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Establishing a standard emotion processing battery for treatment evaluation in adults with autism spectrum disorder: Evidence supporting the Mayer–Salovey–Caruso Emotion Intelligence Test (MSCEIT)

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ABSTRACT

Autism spectrum disorder (ASD) and schizophrenia are neurodevelopmental disorders which show markedly similar deficits in emotion processing, yet treatment evaluation in ASD and treatment comparisons across ASD and schizophrenia are constrained by a lack of empirical work validating a standard emotion processing battery across ASD and schizophrenia. Encouragingly, the Mayer–Salovey–Caruso Emotion Intelligence Test, version 2.0 (MSCEIT (Mayer et al., 2003) spans the range of emotion processing deficits in schizophrenia and ASD. This study therefore aimed to establish MSCEIT's factorial, measurement, and structural invariance in community-residing adults with schizophrenia ($N = 103$) and ASD ($N = 113$) using multigroup confirmatory factor analysis. Consistent with prior studies in normative populations, a two-factor structure comprised of emotional experiencing and emotional reasoning was supported in ASD and schizophrenia. Both groups operationalize MSCEIT measures similarly, with all measures except for Facilitation and Management showing comparability across groups. To our knowledge, this study is not only the first to establish the measurement and structural invariance of a standard emotion perception battery in adults with ASD, it is also the first to establish its comparability across ASD and schizophrenia. Ultimately, these findings underscore MSCEIT's utility for standardizing treatment evaluation of social cognitive outcomes across the autism-schizophrenia spectrum.

1. Introduction

Social cognitive deficits feature prominently in autism spectrum disorder (ASD) (Baron-Cohen and Wheelwright, 2004) and schizophrenia (Penn et al., 2008), with substantial similarities in these impairments observed across both neurodevelopmental disorders (Couture et al., 2010; Eack et al., 2013a). Despite mounting evidence that cognitive remediation treatments improve social cognition not only in schizophrenia adults ($d = 0.65$ reported in the most recent meta-analysis (Wykes et al., 2011)) but also in ASD adults ($d = 0.27$ (Eack et al., 2018)), comparisons and applications of therapeutic elements across ASD and schizophrenia are currently limited by a dearth of social cognitive measures validated in both disorders. This barrier is highlighted in the most recent comprehensive meta-analysis evaluating comparisons of social cognition in ASD and schizophrenia, which indicated significant heterogeneity among the included studies (Fernandes et al., 2018). This heterogeneity may be at least partially attributable to the fact that most comparison studies to date have used social cognitive measures that have not yet been validated across both disorders, thereby obscuring the extent to which an observed group difference or lack thereof in social cognition is reliably and accurately representing the nature of social cognitive abilities across these disorders.

Demonstrating that social cognitive measures show similar measurement properties across ASD and schizophrenia is necessary for interpreting comparisons of social cognitive performance across these disorders. Although recent theoretical and psychometric work in the Social Cognition Psychometric Evaluation (SCOPE) study

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(Pinkham et al., 2018) has validated a set of social cognitive measures for schizophrenia, a standard social cognitive battery for ASD adults has yet to be validated to our knowledge. In particular, recent meta-analyses indicate that emotion processing, a domain of social cognition, is substantially impaired in ASD ($d = -0.41$ (Uljarevic and Hamilton, 2013)) and in schizophrenia ($d \sim -0.89$ (Savla et al., 2013) irrespective of age, emphasizing its potential for remediation in adults. Taken together with the finding that emotion processing is a key predictor of functioning in ASD (Otsuka et al., 2017) and schizophrenia (Fett et al., 2011), emotion processing shows ample prospects for evaluating treatment outcomes across the autism-schizophrenia spectrum.

In selecting a standard battery to assess emotion processing deficits across ASD and schizophrenia, the Mayer–Salovey–Caruso Emotion Intelligence Test, version 2.0 (MSCEIT; Mayer et al., 2003) emerges as a top candidate given its use as a standard assessment of emotion perception and processing in schizophrenia (Lindenmayer et al., 2013; McCleery et al., 2016), and increasingly, in ASD (Boily et al., 2017). Unlike many assessments of emotion processing, MSCEIT is performance-based in that participants are prompted to solve emotional problems rather than report their emotional abilities. Given that MSCEIT enables the evaluation of emotion processing similar to the evaluation of general intelligence by neurocognitive assessments, its Managing Emotions (ME) subscale was recommended by the NIMH-MATRICS (National Institutes of Mental Health, Measurement and Treatment Research to Improve Cognition in Schizophrenia) committee as a measure of social cognition in schizophrenia in the widely implemented MATRICS Consensus Cognitive Battery (MCCB; Green et al., 2005). Furthermore, MSCEIT-ME has been found to be uniquely correlated with functioning relative to the MCCB nonsocial cognitive measures (DeTore et al., 2018), highlighting MSCEIT's potential contribution to evaluating treatment outcomes not encompassed by standard nonsocial cognitive measures.

Comparing emotion processing impairments across ASD and schizophrenia requires establishing that the skills involved in emotion processing within each disorder are attributable to a common set of underlying constructs and are measured without systematic differences in bias across both disorders. This ensures the validity of the emotion processing measures and of their relationships with other constructs. Without testing these assumptions, we can only hold limited confidence in any inference that group mean differences in the measure are due to actual group differences in the underlying construct rather than systematic group differences in response bias and/or other sources of measurement error. Thus, to establish MSCEIT's utility across ASD and schizophrenia, it is important to first examine if performance on MSCEIT is attributable to a set of emotion processing domains (factors) in a population for which validation efforts are already underway, schizophrenia. After identifying a stable set of relationships between measures and emotion processing domains (a factor structure) for MSCEIT in schizophrenia, this factor structure may then be examined in a different population, ASD. Establishing the invariance of this factor structure provides evidence that MSCEIT assesses the same core domains across ASD and schizophrenia.

Despite the increasing use of MSCEIT in schizophrenia since the introduction of expert recommendations for a consensus cognitive battery (Dodell-Feder et al., 2014; Frajo-Apor et al., 2016; Kee et al., 2009), a clear and acceptable factor structure for MSCEIT has not yet been established in schizophrenia using confirmatory factor analysis (CFA). In contrast to exploratory factor analysis (EFA), which makes no assumptions about the relationships between measures and factors, CFA is used to empirically test a theorized factor structure and thus imposes constraints a priori on the relationships between measures and factors. Initial work by our group using CFA in a moderate-sized sample indicated that MSCEIT may demonstrate a two-factor structure in patients with schizophrenia (Eack et al., 2009), which was subsequently replicated using EFA (Lin et al., 2012). To date, no other study has applied CFA to examine MSCEIT's factor structure in schizophrenia. Overall, the limited fits of the revised two-factor model and of alternative models in our initial study (Eack et al., 2009) support the need to re-examine the structural model in schizophrenia. In particular, given the results of a recent meta-analysis reporting that a three-factor model shows better fit in normative samples than the one-, two-, and four-factor models which were most commonly reported in individual studies (Fan et al., 2010) and were tested in our initial study (Eack et al., 2009), the three-factor model should be examined to determine if it may better capture MSCEIT's underlying structure in schizophrenia than the alternative models. Establishing an acceptable-fitting model in schizophrenia is key for supporting the validity of the constructs measured in schizophrenia, as well as interpreting comparisons of emotion processing across schizophrenia and ASD.

Although a growing literature indicates that the behavioral and neural processes associated with emotion processing difficulties in ASD are comparable to processes in schizophrenia (Eack et al., 2013a; Sugranyes et al., 2011), MSCEIT's factor structure has not yet been investigated across these disorders. Thus, building upon our prior work (Eack et al., 2009), we draw upon a non-overlapping, large, community-based sample of verbal ASD adults and adult outpatients with schizophrenia to address the following aims:

(1) Replicate MSCEIT's factorial invariance in schizophrenia and ASD. We hypothesized that the prior two-factor model would demonstrate better fit than other models that have been supported in normative populations and that the model would show a good-fitting factor structure across schizophrenia and ASD (established by configural measurement invariance).
(2) Confirm that schizophrenia and ASD attribute equivalent relationships between MSCEIT measures and the underlying emotion perception domains (established by metric and scalar measurement invariance). We hypothesized that schizophrenia and ASD demonstrate psychometrically similar interpretations of MSCEIT measures, enabling comparisons of the measures' statistics (e.g. means and correlations) across disorders.
(3) Confirm that schizophrenia and ASD attribute similar relationships among MSCEIT emotion processing domains (established by structural invariance). We hypothesized that MSCEIT factor structure is equivalent across schizophrenia and ASD, enabling comparisons of emotion processing domain statistics across disorders.

2. Methods

2.1. Participants

Participants were English-fluent, community-residing outpatients participating in ongoing studies of Cognitive Enhancement Therapy (Eack et al., 2013b; Hogarty et al., 2004). Schizophrenia patients were included in this study if they were aged 18 to 60, met criteria for schizophrenia or schizoaffective disorder according to the Structured Clinical Interview for DSM-IV Disorders (SCID) (First et al., 1995), were adherent to concurrent antipsychotic medication regimens, had an IQ ≥ 80 estimated using the Quick Test (Ammons and Ammons, 1962) or the 2-subtest version of the Wechsler Abbreviated Scale of Intelligence - Second Edition (WASI-II) (Wechsler, 2011), had not been abusing substances within the past 3 months prior to study enrollment, and demonstrated significant cognitive and social disability on the Cognitive Styles and Social Cognition Eligibility Interview (CSSCEI; Hogarty et al., 2004). ASD adults were included if they were aged 16 to 45, met criteria for autism or autism spectrum disorder according to the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 2001) or Autism Diagnostic Interview (ADI) (Lord et al., 1994), had an IQ ≥ 80 estimated using the WASI (Wechsler, 1999), had not been abusing substances within the past 3 months prior to study enrollment, did not receive a concurrent diagnosis of psychotic disorder according to the clinical record, and demonstrated significant cognitive and social disability on the CSSCEI (Hogarty et al., 2004). Schizophrenia and autism participants were pooled using baseline data from separate clinical trials of Cognitive Enhancement Therapy for these conditions. Although the trials shared many similar measures and characteristics, the age inclusion criterion was not completely overlapping.

2.2. Measures

The English-language, web-based MSCEIT is a performance-based battery that assesses four branches of emotional intelligence (Mayer and Salovey, 1997). The battery consists of eight tasks based on 141 items, with two tasks comprising each branch: (1) Perceiving and Expressing Emotion (Perceiving Emotion): Faces, Pictures; (2) Assimilating Emotion in Thought (Facilitating Thinking): Facilitation, Sensation; (3) Understanding Emotion: Changes, Blends; (4) Reflectively Regulating Emotions (Emotion Management): Management, Relations. MSCEIT is scored using unadjusted consensus norms with a normative mean (SD) of 100 (15), such that higher scores indicate better emotion processing. MSCEIT has been validated in normative (Mayer et al., 2003) and schizophrenia patient (Eack et al., 2010; Kee et al., 2009; Nuechterlein et al., 2008) populations.

2.3. Procedure

Participants were recruited for studies of Cognitive Enhancement Therapy in the Pittsburgh region through various outreach efforts in support groups, community agencies, community mental health centers, clinics, colleges and universities, online advertisements, prior studies, and local advocacy groups. Participants underwent diagnostic interview, IQ, and MSCEIT assessments administered by trained clinical interviewers and psychometrists. The investigation was carried out in accordance with the latest version of the Declaration of Helsinki. All participants provided written informed consent prior to study participation, in accordance with procedures approved by the University of Pittsburgh Institutional Review Board.

2.4. Analyses

Data were complete for all eight emotion processing tasks. Given that none of the measures had absolute skewness greater than 2.0 and excess kurtosis greater than 7.0 (values often used as suggestive of moderate non-normality as recommended by West et al. (1995)), scores for each task were then subjected to CFA in Mplus, version 8 (Muthén and Muthén, 2010) using maximum-likelihood estimation.

CFA is founded on the principle that covariation between measures is in part attributable to their communality in measuring a latent construct (factor) which cannot be directly measured. In this case, each factor represents a hypothesized emotion perception domain. Multigroup CFA is conducted by constraining different sets of parameters to equivalence across the two diagnostic groups and examining differences in the fits of nested models with increasingly restrictive invariance constraints using the CFI. The CFI comparison was selected given its robustness to model complexity and sample size as compared to the chi-square difference test; a difference in CFI $\leq .01$ suggested that constraining the parameters did not significantly deteriorate model fit, allowing the null hypothesis of invariance to be retained (Cheung and Rensvold, 2002). Fit indices aided with examining the extent to which a factor structure appropriately captures the relationship within and among factors; model fit was evaluated using the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Squared Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), with adequate fit indicated when CFI and TLI $\geq .90$ and good fit indicated when CFI and TLI $\geq .95$, RMSEA $\leq .06$, and SRMR $\leq .08$ (Hu and Bentler, 1999).

3. Results

3.1. Sample characteristics

The sample was comprised of 103 participants in the schizophrenia group (80 diagnosed with schizophrenia and 23 with schizoaffective disorder) and 113 participants in the ASD group. The schizophrenia sample does not overlap with the smaller schizophrenia sample ($N = 64$) previously reported in our study of MSCEIT's factor structure in schizophrenia (Eack et al., 2009). All schizophrenia participants were taking antipsychotic medication, with an average daily chlorpromazine equivalent dosage of 446 mg (SD = 351 mg), and 44% had a history of substance abuse or dependence. Both groups consisted of young adults aged approximately 24 years, were largely male, Caucasian, and had attended college. Across groups, participants were similar in age, sex, race, education, and IQ (see Table 1). Compared to the ASD group, participants in the schizophrenia group were rated as having greater disorganization and less rigidity, slightly worse vocational ineffectiveness, slightly poorer adjustment to disability, and slightly better interpersonal effectiveness.

3.2. Establishing the factor structure

Means and variances of MSCEIT branches and tasks are presented by group in Table 1.

To confirm MSCEIT's factor structure in schizophrenia and ASD, the fits of the most commonly supported models in the literature were compared, as represented in Fig. 1, where the normative one-factor model is represented in Panel 1, the two-factor model described in our initial work (Eack et al., 2009) in Panel 2, the normative two-factor original model in Panel 3, the normative three-factor model in Panel 4, and the normative four-factor model in Panel 5. As shown in Table 2, the one-factor model showed poor fit in schizophrenia (Model O1) and ASD (Model O2) and fit significantly worse than the two-factor model described in our initial work (Eack et al., 2009) in schizophrenia (Model O3) and ASD (Model O4). Compared to the initial two-factor model we described previously (Eack et al., 2009), the normative two-factor model showed better fit in schizophrenia (Model O5) and ASD (Model O6). The three-factor model demonstrated good fit in schizophrenia (Model O7) but was not admissible in ASD due to negative residual variance for Changes in ASD. Furthermore, the four-factor model was not admissible in schizophrenia or ASD due to a lack of positive-definite matrices resulting from linear dependency between two factors in schizophrenia and negative residual variance for Changes in ASD. The normative two-factor model, comprised of an Emotional Experiencing factor and an Emotional Reasoning factor, was the best-fitting model that was admissible in both schizophrenia and ASD, was more parsimonious than the three-factor model, and showed better fit than the original two-factor model (Eack et al., 2009). Thus, the normative two-factor model was selected for further analyses.

3.3. Establishing factorial invariance

The normative two-factor model was optimized in schizophrenia to better allocate the variation in measures that may be attributable to factors. In particular, error covariance was specified by allowing a measure's error variance to correlate with another measure's error variance within and across factors. Investigating pairs of measures which hypothetically share method variance (e.g. similarities in task stimuli or administration) or emotion perception domain variance (e.g. informing multiple emotion perception domains), the most theoretically informed and parsimonious set of measures were allowed to correlate with each other to improve model fit. Once its fit was optimized in schizophrenia, the fit of this baseline model was subsequently evaluated in ASD. When the same baseline model shows good fit in schizophrenia and ASD, separately, multigroup CFA can be initiated.

Table 1
Demographic and performance characteristics across groups.

Characteristic	Schizophrenia (N = 103) Mean	(SD)	ASD (N = 113) Mean	(SD)	Statistic	p	df
Demographic							
Age	24.83	(5.38)	24.80	(6.65)	0.002	.969	214
Sex	72%		81%		2.263	.133	1
Race	58%		68%		1.865	.172	1
Education	75%		69%		0.663	.416	1
IQ	106.63	(12.54)	108.85	(14.68)	1.361	.245	213
Substance Use History	44%		–		–	–	–
Cognitive Style Deficits							
Impoverishment	12.05	(1.51)	11.60	(1.85)	3.727	.055	210
Disorganization	11.35	(1.41)	10.79	(2.11)	5.123	.025	210
Rigidity	10.08	(1.62)	10.63	(1.85)	5.308	.022	210
Social Cognitive Deficits							
Vocational Ineffectiveness	4.10	(0.54)	3.83	(0.73)	9.063	.003	209
Interpersonal Ineffectiveness	4.05	(0.52)	4.21	(0.47)	5.162	.024	209
Lack of Foresight	4.05	(0.46)	3.96	(0.60)	1.347	.247	209
Gist Extraction Deficits	3.97	(0.46)	4.03	(0.34)	1.058	.305	209
Lack of Adjustment to Disability	3.75	(0.56)	3.54	(0.58)	6.600	.011	209
MSCEIT Branch							
Perceiving Emotions	99.94	(19.58)	104.70	(15.30)	3.999	.047	214
Facilitating Thinking	95.24	(15.54)	95.81	(14.22)	0.078	.780	214
Understanding Emotion	90.33	(12.06)	93.94	(11.96)	4.861	.029	214
Emotional Management	90.46	(12.03)	91.70	(9.52)	0.713	.399	214
MSCEIT Task							
Faces	110.24	(27.50)	115.58	(24.07)	2.312	.130	214
Pictures	95.11	(13.92)	98.44	(12.99)	3.310	.070	214
Facilitation	101.35	(17.91)	100.40	(17.20)	0.159	.691	214
Sensation	93.43	(12.61)	94.35	(10.67)	0.338	.562	214
Changes	90.58	(11.69)	94.71	(12.57)	6.225	.013	214
Blends	92.54	(11.24)	94.44	(9.97)	1.734	.189	214
Management	92.67	(11.45)	92.00	(8.29)	0.248	.619	214
Relations	89.82	(11.50)	92.05	(10.13)	2.298	.131	214

Note. Results of one-way Type III ANOVAs are presented for age, IQ, emotion perception domains and standardized cognitive measures, whereas chi-square tests are reported for sex (% male), race (% Caucasian), and education (% attended some college).
Cognitive style and social cognitive deficits are rated on Likert scales ranging from 1 (rare) to 5 (very severe) by clinicians using the Cognitive Styles and Social Cognition Eligibility Interview (CSSCEI; Hogarty et al., 2004). Cognitive style deficits are rated on three dimensions (basic impairment, functional disability, and social handicap), such that the summary scores for each cognitive style deficit can range from 3 to 15. Social cognitive deficits are rated for each dimension. Eligibility interview data for five participants were missing.
Description of MSCEIT Tasks (Mayer et al., 2003).
Perceiving Emotions:
The Faces task measures the participant's ability to identify emotions when presented with facial expressions.
The Pictures task measures the participant's ability to identify emotions when presented with images and landscapes.
Facilitating Thinking:
The Facilitation task measures the participant's understanding of how emotions can interact with thoughts.
The Sensation task measures the participant's understanding of how emotions can be associated with sensations.
Understanding Emotion:
The Changes task measures the participant's understanding of how emotions can transition within a presented situation.
The Blends task measures the participant's understanding of how emotions can be combined within a presented situation.
Emotional Management:
The Management task measures the participant's ability to integrate emotions into personal decision-making processes.
The Relations task measures the participant's ability to integrate emotions into decision-making processes that involve others.

Two adjustments were introduced to the normative two-factor model to optimize its fit: (1) Within the Emotional Reasoning factor, errors were allowed to correlate between Changes and Blends, as both measure abilities involved in understanding emotions; and (2) Errors were also allowed to correlate between Management and Relations within the Emotional Reasoning factor, as both measure abilities involved in managing emotions (Mayer et al., 2003). With these modifications, the two-factor model demonstrated good fit in schizophrenia (Model O7) and ASD (Model O8). This two-factor model showed identical fit to the three-factor model in schizophrenia and is depicted in Fig. 1, Panel 6. As shown in Table 3, standardized factor loadings for all indicators were moderate to high in both groups, ranging from 0.590 to 0.730 in schizophrenia and from 0.361 to 0.854 in ASD.

3.4. Establishing measurement invariance

Results of factorial, measurement, and structural invariance tests and descriptions of fit for all models are summarized in Table 4.

Configural invariance was confirmed when the measures loaded onto the same factors across groups. Here, all factor loadings were freely estimated in an unconstrained model, and the same pattern of loadings adequately captured performance across groups. This establishes that one group does not consider a measure to inform a different emotion perception domain than the other group. Without any constrained parameters across groups, the modified two-factor model showed good fit across groups and served as the baseline model for multigroup comparisons (Model 1), indicating that MSCEIT shows the same model structure across schizophrenia and ASD.

Across all subsequent analyses, identification of the models (ensuring a sufficient balance of freed and fixed parameters to estimate the

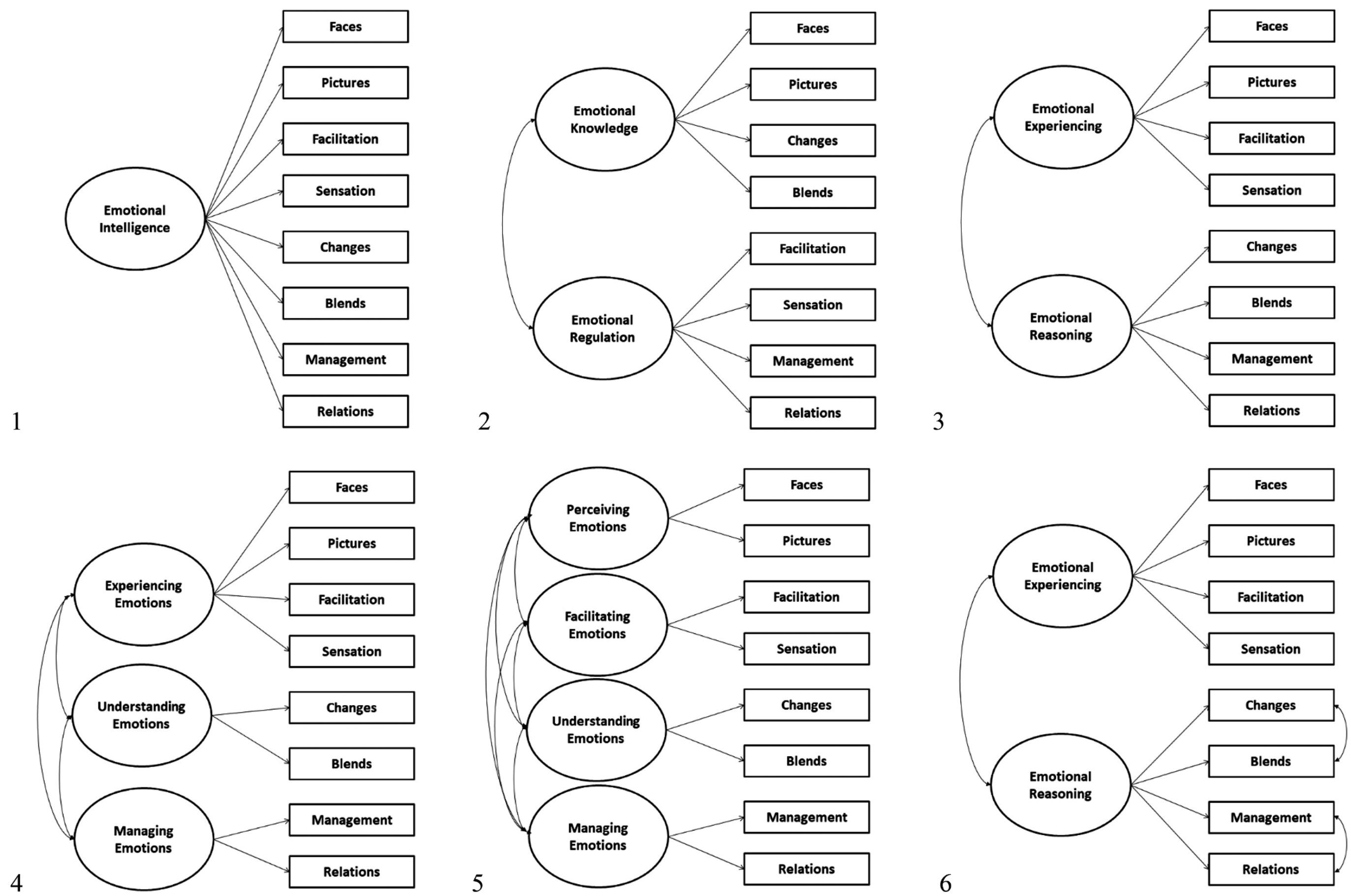

Fig. 1. Path diagrams depicting the candidate factor models of MSCEIT.
Panel 1: 1-factor model. Panel 2: 2-factor model initially confirmed in Eack et al. (2009). Panel 3: 2-factor model. Panel 4: 3-factor model. Panel 5: 4-factor model. Panel 6: Modified 2-factor model with correlated errors, which was used as the configural model.
Description of MSCEIT Tasks (Mayer et al., 2003):
The Faces task measures the participant's ability to identify emotions when presented with facial expressions.
The Pictures task measures the participant's ability to identify emotions when presented with images and landscapes.
The Facilitation task measures the participant's understanding of how emotions can interact with thoughts.
The Sensation task measures the participant's understanding of how emotions can be associated with sensations.
The Changes task measures the participant's understanding of how emotions can transition within a presented situation.
The Blends task measures the participant's understanding of how emotions can be combined within a presented situation.
The Management task measures the participant's ability to integrate emotions into personal decision-making processes.
The Relations task measures the participant's ability to integrate emotions into decision-making processes that involve others.

factor structure) was established by setting a measure's loading in each factor to one in both groups; this measure was the reference loading for standardizing the other measures' loadings. When full metric invariance was not supported (i.e. model fit deteriorated significantly after setting additional constraints), the parameter for each measure was constrained to equivalence across groups one at a time. The fit of this model was compared against the fit of the previous model that had not shown significant deterioration in model fit, and the parameter

Table 2
Candidate models tested separately using CFA in schizophrenia and ASD.

Model	Comparison	χ^2	df	p	CFI	ΔCFI	TLI	RMSEA	SRMR	Decision
Within-Group Models										
O1. Schizophrenia – 1 factor model	–	57.122	20	<.001	0.839	–	0.775	0.134	0.075	Reject
O2. ASD – 1 factor model	–	76.752	20	<.001	0.761	–	0.666	0.158	0.081	Reject
O3. Schizophrenia – 2 factor model by Eack et al. (2009)	O3 to O1	45.162	19	<.001	0.887	0.048	.833	0.116	0.077	Reject
O4. ASD – 2 factor model by Eack et al. (2009)	O4 to O2	62.098	19	<.001	0.819	0.058	0.733	0.142	0.092	Reject
O5. Schizophrenia – 2 factor original model	O5 to O3	39.193	19	.004	0.913	0.026	0.871	0.102	0.060	Modify
O6. ASD – 2 factor original model	O6 to O4	66.706	19	<.001	0.799	0.020	0.704	0.149	0.075	Modify
O7. Schizophrenia – 2 factor modified model	O7 to O5	23.197	17	.143	0.973	0.060	0.956	0.059	0.049	Accept
O8. ASD – 2 factor modified model	O8 to O6	25.034	17	.094	0.966	0.167	0.944	0.065	0.048	Accept
O9. Schizophrenia – 3 factor model	O9 to O7	23.197	17	.143	0.973	0.000	0.956	0.059	0.049	–

Note. CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; RMSEA: Root Mean Squared Error of Approximation; SRMR: Standardized Root Mean Square Residual. Adequate fit is indicated when CFI and TLI ≥ .90 and good fit indicated when CFI and TLI ≥ 0.95, RMSEA ≤ 0.06, and SRMR ≤ .08 (Hu and Bentler, 1999).

Table 3
Standardized factor loadings and covariances for the configural model across groups. .

Factor	Task	Invariant	Schizophrenia	ASD
Standardized Loadings				
Emotional Experiencing	Faces	Yes	0.636*	0.557*
	Pictures	Yes	0.605*	0.379*
	Facilitation	No	0.606*	0.854*
	Sensation	Yes	0.590*	0.389*
Emotional Reasoning	Changes	Yes	0.730*	0.584*
	Blends	Yes	0.592*	0.361*
	Management	No	0.634*	0.517*
	Relations	Yes	0.676*	0.833*
Standardized Covariances (Correlations)				
Changes/Blends		No	0.205	0.552*
Management/Relations		No	0.426*	0.298
Emotional Experiencing/ Emotional Reasoning		Yes	0.751*	0.805*

Note. *parameter significant at $p < .05$.

equivalence was retained if the model fit did not differ significantly from the comparison model's fit. This procedure was reiterated for all parameters until a model with invariant parameters was finalized, thus establishing partial metric invariance.

Metric invariance was confirmed when constraining factor loadings of the configural-invariant model to equivalence across groups did not significantly deteriorate the fit relative to the configural-invariant model, indicating that both groups attribute similar levels of importance for each measure within its respective factor. This establishes that one group does not consider one measure to be more dominant within an emotion perception domain compared to the other group. Constraining all factor loadings to equality in schizophrenia and ASD significantly deteriorated model fit (Model 2). For loadings other than the reference indicator, where the CFI comparison indicated that the factor loading was equivalent across groups, the loading was constrained to equivalence, and the next loading was tested for loading equivalence (Milfont and Fischer, 2010). Thus, in these stepwise tests, partial metric invariance was established for MSCEIT across schizophrenia and ASD (Model 3). This indicated that schizophrenia and ASD participants respond in the same way for all MSCEIT tasks assessing the constructs of Emotional Experiencing and Emotional Reasoning except for the Facilitation and Management tasks. In other words, an increase in the emotion perception domain score is associated with a comparable increase in its respective measures except for Facilitation and Management in both groups.

Scalar invariance was then confirmed when additionally constraining intercepts of the metric-invariant model to equivalence across groups did not significantly deteriorate the fit relative to the metric-invariant model, indicating that both groups show equivalent values of a measure when the mean of its respective factor is set to zero. This establishes that one group does not show a different predicted value for a measure compared to the other group for a given emotion perception domain score. For measures with invariant factor loadings, all intercepts were constrained to equality across schizophrenia and ASD without significantly deteriorating model fit (Model 4). Thus, partial scalar invariance was established for MSCEIT, indicating that a given emotion perception domain score is associated with comparable values of its respective measures except for Facilitation and Management in both groups.

Taken together, the preceding analyses demonstrate that the groups operationalize the measures similarly and that mean differences are not attributable to response bias (Meredith, 1993). An additional measurement invariance analysis was subsequently conducted: error variance invariance was confirmed when constraining the residual variances and covariances of the measures to equivalence across groups for the scalar-invariant model did not significantly deteriorate the fit relative to the scalar-invariant model, indicating that both groups show similar levels of variance and covariances among measures that are not explained by their respective factors. This establishes that one group does not have more variance in a measure that is not explained by its respective emotion perception domain compared to the other group. For measures with invariant factor loadings and intercepts, residual variances and covariances of measures were constrained to equality in schizophrenia and ASD. All error variances were constrained to equality across schizophrenia and ASD without deteriorating model fit. However, constraining covariances between Changes and Blends and between Management and Relations significantly deteriorated model fit. Partial error invariance was thus established across groups (Model 5), indicating that performance in a measure that is not explained by its respective emotion processing domain is generally similar in both groups, except for that of Facilitation and Management, and the intercorrelations in this residual performance variability for two pairs of measures (Changes and Blends, Management and Relations) differs between groups.

Overall, the results of these analyses suggest that parameters for most MSCEIT measures are invariant across schizophrenia and ASD, indicating that individuals with these neurodevelopmental disorders attribute similar meaning to MSCEIT measures except for Facilitation and Management tasks. Given the small proportion of non-equivalent intercepts and that the invariant intercepts were not uniformly higher in one group than the other (Chen, 2008), the regression weights and expected values of MSCEIT measures in relation to the two emotion perception domains can be meaningfully interpreted in comparisons across schizophrenia and ASD. Thus, the final set of analyses focused on examining MSCEIT's structural invariance across schizophrenia and ASD.

Table 4
Fit indexes across models of measurement invariance and structural invariance.

Model	*Comparison*	χ^2	*df*	*p*	*CFI*	*ΔCFI*	*TLI*	*RMSEA*	*SRMR*	*Decision*
Measurement Invariance										
1. Full configural invariance (baseline): Equivalent form across groups	–	48.231	34	.054	.970	–	.950	.062	.048	Accept
2. Full metric invariance: Equivalent factor loadings across groups	2 to 1	66.939	40	.005	.943	.027	.920	.079	.132	Modify
3. Partial metric invariance: Invariant factor loadings constrained to equivalence across groups	3 to 1	52.155	38	.063	.970	< .001	.956	.059	.075	Accept
4. Partial scalar invariance: Invariant factor loadings and intercepts constrained to equivalence across groups	4 to 3	60.248	44	.052	.965	.005	.956	.058	.097	Accept
Structural Invariance										
5. Full factor variance invariance: Equivalent factor variances across groups	5 to 1	49.665	36	.064	.971	.001	.955	.059	.068	Accept
6. Full factor covariance invariance: Equivalent factor variances and covariances across groups	6 to 5	49.867	37	.077	.973	.002	.958	.057	.065	Accept

Note. CFI: Comparative Fit Index; TLI: Tucker-Lewis Index; RMSEA: Root Mean Squared Error of Approximation; SRMR: Standardized Root Mean Square Residual. Adequate fit is indicated when CFI and TLI ≥ 0.90 and good fit indicated when CFI and TLI ≥ 0.95, RMSEA ≤ 0.06, and SRMR ≤ 0.08 (Hu and Bentler, 1999).

3.5. Establishing structural invariance

To identify the structural-invariant model, factor variances were set to one and the mean of a factor for one group was set to zero. This group became the reference group, with each estimated parameter representing the deviation from the reference group's mean. Structural invariance was confirmed when factor variances and covariances are invariant across groups, suggesting that both groups show similar levels of variation within and across factors. This establishes that one group does not show more variance in an emotion perception domain nor more covariation across emotion perception domains compared to the other group. Using the configural model as the baseline model, constraining both factor variances to equality across schizophrenia and ASD did not significantly deteriorate model fit (Model 6). Good model fit was retained after additionally constraining the factor covariance to equality across schizophrenia and ASD (Model 7). Thus, MSCEIT's full structural invariance was established across schizophrenia and ASD, indicating that the two emotion perception domains and their relationship with each other are equivalent across these neurodevelopmental disorders.

Given that the age range differed between groups, invariance analyses were also conducted in the subsample of participants within the overlapping age range (18–45) (N = 101 schizophrenia and 103 ASD). The overall pattern of results remained similar in this subsample (see Supplemental Table 1).

4. Discussion

Extending the results of prior studies in schizophrenia (Eack et al., 2009; Lin et al., 2012), this study demonstrated that MSCEIT is represented by a two-factor structure in schizophrenia and ASD, comprised of Emotional Experiencing and Emotional Reasoning. To our knowledge, this study is the first extend MSCEIT's structure across these neurodevelopmental disorders, confirming MSCEIT's partial measurement invariance and full structural invariance in schizophrenia and ASD.

In contrast to prior work examining MSCEIT's factor structure in schizophrenia (Eack et al., 2009; Lin et al., 2012), where tasks involved in perceiving and understanding emotions loaded onto an emotional knowledge factor and tasks involved in facilitating and managing emotions loaded onto an emotion regulation factor, the two-factor model confirmed in this study indicated greater overlap among tasks involved in perceiving and using emotions loading onto an emotional experiencing factor and overlap among tasks involved in understanding and managing emotions loading onto an emotional reasoning factor. The current two-factor model aligns with the two-area emotional intelligence (EI) structure of MSCEIT proposed in normative samples by Mayer et al. (2003), with the Emotional Experiencing factor indicated by Experiential EI tasks and the Emotional Reasoning factor indicated by Strategic EI tasks. The two pairs of tasks that were allowed to correlate within the Emotional Reasoning factor were separated into two factors of Understanding Emotions and Managing Emotions in the three- and four-factor models. The excessively high intercorrelation of these two factors rendered the four-factor model inadmissible in schizophrenia, and the Understanding Emotion factor encompassed excessive variance on the Changes task in ASD, rendering the three- and four-factor models inadmissible in ASD. One possible reason why these two pairs of tasks show residual covariation is that the two-factor structure was based on a model which was originally confirmed in normative samples. This possibility is further supported by the finding that one of these emotional reasoning tasks (Changes) is the only task to show cross-group mean differences. Thus, although these two pairs of tasks show unique variance that can be parsed into two underlying constructs of emotional understanding and emotional management in normative samples (Fan et al., 2010), these pairs of tasks measure a single underlying construct of emotional reasoning in schizophrenia and ASD. To the extent that the factors reflect shared conceptual variance beyond shared method variance in these tasks, this finding suggests emotional reasoning may be less differentiated in these neurodevelopmental disorders than in controls.

The measurement model for MSCEIT was partially invariant across schizophrenia and ASD. Although the majority of tasks showed invariant factor loadings across schizophrenia and ASD, two factor loadings were noninvariant. Thus, in interpreting comparisons of the factor means and task scores for MSCEIT across schizophrenia and ASD, it is necessary to acknowledge differences between schizophrenia and ASD in the relative importance of the two noninvariant tasks on the respective factors. In particular, using emotions to facilitate actions (Facilitation) is particularly important for emotional experiencing in ASD compared to schizophrenia, whereas managing emotions in oneself and others (Management) is particularly important for emotional reasoning in schizophrenia compared to ASD. Notably, MSCEIT's Management branch (Management and Relations) are the only social cognitive measures in the MATRICS Consensus Cognitive Battery for cognitive assessment in schizophrenia (Nuechterlein et al., 2008).

The structural model for MSCEIT was fully invariant across schizophrenia and ASD, indicating that these neurodevelopmental disorders are associated with similar levels of variability and covariation in emotional experiencing and emotional reasoning abilities. Emotional experiencing and emotional reasoning were highly correlated in both schizophrenia (r = 0.751) and ASD (r = 0.805). Thus, across these neurodevelopmental disorders, skills involved in experiencing emotions are highly related with skills involved in reasoning about emotions. Taken together, schizophrenia and ASD show substantial overlap in the conceptualization of emotion processing as assessed using MSCEIT, extending previous literature demonstrating similar social cognitive deficits across these disorders (Sugranyes et al., 2011).

Overall, the results of multigroup CFA show that most MSCEIT scales, except for Facilitation and Emotions, can be validly compared across schizophrenia and autism. Thus, transdiagnostic comparisons of emotion perception abilities can be conducted using MSCEIT.

4.1. Considerations

This large, community-based sample in this study bears several strengths, including the narrow diagnostic criteria for both groups, the similarities between groups on key demographic characteristics, and the wide range of performance levels assessed in both groups. Compared to the schizophrenia sample in our original study (Eack et al., 2009), the schizophrenia sample in the current study is almost twice as large and adequately powered for testing structural models of MSCEIT.

However, certain limitations should be noted. Although mean age did not differ between the two groups and analyses in the subsample of participants within the overlapping age range did not change the overall pattern of results, emotion perception may change with age in different ways between ASD and schizophrenia (Fernandes et al., 2018). Furthermore, our sample consists of community-residing adults with ASD or schizophrenia who demonstrate significant cognitive and social disability. Thus, the ASD and schizophrenia groups may be more similar to each other than the broader population of adults with ASD and adults with schizophrenia, though some differences were observed in cognitive and social functioning across groups. Although few studies to date have directly compared cognitive or social deficits across ASD and schizophrenia, studies within diagnoses suggest that adults with ASD demonstrate similar levels of impairment in social functioning to adults with schizophrenia (Chamak and Bonniau, 2016; Velthorst et al., 2016). Overall, the deficits in cognitive and social functioning across the ASD and schizophrenia groups in our sample align with prior studies of adults with ASD and adults with schizophrenia.

Similarly, given that the ASD group was restricted to verbal adults, these findings may not generalize to non-verbal ASD adults and those with comorbid intellectual disability. In addition, only schizophrenia patients were assessed for substance abuse history, so it is unclear whether the ASD participants show similar levels of heterogeneity in substance abuse history compared to controls. Furthermore, all schizophrenia participants were stabilized on antipsychotic medication, which may affect social cognitive performance, though the effects of antipsychotic medication on social cognition are mixed (Kucharska-Pietura and Mortimer, 2013). More importantly, despite these possible differences between groups, structural invariance was established, supporting the generalizability of MSCEIT's factor structure across schizophrenia and ASD.

4.2. Applications

To compare emotion perception domain performance across schizophrenia and ASD for individuals who have completed the entire MSCEIT, each measure's factor loading (Table 3) can be multiplied by the measure's raw score. The sum of these weighted raw scores across the contributing measures yields the emotion perception domain factor score.

4.3. Implications

Aligning with emerging advances in studying transdiagnostic features of psychiatric and developmental disorders (Insel et al., 2010), our findings indicate that MSCEIT measurement of emotion perception is largely generalizable across ASD and schizophrenia. Our recent report of emotion processing improvements in ASD adults following Cognitive Enhancement Therapy is among the first to indicate that emotion perception in ASD adults can markedly improve through therapeutic approaches that have a proven track record of improving emotion perception in schizophrenia adults (Eack et al., 2018). To this end, we hope that MSCEIT's adoption for treatment evaluation in schizophrenia and ASD adults will spur the standardization of evidence-based treatments across the autism-schizophrenia spectrum.

Declarations of interest

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Supplementary materials

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