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Differential Profiles in Auditory Social Cognition Deficits between Adults with Autism and Schizophrenia Spectrum Disorders: a Preliminary Analysis

Russell H. Tobe, MD^{1,2}, Cheryl Corcoran, MD^{2,3}, Melissa Breland, MA¹, Anna MacKay-Brandt, PhD^{1,5}, Casimir Klim, BA², Stanley J. Colcombe, PhD¹, Bennett L. Leventhal, MD^{1,4}, Daniel C. Javitt, MD PhD^{1,2,3,*}

¹Nathan Kline Institute for Psychiatric Research, Orangeburg, NY

²Columbia University, Department of Psychiatry, New York, NY

³New York State Psychiatric Institute, New York, NY

⁴University of California San Francisco, Department of Psychiatry, San Francisco, CA

⁵Columbia University, Department of Neurology, Cognitive Neuroscience Division, New York, NY

Abstract

Impairment in social cognition, including emotion recognition, has been extensively studied in both Autism Spectrum Disorders (ASD) and Schizophrenia (SZ). However, the relative patterns of deficit between disorders have been studied to a lesser degree. Here, we applied a social cognition battery incorporating both auditory (AER) and visual (VER) emotion recognition measures to a group of 19 high-functioning individuals with ASD relative to 92 individuals with SZ, and 73 healthy control adult participants. We examined group differences and correlates of basic auditory processing and processing speed. Individuals with SZ were impaired in both AER and VER while ASD individuals were impaired in VER only. In contrast to SZ participants, those with ASD showed intact basic auditory function. Our finding of a dissociation between AER and VER deficits in ASD relative to Sz support modality-specific theories of emotion recognition dysfunction. Future studies should focus on visual system-specific contributions to social cognitive impairment in ASD.

*Corresponding Author: Nathan Kline Institute for Psychiatric Research, 140 Old Orangeburg Road, Building 35, Orangeburg, NY 10962. javitt@nki.fmh.org (D. Javitt).

Contributors

DCJ developed and oversaw the research protocol. RHT, CC, MB, and DCJ contributed to participant recruitment. RHT and MB conducted ADOS assessments. CC and CK collected the data. RHT, CC, CK, and DCJ performed the literature review. RHT, MB, AMB, SJC, and DCJ performed statistical analysis. All authors contributed to and approved the final manuscript.

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INTRODUCTION

Autism Spectrum Disorder (ASD) and schizophrenia (SZ) are complex neuropsychiatric disorders characterized by significant impairments in social cognition (Solomon et al., 2011). While natural history and symptom expression differentiate these disorders, overlap in risk genes and domains of functional impairment also exist (Crespi et al., 2010; Gilman et al., 2012; Rapoport et al., 2009; Watkins et al., 1988). Nevertheless, few studies have compared patterns of social cognition deficits across these two disorders, or have examined dissociations in impairment which may inform underlying pathophysiology.

Social cognition is the ability to process, store, and apply information about others. It includes a range of neural capabilities related to both visual (or facial) emotion recognition (VER) and auditory (or voice) emotion recognition (AER) (Sasson et al., 2011). Essential substrates for these processes include low level sensory regions that process cues such as face configuration or auditory tonal variation critical for conveying emotion, as well as higher order emotion regulatory regions of the brain such as limbic or prefrontal regions that play critical roles in maintaining representations of emotion precepts (Leppanen & Nelson, 2009).

Functional magnetic resonance imaging (fMRI) and human lesion studies demonstrate that VER processing involves a right-lateralized circuit including occipital face areas, fusiform and superior temporal gyri, somato sensory cortex, amygdala and both medial and dorsolateral prefrontal regions (Adolphs et al., 2002; Dal et al., 2013; Jehna et al., 2011; Philippi et al., 2009; Vuilleumier et al., 2004). Deficits in AER, notably in individuals with congenital and acquired amusia, support the relevance of bottom-up auditory impairments through changes in primary auditory cortex but also impairments in higher-order cortical regions (Sarkamo et al., 2009; Sarkamo et al., 2010), often overlapping with areas responsible for VER.

Of the two emotion recognition domains, VER has been more extensively studied than AER in both ASD and SZ, using well-validated batteries such as the Penn Emotion Recognition Test (ER-40) (Gur et al., 2010), Reading the Mind in the Eyes test (Baron-Cohen et al., 2001), and the Ekman 60 Faces Test (Diehl-Schmid et al., 2007). Robust deficits have been observed in both schizophrenia and ASD, although the underlying neural mechanisms remain obscure (Bolte & Poustka, 2003; Eack et al., 2013; Kohler et al., 2010). For schizophrenia, it has been hypothesized that VER deficits are significantly related to the inability to process low level visual information, particularly that conveyed by the magnocellular visual pathway (Bedwell et al., 2013; Butler et al., 2009; Javitt, 2009). Though disturbances in low level visual processing are reported in ASD (Greenaway et al., 2013; Spencer et al., 2000), their contributions to VER impairments have not been established.

Batteries assessing AER are less well-established, with fewer manuscripts addressing patterns of deficit in neuropsychiatric disorders. In recent years, we have adapted and validated several social cognition tests to study schizophrenia, including the Juslin & Laukka Auditory Emotion Recognition Battery (JL-AER); (Juslin & Laukka, 2003) and the Ross

Attitudinal Prosody Battery (RAP); (Orbelo et al., 2005). Both have strong psychometric properties and sensitivity to deficits in AER and sarcasm recognition, respectively, in SZ (Gold et al., 2012;Kantrowitz et al., 2014)

Investigations of AER within ASD are limited. Studies evaluating AER of basic emotion (happiness, sadness, fear, anger, surprise and disgust) have yielded inconsistent findings (Rutherford et al., 2002;Hollander et al., 2007;Boucher et al., 1998;Baker et al., 2010) despite reports of impaired sensory activation to basic vocal stimuli (Gervais et al., 2004), while AER tasks evaluating more complex emotion types such as those in the ‘Reading the Mind in the Voice’ test have been demonstrated to be impaired in ASD participants (Golan et al., 2007). To our knowledge, AER has only been studied in parallel with VER in one study of ASD children, who demonstrated impairment relative to healthy control participants(Taylor et al., 2015). In contrast, participants with SZ show severe deficits in basic VER and AER. AER impairment (as well as sarcasm detection) in SZ correlate with deficits in basic auditory sensory processing, as reflected in impaired tone matching ability, supporting a bottom-up model of social cognitive impairment. However, AER deficits in populations with SZ survive covariation for specific sensory impairments, suggesting parallel high level contributions to overall social cognitive impairment (Gold et al., 2012).

In SZ, the ER40 and JL-AER possess similar discrimination power for detecting emotion recognition impairments; moreover, deficits detected by each of these instruments correlate with modality specific reductions in sensory processing (Gold et al., 2012). The RAP also has been shown to be sensitive to prosodic processing impairments compared to deficits in basic auditory processing. Application of these batteries in concert to ASD individuals relative to SZ and control individuals thus permits comparison of patterns of social cognitive dysfunction across, as well as within, specific neuropsychiatric disorders. Herein, we apply these tasks within ASD, SZ and healthy control populations to determine if unique performance profiles (in presence or intensity of impairment) may lend insight into shared and differential neurobiology.

METHODS

Participants:

The ASD sample of 19 individuals was ascertained from the central research databases at both the Nathan Kline Institute (NKI) and New York State Psychiatric Institute (NYSPI). Participants with ASD were compared to a sample of 92 participants (inpatient or outpatient) with schizophrenia or schizoaffective disorder and 73 healthy control participants. Diagnoses were based on research consensus clinical diagnosis determined after administration of the Structured Clinical Interview for DSM-IV (SCID)(First MD et al., 1994). ASD diagnoses were confirmed by application of DSM-IV criteria, and for 9 out of 19 individuals, clinical information was obtained from the Autism Diagnostic Observation Schedule, Second Edition (ADOS) administered by a research reliable examiner. ASD participants were considered “high-functioning” because education levels were similar to that of healthy participants (Table 1). Healthy control participants were obtained through a central Volunteer Recruitment Pool at NKI and through independent postings and advertisements. The investigation was carried out in accordance with the latest version of the

Declaration of Helsinki, the study design was reviewed and approved by the institutional review boards of both NKI and NYSPI; informed consent was obtained from the participants after the nature of the procedures had been fully explained.

Procedure:

Tone matching was assessed using the Tone Matching Test (TMT) with pairs of 100-msec tones in series, with a 500-msec intertone interval (Gold et al., 2012). Within each pair, tones (50% each) either were identical or differed in frequency by a specified amount in each block (2.5%, 5%, 10%, 20%, or 50%). Participants reported whether the pitch was the same or different. Three base frequencies (500, 1000, and 2000 Hz) were used within each block to avoid learning effects. In all, the test consisted of five sets of 26 pairs of tones.

The auditory emotion recognition (AER) battery was adapted from the JL-AER. It consisted of 32 audio recording stimuli of native English speakers conveying four emotions while reading sentences otherwise neutral in content: anger, fear, happiness and sadness or no emotion (Gold et al., 2012). Participants were asked to rate both the affective category and intensity of emotion.

Attitudinal prosody (sarcasm perception) was assessed using the attitudinal subtest of the RAP (Orbelo et al., 2005). This battery consists of 10 semantically neutral sentences recorded by a female speaker in both a sincere and a sarcastic manner for a total of 20 unique utterances (10 pairs). These utterances were repeated twice for a total of 40 stimuli. After each stimulus, participants were instructed to state whether the speaker was sincere or sarcastic.

Recognition of visual emotion was assessed using the ER-40 (Gold et al., 2012; Gur et al., 2010) which utilizes 40 color photographs of adult faces expressing four basic emotions (happiness, sadness, fear, anger) along with neutral expressions. Eight photographs from each category are presented in random order. Using a computer mouse, participants are asked to select the emotion that best describes the photograph from five choices listed on the screen; they choose as rapidly as they can without sacrificing accuracy.

Processing speed was assessed using the digit symbol coding and symbol search subtests of the WAIS-III (Wechsler, 1997). Performance on these two subtests was combined to form a processing speed index (PSI) (Gold et al., 2012).

Data Analysis:

Between-group comparisons were performed using multivariate ANOVA, with follow-up independent-sample *t* tests, as required (Dunnett). The relationship between the social cognition measure (tone matching, AER, VER, and RAP) and a main effect of diagnosis was assessed using analysis of covariance (ANCOVA) with education level, PSI, age, and gender as covariates. Tone matching was also evaluated as a covariate in models of AER and RAP. In addition to main effects, we considered all 2-way interactions. Non-significant terms were eliminated via backward stepwise regression with the constraint that all lower-order component terms were included in the model, regardless of statistical significance. Analysis of chlorpromazine dose equivalence on each social cognition measure was performed with

multivariate ANOVA for the schizophrenia subgroup. Repeated measures ANOVA were used to evaluate effects of emotion and emotion by group interactions. All statistical tests were two-tailed, with alpha set at 0.05, and were computed using SPSS, version 22.0 (SPSS, Chicago). Effect sizes (d) were calculated based upon as mean difference divided by pooled standard deviation between groups, and interpreted according to the conventions of Cohen (Cohen, 1992).

RESULTS

General function:

Groups did not differ by age ($F = .92$, $df = 2, 181$, $p = 0.40$). Mean socioeconomic status (SES) differed significantly across groups ($F = 39.22$, $df = 2, 138$, $p < .001$), with ASD subjects showing lower SES vs. controls ($t = 2.66$, $df = 78$, $p = 0.01$, $d = .60$) but greater SES than individuals with SZ ($t = 3.27$, $df = 78$, $p = 0.002$, $d = .74$). Education differed significantly across groups ($F = 32.33$, $df = 2, 175$, $p < 0.001$), with ASD subjects (mean grade 14.9, $SD = 2.4$) showing no difference vs. controls (mean grade 13.5, $SD = 2.6$) ($t = .203$, $df = 86$, $p = .84$, $d = 0.06$). SZ participants had lower grade achievement (mean grade 12.2, $SD = 2.3$) relative to both ASD subjects ($t = 4.39$, $df = 104$, $p < 0.001$, $d = 0.861$) and controls ($t = 7.64$, $df = 160$, $p < 0.001$, $d = 1.20$). PSI also differed significantly across groups ($F = 67.02$, $df = 2, 157$, $p < .0001$), with ASD patients showing impaired performance relative to controls ($t = 2.89$, $df = 24.83$, $p < .01$, $d = .85$), but superior performance relative to SZ individuals ($t = 2.72$, $df = 20.49$, $p = .01$, $d = .76$).

Emotion Recognition Task Analysis

Across the three groups, there was a highly significant main effect of group ($F = 30.91$, $df = 2, 156$, $p < 0.001$) and a significant modality by group interaction ($F = 3.24$, $df = 2, 156$, $p = 0.042$). Based upon this, separate analyses were performed for the VER and AER measures.

For VER, the main effect of diagnostic group was significant ($F = 6.99$, $df = 2, 130$, $p = 0.001$), even when adjusted for covariates of age, gender, education level, and PSI. Significant *post hoc* differences were observed for participants with ASD ($t = 2.73$, $df = 21.18$, $p = 0.013$, $d = 1.19$) and Sz ($t = 7.07$, $df = 126.87$, $p < 0.001$, $d = 1.24$), relative to controls. However, there was no significant difference between the two patient groups ($t = .90$, $df = 94$, $p = 0.37$, $d = 0.19$) (Figure 1). A repeated measures ANOVA with within-subjects factor of VER subscale (happy, sad, angry, fear, neutral), between-subjects factor of group and covariates for age, gender, education level and PSI indicated Mauchly's test of sphericity had been violated ($\epsilon = 75.26$, $df = 9$, $p < 0.001$). Therefore degrees of freedom were estimated using the Greenhouse-Geisser correction ($\epsilon = 0.82$). The main effect of emotion was significant following Greenhouse-Geisser correction ($F = 2.55$, $df = 3.28$, 426.06 , $p = 0.05$). However, no significant group X emotion interaction effects were found ($F = 1.54$, $df = 6.56$, 426.06 , $p = 0.16$).

For AER, the main effect of diagnostic group was also significant ($F = 21.30$, $df = 2, 145$, $p = 0.02$), even when adjusted for covariates of age, gender, education level, TMT and PSI. However, although participants with SZ showed impaired AER performance relative to

controls ($t = 8.09$, $df = 163$, $p < 0.001$, $d = 1.27$), participants with ASD were not impaired ($t = 1.59$, $df = 90$, $p = 0.12$, $d = 0.34$) and, moreover, showed significantly better performance than those with Sz ($t = 3.03$, $df = 109$, $p = 0.003$, $d = 0.58$) (Figure 1).

Performance relative to tone matching ability

For tone matching, the main effect of diagnostic group was significant ($F = 8.24$, $df = 2$, 146 , $p < 0.001$), even when adjusting for age, gender, education level, and PSI. In *post hoc* tests, participants with SZ had significant deficits relative to healthy controls ($t = 7.03$, $df = 162$, $p < 0.001$), $d = 1.10$ whereas participants with ASD had intact tone matching performance ($t = .47$, $df = 90$, $p = 0.67$, $d = -0.10$) that was significantly better than for Sz ($t = 4.61$, $df = 108$, $p < 0.001$, $d = 0.89$) (Figure 1).

Although AER and tone matching were impaired only in SZ, tone matching was a significant predictor of AER performance controlling for group, age, and gender ($F(1, 177) = 36.98$, $p < .001$). The correlation was also significant in separate models for each group controlling for age and gender ($F(1, 87) = 20.88$, $p = .006$ for SZ; $F(1, 15) = 12.17$, $p = .003$ for ASD; $F(1, 69) = 6.54$, $p = .01$ for control). Further, as demonstrated previously for healthy control vs. schizophrenia participants (Gold et al., 2012), when sensory detection (TMT, $F = 13.6$, $df = 1$, 136 , $p < 0.001$), emotion identification (ER-40, $F = 9.73$, $df = 1$, 136 , $p = 0.002$) and general cognitive speed (PSI, $F = 5.07$, $df = 1$, 136 , $p = 0.026$) were considered collectively, the across group difference (SZ, ASD, control) in AER was no longer significant ($F = 0.91$, $df = 2$, 136 , $p = 0.40$), suggesting that these factors accounted for the AER deficit in participants with schizophrenia vs. controls as well as between SZ and those with ASD.

Sarcasm detection (Attitudinal Prosody)

For RAP performance, the main effect of diagnostic group was significant ($F = 53.63$, $df = 2$, 178 , $p < 0.001$) and remained so when controlling for age, gender, education level, TMT, and PSI. *Post hoc* tests demonstrated that RAP performance was impaired for participants with either SZ ($t = 10.40$, $df = 160$, $p < 0.001$) or ASD ($t = 2.29$, $df = 89$, $p = 0.024$), relative to healthy controls, although performance by participants with ASD was superior to those with Sz ($t = 4.05$, $df = 107$, $p < 0.001$) (see Figure 1).

To further evaluate the pattern of deficit, repeated measures ANOVA was conducted across the three groups, comparing rates of misses (i.e., identifying sarcastic stimuli as sincere) versus false alarms (i.e. identifying sincere stimuli as sarcastic). In addition to a significant main effect of group ($F = 54.95$, $df = 2$, 178 , $p < 0.001$), there was a highly significant group X error type interaction ($F = 9.35$, $df = 2$, 178 , $p < 0.001$). Separate analyses were therefore conducted for rates of misses and false alarms. For misses, there was significant heterogeneity across groups ($F = 34.58$, $df = 2$, 178 , $p < 0.001$); participants with ASD were similar to controls ($t = .94$, $df = 89$, $p = 0.35$, $d = 0.20$), and superior to participants with SZ ($t = 3.95$, $df = 107$, $p < .001$, $d = 0.76$). By contrast, for false alarms there was again significant heterogeneity across groups ($F = 12.22$, $df = 2$, 178 , $p < 0.001$). However, in this case, participants with ASD showed error rates similar to participants with SZ ($t = .58$, $df = 107$,

$p=0.56$, $d=0.11$) and significantly higher than controls ($t = 3.08$, $df = 22.08$, $p=0.006$, $d=1.31$).

DISCUSSION

Impairment in social cognition is a core symptom in both ASD and SZ and may be driven by impaired emotion recognition, at least in part. Recently, studies have shown similar magnitude deficits in both auditory (AER) and visual (VER) recognition in schizophrenia, consistent with involvement of both auditory and visual systems (Gold et al., 2012). Using the same instruments, we now demonstrate that subjects with ASD show deficits only in VER, suggesting relative sparing of the AER system. Though often surviving corrections for a number of salient population characteristics, these findings should be considered preliminary. All potential differential variables impacting social exposure such as hospitalization history, domains of symptom expression and symptom severity were not fully captured and may have contributed to the results.

In general, emotion processing may be viewed as first involving sensory-specific mechanisms that extract necessary auditory and visual information, and then involving sensory non-specific emotional circuits in limbic or frontal regions. To the extent this formulation is correct, the preservation of AER in ASD suggests not only that low level auditory systems are intact, but also that higher level, sensory-independent functions may also be unaffected. By contrast, high functioning ASD participants show the same degree of deficit in VER as do individuals with SZ despite having preserved processing speed. In SZ, deficits in both AER and VER are strongly tied to overall psychosocial function. The present study therefore suggests that VER deficits may represent a significant source of social impairment even in high functioning ASD patients.

Our findings regarding VER deficits in ASD and SZ are consistent with a large number of prior investigations which have shown significant deficits in facial affect recognition in ASD and SZ. Moreover, the relatively large deficit observed in our ASD cohort is consistent with the meta-analytic finding that deficits may increase in magnitude with age in ASD, reflecting relatively deficient maturation across development (Lozier et al., 2014). Although some investigators have suggested that VER deficits in ASD reflect dysfunction primarily in basic face-processing regions, such as the fusiform gyrus, others have suggested that the key dysfunction lies in higher order regions. Increasing evidence, however, points to complex neural networks underlying face processing (Nomi & Uddin, 2015). In the present study, the finding of intact AER argues strongly in favor of sensory-specific deficits in face processing in ASD. This is consistent with literature supporting face processing deficits in individuals with ASD such as differences in facial scanning and cueing in participants with ASD, relative to neurotypical controls (Harms et al., 2010). Though ASD participants identify neutral faces with similar accuracy and speed relative to neurotypical controls, functional neuroimaging during such paradigms demonstrates hypoactivation of brain regions comprising the “core face network” including fusiform gyrus, the occipital face area, STS, inferior frontal cortex and amygdala. Tasks involving facial affect recognition in ASD show similar hypoactivation in the core face network in addition to impaired behavioral performance (Nomi & Uddin, 2015).

By contrast, AER has been studied in ASD to only a limited degree, with somewhat conflicting results. Hollander et al. (2007) examined the effects of oxytocin on AER performance in adults with ASD using a battery similar to ours, but did not explicitly include a control group, leaving absolute level of performance relative to controls unclear. Gervais et al. (2004) showed impaired cortical activation to vocal vs. non-vocal auditory stimuli using fMRI, but did not explicitly evaluate modulation by tonality. Taylor et al. (2015) showed impairment of VER and AER in ASD children but did not evaluate teens or adults. Bonnel et al. (2010) showed enhanced pure tone pitch discrimination among children with autism as diagnosed by a history of speech delay. By contrast, Asperger syndrome individuals without a history of speech delay had intact discrimination both of simple tones, and of spectrally rich (i.e. frequency modulated) tones. Our findings of intact simple tone processing in high functioning subjects with ASD, along with intact prosodic discrimination of speech samples, is thus consistent with the findings of Bonnel et al. (2010). This suggests that deficits in emotion processing in ASD are face-specific and hence likely related to more basic face-processing deficits, unlike SZ, in which emotion recognition deficits across sensory domains argues for a more global pathophysiology, with greater neural complexity.

One reason why AER ability may have been relatively understudied in both ASD and SZ until recently, is that there were few validated AER assessment measures previously available. We used a battery that is sensitive to AER deficits in SZ (Gold et al., 2012), finding no AER deficit in ASD individuals, but deficit in VER similar to SZ. Overall, these findings add to the literature on intact auditory sensory processing in ASD, even in individuals with significant VER impairment.

To our knowledge, only one prior study (Eack et al., 2013) has directly evaluated visual emotion recognition impairment across ASD and SZ populations. Though individuals with either ASD or SZ separated from control participants in our sample, Eack et al. (2013) demonstrated selective impairment in the group with ASD ($p = 0.004$, $d = -0.84$) but not SZ ($p = 0.126$, $d = -0.40$) relative to healthy controls. Use of different modalities for evaluation of speed of processing limits the ability to directly compare patient populations between these studies. However, though ER-40 performance (total correct response) for ASD (avg = 30.77, SD 4.14) and healthy (avg = 34.25, SD 2.40) participants in the Eack et al. did not differ from our sample of ASD (avg = 30.53, SD = 4.94; $p = 0.086$) and healthy (avg = 33.74, SD = 2.63; $p = 0.40$) participants, significant differences were determined between participants with SZ in the Eack et al. sample (avg = 32.44, SD 4.34) versus our sample (avg = 29.48, SD = 4.43; $p < 0.001$, $d = 0.675$ vs. Eack et al.). This differential ER-40 performance in the SZ participant groups between these two studies may suggest that individuals with SZ in our study had worse symptomatology overall, or at least with respect to social cognition. Irrespective of this difference, both studies argue for impaired VER performance in ASD relative to healthy controls. Because tone matching and AER measures were not included in Eack et al. (2013), divergence between AER and VER could not be determined in that study and, in our investigation, argue against close commonality in either deficit pattern of pathogenesis across disorders.

A final finding of interest in the present study is the divergence of findings regarding processing of attitudinal prosody (sarcasm) in individuals with ASD vs. SZ. Sarcasm is

conveyed by a subtle shift in tone of voice, whereby a small change in base pitch and emphasis leads to a dramatic shift in meaning. In individuals with SZ, deficits in ability to detect small changes in pitch, as reflected in impaired tone matching ability, lead to reduced sensitivity to attitudinal prosody and thus impaired sensitivity to sarcasm as reflected in increases in both false positives and false negatives. By contrast, patients with ASD show no difficulty detecting sarcastic utterances, consistent with their intact tone matching ability, but nevertheless show a significant tendency to perceive sincere stimuli as sarcastic. These findings may reflect cognitive “style” to a greater extent than a pure discrimination deficit, but nevertheless may contribute to social impairment within the group with ASD. These findings are thus consistent with prior reports of ToM impairment in ASD, in relationship to reductions in empathy (Mathersul et al., 2013), and suggest need for further investigation.

Limitations

First, while our measures of emotion recognition are valid and comprehensive, we did not assess audio-visual integration in social cognition in ASD and SZ; this will be the focus of future studies. Second, there is some possibility that the finding of isolated VER impairment in ASD could be due to differential sensitivity of the VER and AER tasks in ASD; however, our prior investigations in SZ have shown similar sensitivity between the two measures (Gold et al., 2012). Third, dopamine antagonists were uniformly prescribed to participants with SZ but only one with ASD. While eliminating any possibility of medication contribution to our findings was not possible, we found no correlation of chlorpromazine equivalent dosage with emotion recognition in SZ (Gold et al., 2012). Fourth, while we considered processing speed and educational level in analyses, other confounds that differ between ASD and SZ could have contributed to variable performance on social cognition tasks, particularly since many SZ participants were inpatient. For instance, intensity and duration of negative symptoms in the SZ group was not obtained. It is reasonable to consider that individuals with greater intensity and duration of negative symptoms would have less interpersonal interaction and, therefore, less opportunity to develop social cognition skills. In future investigations, symptom severity and broader cognitive characterizations may clarify drivers these differential emotion recognition profiles. Fifth, several analyses were exploratory or *post hoc* and should be interpreted with caution, as they were not hypothesis-driven. Finally, biological correlates, such as electroencephalography, eye tracking, and neuroimaging were not investigated in this study. Future investigations of biological correlates with these social cognition paradigms could provide insights into differential cortical processing in these groups.

Conclusions

In summary, clinical research has largely been conducted within diagnostic groups. By contrast, recent initiatives such as the NIMH Research Domain Criterion (RDoC) initiative encourage research dimensionally across populations. Though results should be considered preliminary given the above limitations, the present study demonstrates both commonalities and differences in patterns of social cognitive impairment across ASD and SZ, and thus suggests that comparison across, as well as within, groups may shed unique light into underlying pathophysiological mechanisms. In specific, the present study encourages more research into local visual mechanisms underlying the highly significant VER deficits in

ASD. Understanding shared and differential neurobiology amongst sensory processing pathways may inform further strategies in cognitive remediation and treatment.

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Figure 1. Relative Between-Group Performance on Social Cognition measures

Significant difference between groups at $p < 0.05$ are demonstrated for visual emotion recognition via Penn Emotion Recognition Task with $ASD = SZ < Ctl$, basic acoustic detection via the Tone Matching Task with $SZ < ASD = Ctl$, auditory emotion recognition via the adapted Juslin & Laukka Auditory Emotion Recognition Battery with $SZ < ASD = Ctl$ and attitudinal prosody via the Ross Attitudinal Prosody Battery with $SZ < ASD < Ctl$. Error bars indicate standard error of the mean. *Indicates between group significant difference ($p < 0.05$).

SZ = Schizophrenia Participants, ASD = Autism Spectrum Disorder Participants, Ctl = Comparison Participants.

Table 1.

Demographics by Group (Schizophrenia, Autism Spectrum Disorder, and No Diagnosis Comparison Group)

Variable	Schizophrenia Group (N=92)	ASD Group (N=19)	Comparison Group (N=73)	P-value	Post-hoc t-tests
	N (%)	N (%)	N (%)		
Male	79 (86%)	17 (89%)	45 (62%)	<0.001	(S = ASD) > NDC
	M (SD)	M (SD)	M (SD)		
Age	37.8 (10.4)	39.4 (12.5)	36.0 (11.8)	0.40	S = AS = NDC
Highest Grade Achieved	12.2 (2.3)	14.9 (2.4)	13.5 (2.6)	<0.001	S < (ASD = NDC)
Processing Speed Index	79.5 (11.0)	93.0 (20.7)	107.8 (15.9)	<0.0001	S < ASD < NDC

Pair-wise comparison by Group (Schizophrenia (S), Autism Spectrum (AS), No Diagnosis Comparison (NDC)) for age, education, Processing Speed Index, and gender. With respect to post-hoc t-tests, arrows indicate direction of significant group differences (all $ps < .05$) while equal signs indicate no statistically significant group difference.