PubMed: 19913072]
- Loughland CM, Williams LM, Gordon E. Visual scanpaths to positive and negative facial emotions in an outpatients schizophrenia sample. *Schizophr Res*. 2002; 55:159–170. [PubMed: 11955975]
- Maddock RJ, Garrett AS, Buonocore MH. Posterior cingulate cortex activation by emotional words: fMRI evidence from a valence decision task. *Hum Brain Mapp*. 2003; 18:30–41. [PubMed: 12454910]
- Maldjian JA, Laurienti PJ, Kraft RA, Burdette JH. An automated method for neuroanatomic and cytoarchitectonic atlas-based interrogation of fmri data sets. *Neuroimage*. 2003; 19:1233–1239. [PubMed: 12880848]
- Mayer, JD.; Salovey, P. What is emotional intelligence?. In: Salovey, P.; Sluyter, D., editors. *Emotional development and emotional intelligence: Implications for educators*. Basic Book; New York, NY: 1997. p. 3-31.
- Mayer JD, Salovey P, Caruso DR, Sitarenios G. Measuring emotional intelligence with the MSCEIT V2. 0. *Emotion*. 2003; 3(1):97–105. [PubMed: 12899321]
- Mitchell RLC, Crow TJ. Right hemisphere language functionals and schizophrenia: the forgotten hemisphere? *Brain*. 2005; 128(5):963–978. [PubMed: 15743870]
- Nuechterlein KH, Green MF, Kern RS, Baade LE, Barch DM, Cohen JD, Essock S, Fenton WS, Frese FJ, Gold JM, Goldberg T, Heaton RK, Keefe RS, Kraemer H, Mesholam-Gately R, Seidman LJ, Stover E, Weinberger DR, Young AS, Zalcman S, Marder SR. The MATRICS consensus cognitive battery, part 1: test selection, reliability, and validity. *Am J Psychiatry*. 2008; 165(2):203–213. [PubMed: 18172019]
- Pinkham AE, Hopfinger JB, Pelphrey KA, Piven J, Penn DL. Neural bases for impaired social cognition in schizophrenia and autism spectrum disorders. *Schizophr Res*. 2008; 99:164–175. [PubMed: 18053686]
- Pinkham AE, Penn DL, Perkins DO, Lieberman J. Implications for the neural basis of social cognition for the study of schizophrenia. *Am J Psychiatry*. 2003; 160:815–824. [PubMed: 12727681]
- Saxe R. Uniquely human social cognition. *Current Opinion in Neurobiology*. 2006; 16:235–239. [PubMed: 16546372]
- Shamay-Tsoory SG, Lavidor M, Aharon-Peretz J. Social learning modulates the lateralization of emotional valence. *Brain Cogn*. 2008; 67(3):280–291. [PubMed: 18343548]
- Surguladze S, Russell T, Kucharska-Pietura K, Travis MJ, Giampietro V, Davis AS, Phillips ML. A reversal of the normal pattern of parahippocampal response to neutral and fearful faces is associated with reality distortion in schizophrenia. *Biol Psychiatry*. 2006; 60:423–431. [PubMed: 16487943]
- Takeuchi H, Taki Y, Sassa Y, Hashizume H, Sekiguchi A, Fukushima A, Kawashima R. Regional gray matter density associated with emotional intelligence: evidence from voxel-based morphometry. *Hum Brain Mapp*. 2011; 32:1497–1510. [PubMed: 20740644]

- Taylor SF, Kang J, Brege IS, Tso IF, Hosanagar A, Johnson TD. Meta-analysis of functional neuroimaging studies of emotion perception and experience in schizophrenia. *Bio Psychiatry*. 2012; 71:136–145. [PubMed: 21993193]
- Tzourio-Mazoyer N, Landeau B, Papathanassiou D, Crivello F, Etard O, Delcroix N, Mazoyer B, Joliot M. Automated anatomical labeling of activations in SPM using macroscopic anatomical parcellation of the MNI MRI single-subject brain. *Neuroimage*. 2002; 15:273–289. [PubMed: 11771995]
- Vauth R, Rüsch N, Wirtz M, Corrigan PW. Does social cognition influence the relation between neurocognitive deficits and vocational functioning in schizophrenia? *Psychiatry Res*. 2004; 128(2): 155–165. [PubMed: 15488958]
- Walter H, Ciaramidaro A, Adenzato M, Vasic N, Ardito RB, Erk S, Bara BG. Dysfunction of the social brain in schizophrenia is modulated by intention type: an fMRI study. *Soc Cogn Affect Neurosci*. 2009; 4:166–176. [PubMed: 19287044]
- Ward, DB. *Simulations Inference for fMRI Data*. Milwaukee, WI: Medical College of Wisconsin; 2000.
- Yamada M, Hirao K, Namiki C, Hanakawa T, Fukuyama H, Hayashi T, Murai T. Social cognition and frontal lobe pathology in schizophrenia: a voxel-based morphometric study. *Neuroimage*. 2007; 35:292–298. [PubMed: 17240165]

Highlights

1. Investigation of the neural correlates of MSCEIT performance in early schizophrenia.
2. Parahippocampal gyrus lower gray matter associated with poorer MSCEIT scores.
3. Posterior cingulate lower gray matter also related to poorer MSCEIT performance.
4. Findings support MSCEIT validity as a social-cognitive measure in schizophrenia.

Figure 1. Right Posterior Cingulate and Left Parahippocampal Gyrus Reduced Gray Matter Density Associated With Attenuated Performance on the Managing Emotions Subscale of the MSCEIT.

Figure 2.
Association Between Attenuated Performance on the MSCEIT Subscale of Managing Emotions and Lower Gray Matter Volume (mL³) in the Right Posterior Cingulate Cortex.

Table 1

Social-Cognitive Behavioral Performance of 51 Early Course Schizophrenia Patients Measured by the MSCEIT.

MSCEIT Scale	<i>M (SD)</i>	<i>t</i>	<i>p</i> (2-tailed)
Perceiving Emotions	91.59 (16.49)	-3.63	0.001
Facilitating Emotions	94.09 (17.54)	-2.40	0.020
Understanding Emotions	87.60 (12.38)	-7.14	< 0.001
Managing Emotions	86.92 (12.50)	-7.46	< 0.001
Total	86.42 (16.10)	-6.01	< 0.001

Note. MSCEIT = Mayer-Salovey-Caruso Emotional Intelligence. Scores are scaled to a normative sample mean of 100 (*SD* = 15) (Mayer et al., 2003). A one-sample *t*-test was used to test differences between the normative mean of 100 and mean scores from the schizophrenia patients in this investigation.

Voxel-Based Morphometric Analyses Examining Associations Between Regions of Interest and Performance on the MSCEIT

Table 2

MNI coordinates (x,y,z)	Cluster Size	Location	BA	z	p	p _{corrected}	Direction
MSCEIT Total Score							
-18, -12, -28	145	Left parahippocampal gyrus	28/35/36	4.17	< .001	.047	Positive
Perceiving Emotions							
-	-	-	-	-	-	-	-
Facilitating Emotions							
-18, -12, -28	197	Left parahippocampal gyrus	28/35/36	4.22	< .001	.047	Positive
4, -46, 30	101	Right posterior cingulate	31	3.66	< .001	.047	Positive
Understanding Emotions							
-18, -16, -28	94	Left parahippocampal gyrus	28/35/36	4.35	< .001	.047	Positive
Managing Emotions							
-16, -12, -28	70	Left parahippocampal gyrus	28/35/36	3.61	< .001	.047	Positive
6, -46, 30	61	Right posterior cingulate	31	3.51	< .001	.047	Positive

Note. p is the uncorrected voxel-wise significance level and p_{corrected} is the voxel-wise corrected significance threshold value indicated by AlphaSim (Ward, 2000). BA = Brodmann Area