Social Brains, Social Bodies:

The Role of Personality in Embodied Emotion

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Under the Mentorship of Dr. Sohee Park

Abstract

Accurate emotion perception is essential for adaptive social functioning. Abnormal emotion perception and associated social impairments are core features of neuropsychiatric conditions such as schizophrenia and autism. Such deficits extend to healthy individuals who share latent liability for these conditions, such as those with elevated schizotypal or autistic traits. Although much is known about emotion perception deficits in the schizophrenia- and autism-spectrum, underlying mechanisms have not been elucidated. One proposed mediating mechanism is alexithymia, a difficulty labeling and describing feelings. In turn, alexithymia is associated with abnormal interoception and experience of embodied emotion. The goal of the current study was to examine alexithymia's contribution in the impact of schizotypal and autistic traits on embodied emotion, as assessed by an emotion perception task that asks participants to discriminate emotions from the gait of polygonal avatar walkers and a visual body mapping task that asks participants to map emotions onto an outline of a body. Results indicated negative correlations between low-threshold emotion perception via gait and autism-spectrum quotient ($\rho = -0.23$, $p < 0.05$), as well as positive schizotypy ($\rho = -0.28$, $p = 0.01$) but not alexithymia. Decreased emotion perception was associated with decreased report of embodied emotion, on the body mapping task. The study also replicated previously demonstrated correlations between alexithymia, schizotypy, and autism-spectrum quotient ($p < 0.05$), serving as further validation of the AQ-10 item version. In summary, the current study further clarifies our understanding of emotion perception in the extended phenotypes of autism- and schizophrenia-spectrum, while also indicating connections between interpersonal and intrapersonal embodied emotion.

Acknowledgements

~ First, I give my dearest thanks to Dr. Park, without whom neither this project nor my program of research could exist. You were the "S.Park" that made me excited to pursue a career in science. Know that you have my greatest admiration and appreciation—now and forever.

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Table of Contents

List of Tables

List of Figures

"Emotion always has its roots in the unconscious and manifests itself in the body."

~Irene Claremont de Castillejo (*Knowing Woman: A Feminine Psychology*, 1997)

Introduction

Emotion Perception

Emotion perception refers to an individual's ability to extract emotional information from social stimuli such as voices, faces, or gait. This ability allows humans to adaptively function in a social world that is dynamic and fast-paced. The neural architecture that supports the processing of social and emotional information—collectively termed the "social brain network"—may have emerged as a way to distinguish humans (a species of relatively moderate physical stature) from other, more physically imposing animals (Dunbar, 1998). As such, these social-cognitive abilities, including emotion perception, serve adaptive functions in the "real world" and correlate positively with real life social outcomes such as negotiation success (Elfenbein, Foo, White, & Tan, 2007).

While emotion perception can be studied using a variety of stimuli, the most typically utilized stimuli are faces. Early studies of facial affect by Ekman identified six basic emotions that can be signaled through facial communication: anger, fear, happiness, sadness, surprise, and disgust (Ekman, 1993; Ekman & Friesen, 1969). Even today, many emotion perception tasks focus on the ability to recognize and label these basic emotions, and how this ability is altered in various clinical populations. Since the work of Ekman, affective scientists have now expanded the framework of facial affect to account for combinations of emotions (Martin, Niewiadomski, Devillers, & Buisine, 2006), more complex emotions (Martinez & Du, 2012), and dynamic face movements instead of only still images (O'Toole, Roark, & Abdi, 2002).

While comparatively neglected in the literature, we use a variety of channels to perceive and express emotions in the real world such as voices, smells, and bodily cues. Notably, emotion perception can involve the processing of cues from gait patterns, especially when the stimuli are at a distance and/or if faces cannot be readily perceived (Atkinson, Tunstall, & Dittrich, 2007; de Gelder, 2006). In contrast to faces, which can only be viewed at close proximity, gait patterns can provide valuable emotional and social information to the viewer from a greater distance (Ikeda & Watanabe, 2009). In real life, much of our social perception of other humans occurs through the recognition of emotion from gait, which can influence who we choose to approach and interact with. For instance, we may be more likely to approach an unfamiliar person walking in the distance if their gait pattern indicates happiness rather than anger or fear. As much of our social environment is determined even before face-to-face interactions occur, it is essential to expand the study of full-body related emotion perception.

Deficits in Emotion Perception

As properly functioning emotion perception is vital for adaptive social interaction, those with deficits in affect recognition can face difficulty in navigating complex human social networks. Two disorders that are commonly associated with deficits in emotion perception are autism spectrum disorder (ASD) and schizophrenia (SZ) (Couture, Penn, Losh, Adolphs, Hurley et al., 2010; Hubert, Wicker, Moore, Monfardini, & Duverger 2007; Kohler, Turner, Bilker, Brensinger, Siegel, Kanes, Gur, & Gur, 2003; Lozier, Vanmeter, & Marsh, 2014; Peterman, Christensen, Giese, & Park, 2014). Members of these diagnostic groups also show altered activity and connectivity of brain networks associated with social-cognitive processing (Ciaramidaro, Bölte, Schlitt, & Hainz, 2015; Pinkham, Hopfinger, Pelphrey, Piven, & Penn, 2008). For individuals with ASD and SZ, deficits in emotion perception and social cognition interfere with the ability to adaptively function in social aspects of life such as succeeding in a career and forming close relationships.

While emotion perception deficits are quite pronounced among individuals diagnosed with ASD or SZ, neurotypical individuals with high levels of autistic or schizotypal traits may also exhibit decreased abilities. It is possible to assess these traits in the general population, with self-report measures such as the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) and the autism-spectrum quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Individuals with high scores on the AQ have shown impairment in emotion perception tasks involving facial affect recognition (Poljac, Poljac, & Wagemans, 2013) and emotion recognition from eye stimuli (Miller & Saygin, 2013). Individuals with high AQ also show difficulty distinguishing between biological and non-biological motion (Miller and Saygin, 2013). Nonetheless, other research has shown contradictory results, with high AQ individuals showing no associated deficits in emotion perception abilities (Wright, Clarke, Jordan, Young, Clarke et al., 2008). Similarly, studies have shown decreased performance on facial affect recognition tasks for individuals with high levels of schizotypal traits (Mikhailova, Vladimirova, Iznak, Tsusulkovskaya, & Sushko, 1996; Miller & Lenzenweger, 2012; Platek, Fonteyn, Myers, & Izzetoglu, 2005; Poreh, Whitman, Weber, & Ross, 1994). However, other studies have shown that schizotypy is not associated with decreased emotion perception abilities (Toomey & Schuldberg, 1995; Waldeck & Miller, 2000). Thus, whether or not high scores on the AQ and SPQ are associated with impaired emotion perception remains unclear.

One possible explanation for these inconclusive results is a high co-occurrence of schizotypal and autistic traits with alexithymia (Lockwood, Bird, Bridge, & Viding, 2013;

Seghers, McCleery, & Docherty, 2011). Alexithymia refers to an inability to adequately identify and describe one's own emotions (Lane, Ahern, Schwartz, & Kaszniak, 1997). The most commonly used metric of alexithymia is the Toronto Alexithymia Scale (TAS-20; Bagby, Parker, & Taylor, 1994). Alexithymia research often focuses on the personal experience of complex affective states and how this relates to affective sharing and empathy (Decety & Moriguchi 2007; Moriguchi, Decety, Ohnishi, Maeda, Mori, & Nemoto, 2007). Some researchers propose that alexithymia and not the presence of clinical symptomology, per se, leads to decreased social-cognitive functioning in groups such as ASD and schizophrenia; this has been dubbed the "alexithymia hypothesis" (Bird & Cook, 2013). There is also evidence that "lower-level" emotion perception abilities (e.g., detecting and rating the intensity of facial expressions) may be negatively impacted by alexithymia (Prkachin, Casey, & Prkachin, 2008). If there is, in fact, an association between high alexithymia and lower-level emotion perception deficits, perhaps the inconclusive findings involving AQ and SPQ scores could be explained by mediation of the relationship between these traits and emotion perception abilities by alexithymia. Previous research shows such mediation of the relationship between AQ/SPQ scores and empathy by alexithymia (Aaron, Benson, & Park, 2015). Evidence of such a mediation relationship for alexithymia and emotion perception could extend the "alexithymia hypothesis" relating alexithymia and empathy to also include lower-level perceptual processes that contribute to emotion processing. While this would reveal possible downstream effects of alexithymia, it still does not explain the underlying mechanism. Although the etiology of alexithymia is still somewhat unclear, many psychologists theorize that it stems from core deficits in interoceptive awareness and the experience of embodied emotion.

Embodied Emotion and Interoceptive Awareness

Interoception refers collectively to the bodily signals that arise from an individual's physiological states and influence cognition and behavior. "Interoceptive awareness" is one's ability to consciously intuit and interpret this bodily information (Cameron, 2001). Psychologists have been aware of connections between physiological and emotional information as early as when William James (1884) presented his theories of emotion. Modern affective science researchers suggest that bodily awareness is essential for emotional awareness (Silani, Bird, Brindley, Singer, Frith, & Frith, 2008; Singer, Critchley, & Preuschoff, 2009), and thus, elevated alexithymia may be caused primarily by deficits in interoceptive awareness (Herbert, Herbert, & Pollatos, 2011). This theory is also backed by recent research showing associations between heightened alexithymia and decreased activation in the anterior insula and other areas of the "interoceptive cortex" (Bird, Silani, Brindley, White, Frith et al., 2010; Ihme, Dannlowski, Lichev, Stuhrmann, Grotegerd et al., 2013). Because of this relationship, inability to consciously reflect on internal bodily states may result in decreased emotional awareness at multiple levels of affective processing.

One process that is directly related to interoceptive awareness and significantly contributes to higher-level emotional processing is embodied emotion. Broadly conceptualized, embodied emotion refers to one's conscious awareness of the experience of emotions as related to their own body, as well as the unconscious activation of somatic states associated with specific emotions. Research shows that thinking about or actively experiencing emotional states results in the activation of relevant somatic states. For example, social rejection is associated with physical pain (Eisenberger, Jarcho, Lieberman, & Naliboff, 2006) and prosocial bonds are associated with physical warmth (Bargh & Shalev, 2012). This connection is also seen in the ways we colloquially discuss emotions, including popular phrases that exemplify embodied emotion such as “heartwarming”, “cold feet”, and “chilling.” The physiological changes associated with emotions may serve to promote adaptive behavior, as well as more effective simulation of others’ emotions to facilitate social cognition (Niedenthal, 2007; Keysers, Kaas, & Gazzola, 2010). Thus, deficits in the experience of embodied emotion may be associated with impaired affective processing at both the individual and interpersonal levels. More specifically, research suggests that deficits in embodied emotion may contribute to impairment in emotion perception in groups with impaired social cognition such as ASD (Winkielman, 2010). Consequently, it is essential to conduct additional research that furthers the understanding of the relation between embodied emotion, emotion perception, and traits associated with impaired socio-emotional functioning.

The Current Study

The current study investigates relations among personality, embodied emotion, and gait perception. Participants included healthy college students, recruited to examine individual differences in emotion perception from gait and reports of embodied emotion in relation to three traits: schizotypal, autistic, and alexithymic. The study expands previous research examining emotion perception from gait (e.g., Peterman et al., 2014), contributing to the sparse yet growing literature on emotion perception using full-body stimuli. To assess emotion perception, participants were asked to identify positive and negative emotions from cues available in the gait of standardized cylindrical walkers (Giese & Poggio, 2000; Roether, Omlor, Christensen, & Giese, 2009). Furthermore, to measure embodied emotion, participants completed an adapted version of the EMBODY task (Nummenmaa, Glerean, Hari, & Hietanen, 2013), in which they were asked to highlight areas of human body outlines based on where their own body gets more or less active during the experience of 14 different emotions. I hypothesized that scores on all three personality measures (SPQ, AQ, and TAS-20) would correlate negatively with performance on the gait perception task, specifically for performance on the 50% intensity stimuli. I also hypothesized that alexithymia would mediate the effects of schizotypy and autism traits on emotional gait task performance. In regard to the EMBODY task, I hypothesized that decreased overall shading would be associated with elevated alexithymia and with decreased performance on the gait perception task.

Methods

Participants

80 undergraduate students (21 men, 59 women; mean age = 19.63, *SD* = 1.14) were recruited using the Vanderbilt University Psychology Department research participant pool (SONA). Racial/ethnic background of the participants were 68.8% White/Caucasian, 17.5% Asian, 11.3% Black/African-American, 1.3% Latino/Hispanic, and 1.3% other. 86.3% of participants were right handed. Mean digit span of participants was 5.94 (*SD* = .81). The study protocol was approved by the Vanderbilt University Institutional Review Board, and all participants gave written informed consent prior to testing. Participants received course credit for their participation.

Procedure

Overview

For each participant, the study took place during a visit to the Vanderbilt University Clinical Neuroscience Lab. Each visit lasted approximately 1 hour and 15 minutes. First, each participant completed informed consent, basic demographic information, and a brief digit span task (to be included as a covariate for general cognitive functioning/working memory in analyses). Participants then completed self-report personality measures, followed by the two experimental tasks described below. The following order of presentation of self-report measures and experimental tasks was used: SPQ, TAS-20, AQ-10, gait perception task, and then the EMBODY body-mapping task.

Self-Report Questionnaires

The Autism-spectrum Quotient – 10 Item (AQ-10; Allison, Auyeung, & Baron-Cohen, 2012)

The AQ-10 is self-report questionnaire consisting of 10 items. The AQ is designed specifically to assess autism traits in adults with average or higher IQ. The AQ assesses areas associated with autism and its extended phenotype, including social skill, attention switching, attention to detail, communication, and imagination. The AQ-10 is designed as a brief version of the original AQ, originally intended for use as a clinical screener for ASD in high functioning adults. Participants respond using a four-point Likert scale (1 = strongly disagree; 4 = strongly agree). Responses are coded as zero or one, with one point awarded if a participant chooses the "autistic trait" response. The "autistic trait" is indicated by a response of strongly/slightly agree for half of the items, and slightly/strongly disagree for the other half.

The Schizotypal Personality Questionnaire (SPQ; Raine, 1991)

The SPQ is a self-report questionnaire consisting of 74 statements that require Yes or No response. SPQ breaks down into three separate factors: positive, negative, and disorganized, which correspond with specific symptomatology profiles of schizophrenia (Raine, Reynolds, Lencz, Scerbo, Triphon, & Kim 1994).

The 20-Item Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994)

This self-report measure of alexithymia consists of 20 items over three separate domains: difficulty identifying feelings, difficulty describing feelings, and externally-oriented thinking. Participants rank how well they agree with each item on a 5-point Likert scale.

(See Appendix C for specific items contained in the above self-report personality measures.)

Experimental Tasks

Emotion perception from gait

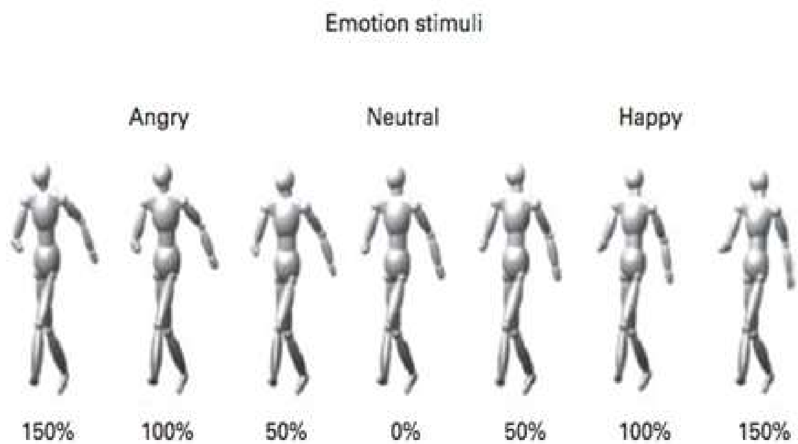

Figure 1. Gait Perception Stimuli (Taken from Peterman et al., 2014)

The creation and standardization of the emotional gait stimuli are well documented (Peterman et al., 2014; Giese & Lappe, 2002; Roether et al., 2009). The stimuli were polygonal 'walking' avatars. In order to show a full perspective of gait, each avatar was angled to the participant's left side (see Fig. 1). The polygonal avatar stimuli were created with motion morphing (Giese & Poggio, 2000), which allowed for parametric adjustment of the emotional or gendered 'signal' in the stimulus. For each stimulus type (e.g., 'happy', 'angry') three intensity levels were generated. For example, there were three happy gait stimuli: a 50% (attenuated) happy gait walker, a 100% (prototypical) happy gait walker, and a 150% (exaggerated) happy gait walker. Aspects of the movement that defined the emotional content in the emotion stimuli were flexion of the head and arms (head tilted forward for anger and tilted backward for happy), and postural positioning of the torso (pitched forward for anger and leaned back for happy). The neutral stimulus was devoid of emotional components in its gait.

Procedure: At the beginning of the emotion perception task, participants were told that they would view avatars walking and that they would decide whether the avatar's gait resembled happy or angry emotions. Participants were asked to place their left and right index fingers on two keys labeled with H (for happy) and A (for angry). Each stimulus was presented for 1 s. After viewing the stimulus, participants pressed H or A to record their response. There was no time limit for the participant's response. An example of each of the stimuli used is presented in Fig. 1. Accuracy and reaction time data were recorded for each participant, for each stimulus.

Body mapping of emotions

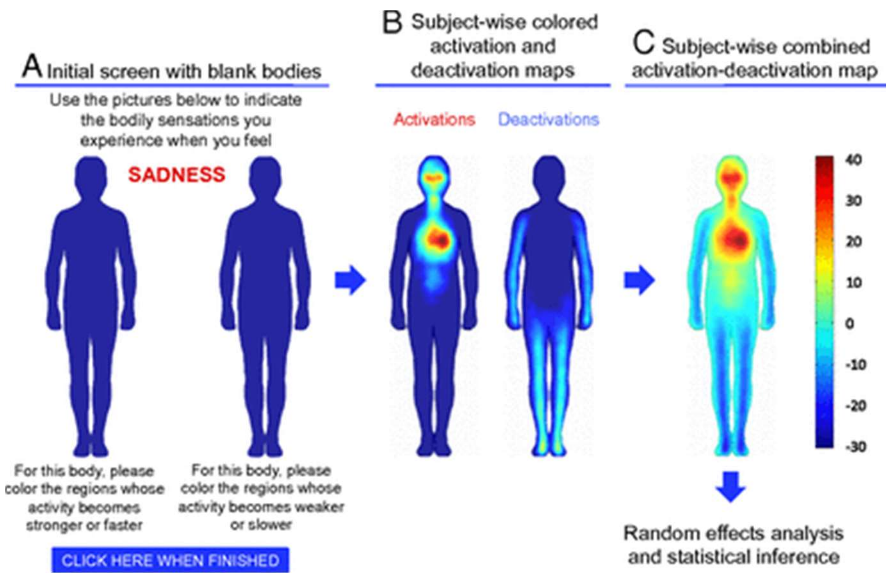

Figure 2. The EMBODY Task (Taken from Nummenmaa et al., 2013)

The creation and a full characterization of the EMBODY task is explained in previous literature (Nummenmaa et al., 2013). For this task, participants were presented with 14 different emotion words including six basic emotions (anger, fear, disgust, happiness, sadness, and surprise), seven non-basic emotions (anxiety, love, depression, contempt, pride, shame, and envy), and a neutral state. For each emotion condition, participants shaded two human body outlines based on where their body became more or less active. An online, computer-based interface was used to administer the task.

Procedure: Participants were told that they would view a series of emotional words. Upon seeing each emotion word, participants were to imagine what their body feels like when they experience the given emotion. Then, they shaded-in the two human outlines on the screen, based on what areas of their body become more active or less active when they experience the given emotion.

Data Analysis

Statistical analysis will be conducted using SPSS (IBM Corp, 2013) and R (*R* Development Core Team, 2008). The PROCESS Plug-in for SPSS was used to conduct all mediation and moderation analyses (Hayes, 2013). MATLAB was used for the generation of body maps (MathWorks Inc, 2015).

Computation of Gait Perception Variables

For each emotion and stimuli intensity level, total accuracy was computed as the number of "hits" out of the total presentations for each intensity-emotion pair (a total of 32 trials for each emotion-intensity pair were presented throughout the task). Total accuracy variables were created for each intensity level (for a total of 64 trials at each intensity level). Total accuracy variables for each emotion and a composite accuracy variable were also created. A "happy-bias" variable was created by calculating the number of neutral stimuli each participant labeled as happy. Total reaction time variables were created for each class of stimuli (happy, angry, and neutral).

Analysis of Body Maps

First, participants who demonstrated anomalous painting behavior (e.g., scribbling randomly or drawing symbols) were manually excluded. Body mapping data was then be analyzed using MATLAB scripts and analysis procedures created for the original EMBODY study (Nummenmaa et al., 2013). Specifically, visualizations were created of the significantly shaded areas (across all participant), after correction for False Discovery Rate (FDR). A detailed description of the analytical procedures used in the current study can be found in the aforementioned paper.

Descriptive Statistics

Means and standard deviations were calculated on task variables and for personality measures, including composite scores and SPQ sub-factors.

Correlations of SPQ, AQ-10, TAS-20 Scores with Gait Perception Performance

Correlational analyses were conducted to determine the relationship between personality metrics and performance (accuracy) on the gait perception task. Post-hoc exploratory correlational analyses were conducted to examine the relationship between SPQ sub-factors/subscales and gait perception accuracy.

Group Differences in Gait Perception Performance

Independent samples t-tests were performed to assess differences in gait perception accuracy between high (top quartile) and low (bottom quartile) groups for SPQ, AQ-10, and TAS-20.

Post-hoc Mediation/Moderation Analyses

Post-hoc analyses for mediation and moderation were conducted to further explore relationships among variables that showed significant or trending correlations.

Correlations of SPQ, AQ-10, and TAS-20 Scores

Correlational analyses were conducted to analyze relationships between scores on the various personality metrics incorporated in the study.

Results

Descriptive Statistics for Key Personality/Task Variables

Means and standard deviations for gait perception performance variables and personality measures were calculated and are displayed in Tables 1 and 2, respectively. Happy bias variable was calculated as the number of neutral gait stimuli labeled as happy.

Table 1. Gait Perception Accuracy

Task performance at three intensities		**Mean Raw score (s.d.)**	**Mean % correct (s.d.)**
Happy	50%	30.3 (2.4)	94.7 (7.5)
	100%	31.2 (1.3)	97.5 (4.2)
	150%	31.3 (1.2)	97.8 (3.8)
Angry	50%	19.4 (6.6)	60.6 (20.7)
	100%	28.6 (3.5)	89.4 (11.1)
	150%	30.7 (1.7)	95.9 (5.4)
Total	50%	49.7 (5.8)	77.7 (9.1)
	100%	59.7 (3.8)	93.3 (6.0)
	150%	62.0 (2.4)	96.9 (3.7)
Happy Bias		24.6 (6.0)	76.9 (18.8)

Table 2. Self-report Personality Measures

Questionnaires		Mean (s.d.)
AQ-10		3.06 (1.59)
SPQ	Total	18.03 (10.95)
	Positive	6.78 (5.28)
	Negative	8.51 (6.31)
	Disorganized	4.56 (3.52)
TAS-20		43.50 (8.98)

Correlations between Gait Perception Accuracy and Personality Measures

First, to determine whether cognitive ability/working memory should be included as a covariate in further analyses, the Pearson product correlation was calculated for digit span and gait perception accuracy (at the various emotions/intensity levels). There were no significant correlations between digit span and gait perception accuracy for total accuracy, intensity-specific accuracy variables, or emotion specific accuracy variables ($p > .05$), so digit span was not included as a covariate in any further analyses.

Correlational analyses were then performed between the three personality measures (i.e., AQ-10, SPQ, and TAS-20) and gait perception accuracy variables (total accuracy, intensity-specific variables, and emotion specific variables). Because the self-report personality questionnaires did not utilize interval scales and therefore may not meet all of the assumptions of parametric data, Spearman’s Rho was used in the initial calculation of all correlations.

Descriptive statistics indicated that performance for 100% and 150% intensity stimuli (happy and overall) was at/near ceiling, while performance on 50% intensity stimuli (total, happy, and angry) as well as angry stimuli at 100% intensity was not at ceiling. Thus, in the computation of correlations between gait perception accuracy and personality, analyses involving low-intensity and high-intensity variables were considered to constitute separate families of analyses.

There were no significant correlations between personality measures and total gait perception accuracy or total happy/angry gait perception accuracy (see Table A1). Furthermore, there were no significant correlations between high-intensity gait perception accuracy and personality, but there was a positive trend between SPQ and happy accuracy at 100% (see Table A2).

There were, however, significant and trending correlations between personality measures and low-intensity gait perception (see Table A3). Specifically, total gait perception accuracy at 50% intensity correlated negatively with autism-spectrum quotient ($\rho = -0.233$, $p < 0.05$; see Fig. A1) but did not correlate with overall schizotypy ($\rho = -0.157$, $p = .16$; see Fig. A2) or with alexithymia ($\rho = -0.006$, $p = .959$; See Fig. A3). Because the relation between overall schizotypy and gait perception was approaching trend-level significance, an exploratory Pearson correlation was computed, revealing a negative trend between schizotypy and gait perception at 50% intensity ($r = -0.184$, $p = 0.1$; see Fig. A2).

Full Spearman correlations matrixes (separated by total, high-intensity, and low-intensity analyses) are presented in Appendix A. Key correlations are visualized using scatter plots in Appendix B.

Group Differences in Gait Perception Accuracy

In light of the correlations/trends of AQ-10 and SPQ with task performance, post-hoc t-tests were performed to determine whether individuals with high vs. low autism-spectrum quotient and schizotypy differed in task performance (for the 50% intensity stimuli). There was a trend-level significant difference in accuracy at 50% between individuals with low and high AQ-10 scores ($t(26) = 1.82$, $p < 0.1$; see Fig. 3). Individuals with high SPQ did not show significantly different accuracy than individuals with low SPQ ($t(24) = 1.61$, $p = 0.12$; see Fig. 4).

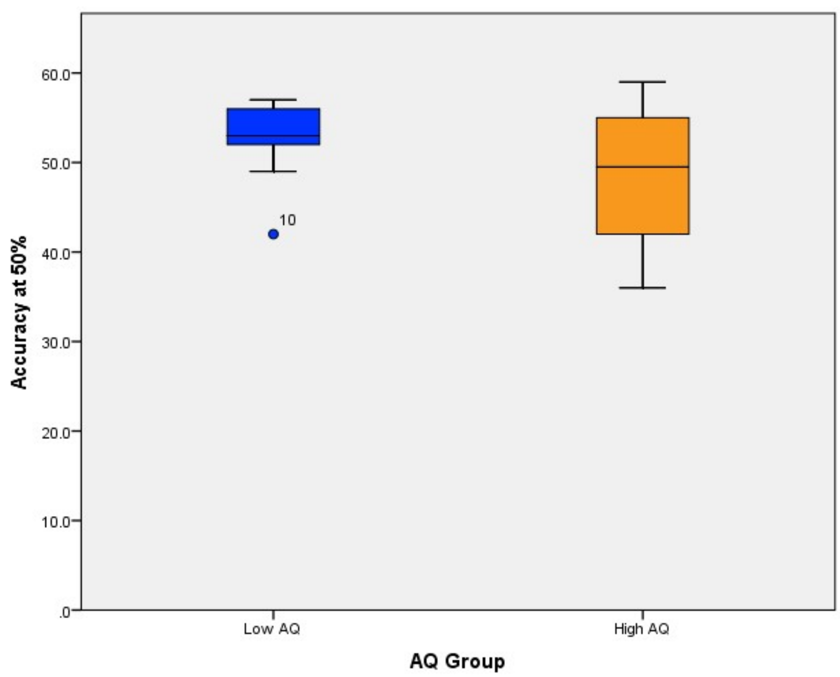

Figure 3. AQ-10 Group Differences in Gait Perception Accuracy

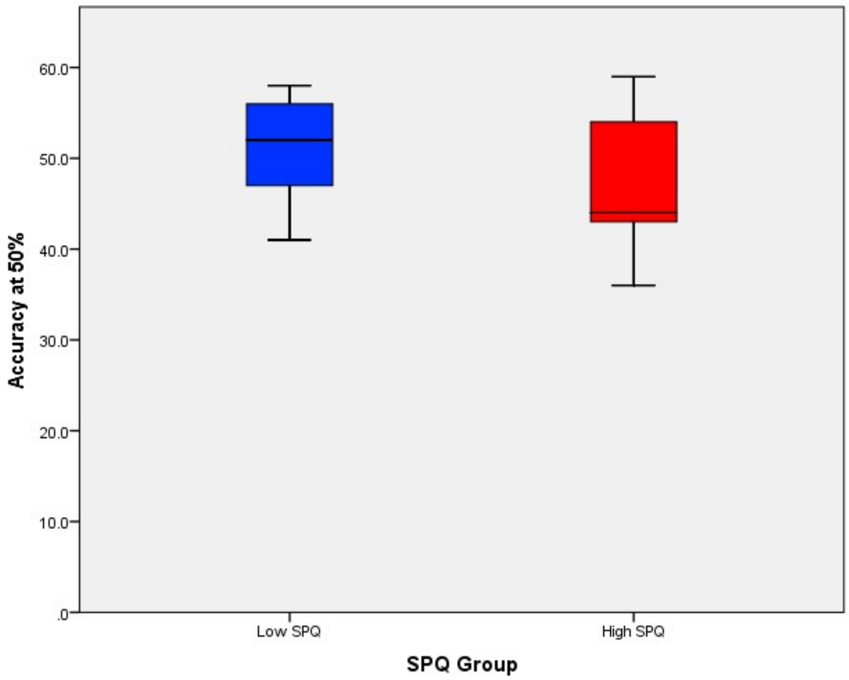

Figure 4. SPQ Group Differences in Gait Perception Accuracy

Post-hoc Analyses of SPQ Sub-Factors and Gait Perception

Since the relation between SPQ and gait perception accuracy (at the 50% intensity) was approaching trend-level significance, exploratory post-hoc analyses were conducted to examine whether specific factors of the SPQ might be more strongly correlated with gait perception accuracy. For these analyses, a three factor model mirroring the symptomology of schizophrenia was used, and included the following: positive, negative, and disorganization. Gait perception accuracy at 50% correlated negatively with positive schizotypy ($\rho = -0.28$, $p = 0.01$; see Fig. 5), but not for negative schizotypy ($p = 0.61$) or disorganization ($p = 0.33$).

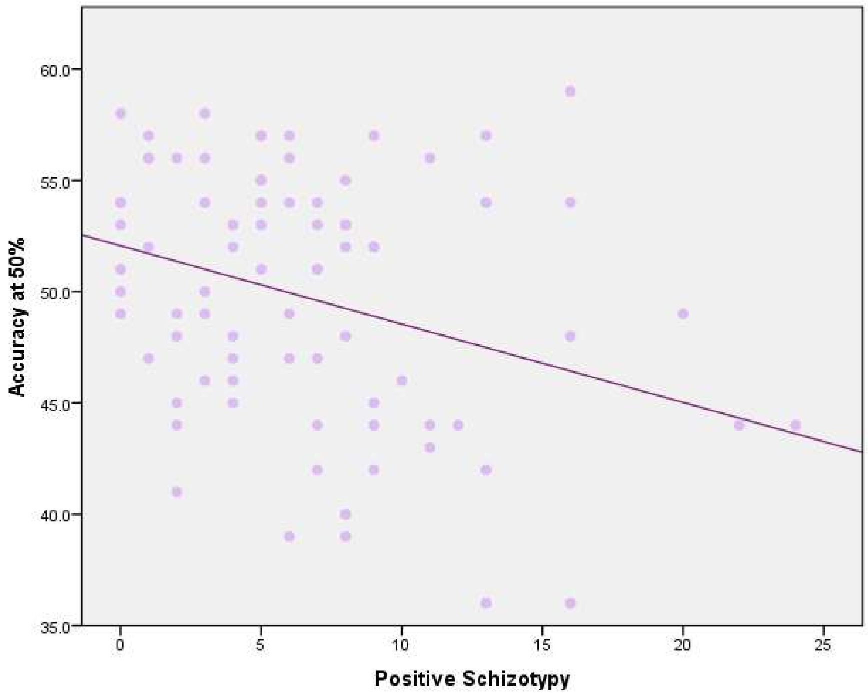

Figure 5. Association between Gait Perception Accuracy and Positive Schizotypy

Mediation Analysis of Positive Schizotypy, Response Bias, and Gait Perception

In order to better understand possible mechanism of the relationship between positive schizotypy and gait perception accuracy, potential mediators were assessed using exploratory correlational analyses. Potential mediators considered included non-accuracy performance variables such as happy bias. Pearson product (rather than Spearman) correlations were utilized to facilitate use of partial correlations/regression coefficients in mediation analyses. Correlational analyses revealed that tendency to label neutral stimuli as happy positively correlated with positive schizotypy ($r = .30$, $p < 0.01$; see Fig. 6). Positive schizotypy was also positively correlated with tendency to label angry stimuli at the 50% intensity level as happy ($r = .30$, $p < 0.01$). In light of these finding, the correlation between happy-bias and accuracy was analyzed and a negative correlation was found (r = -0.57, $p < 0.001$; see Fig. 7). Because of these co-occurring correlations, mediation analyses were conducted. Mediational analyses conducted using both Sobel's *Z* and bootstrapping revealed partial mediation of the relationship between positive schizotypy and accuracy by tendency to label neutral stimuli as happy (Fig. 8). However, both direct and indirect effects remained significant (or trending).

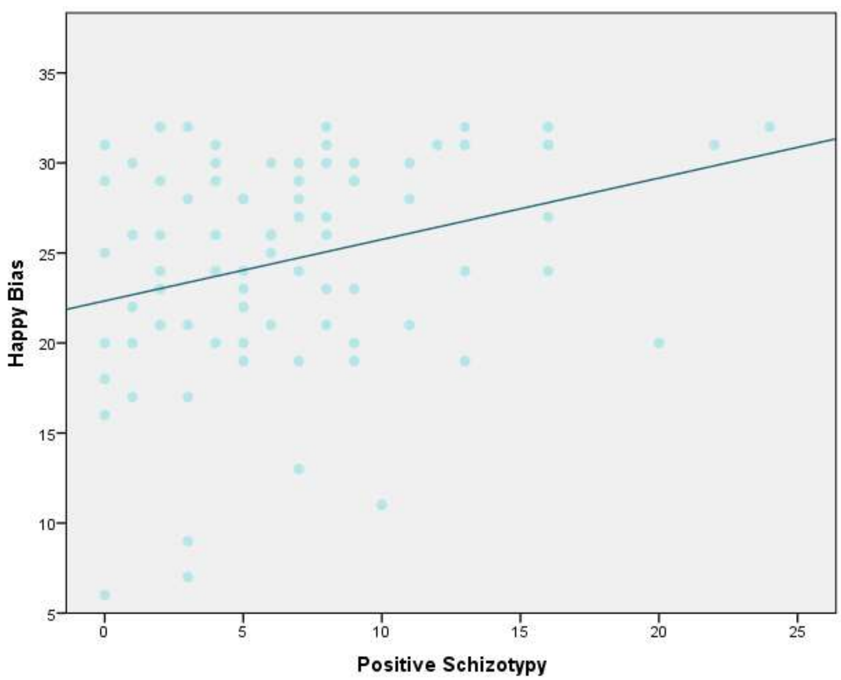

Figure 6. Association between Positive Schizotypy and Happy Bias

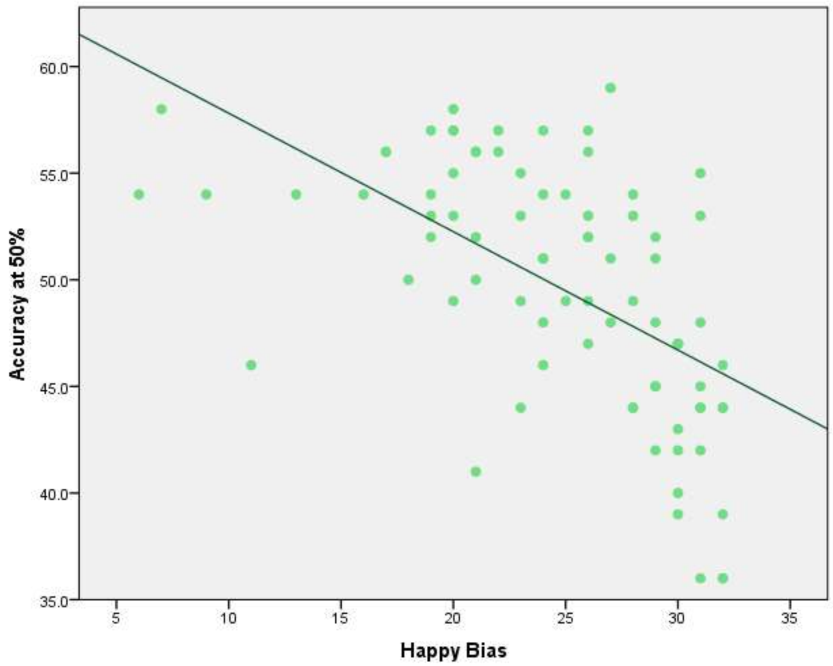

Figure 7. Association between Happy Bias and Gait Perception Accuracy

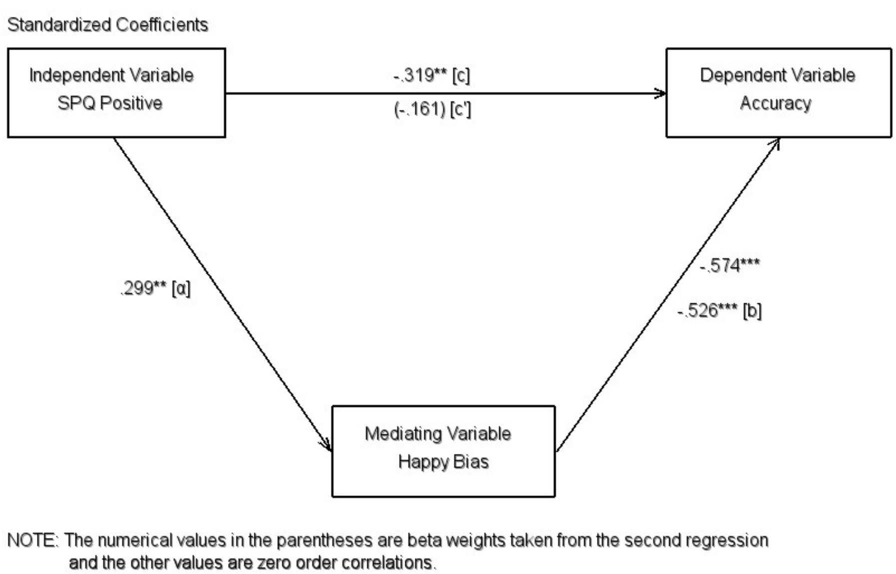

Figure 8. Mediation of the Relation between Positive Schizotypy and Accuracy by Happy Bias

Additional Exploratory Correlational Analyses – Other Task Variables

In light of the above mediation analyses, additional exploratory correlations were computed to assess the relation between positive schizotypy and task performance (i.e., reaction time, accuracy; see Table 3). In light of significant findings for positive schizoptypy, similar correlations were explored for AQ-10 and no significant associations were found (Table 3).

Table 3. Spearman Correlations between Personality Measures and RTs

	Positive SPQ	AQ-10
Angry RT	-0.14	-0.02
Happy RT	-0.28*	-0.13
Neutral RT	-0.25*	-0.13

** p < .05, * p < .05, + p < .1

Additional Exploratory Correlational Analyses – SPQ Subscales

Furthermore, exploratory analyses were conducted to determine Spearman Correlations between gait perception accuracy and specific subscales of the SPQ, using the original 9-subscale model (Table 4).

Table 4. Spearman Correlations between Accuracy and SPQ Subscales

	Gait Perception Accuracy at 50%
Ideas of Reference	-0.19
Excessive Social Anxiety	-0.07
Odd Beliefs	-0.31**
Unusual Perceptual Experiences	-0.27*
Odd/Eccentric Behavior	-0.01
No Close Friends	0.06
Odd Speech	-0.13
Constricted Affect	-0.03
Suspiciousness	-0.11

** p < .05, * p < .05, $^{+}$ p < .1

Moderation Analyses

Interaction analyses were conducted between personality measures in predicting gait perception accuracy at 50% intensity. No interaction effects were observed between TAS-20 and AQ, nor were three way interactions observed.

TAS-20 was then examined as a moderator of the relation between SPQ and gait perception accuracy. SPQ and TAS-20 were entered in the first step of the regression analysis. In the second step of the regression analysis, the interaction term between SPQ and TAS-20 was also entered, and it explained a significant increase in variance in labeling target emotions ($\Delta R2 = 0.047$, $F(1, 76) = 3.93$, $p = 0.05$). Thus, alexithymia was a significant moderator of the relationship between Schizotypy and task performance. This relation is visualized in Figure 9.

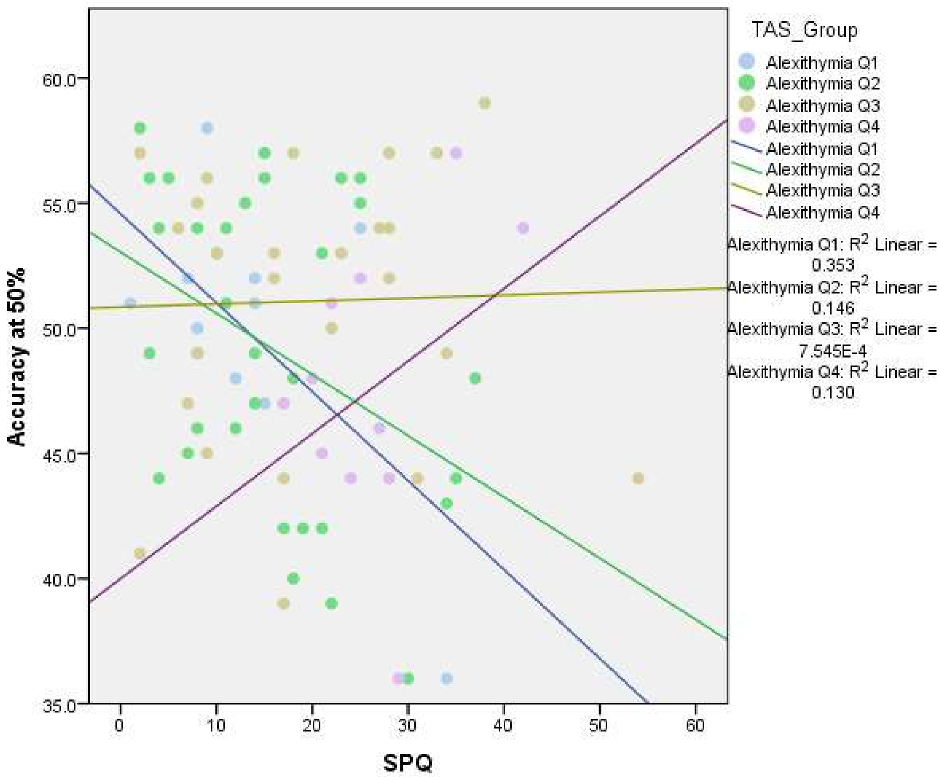

Figure 9. Moderation of the Relation between Schizotypy and Accuracy by Alexithymia

Body Maps of Emotions

Composite body maps were generated for each of the 14 emotions for which participants provided EMBODY data (Fig.10). These visualizations represent the areas of the body that were shaded with statistical significance across all participants, after employing the false discovery rate correction. Additional body maps were created that utilized a median split of participants, for gait perception accuracy, alexithymia, autism-spectrum quotient, and schizotypy. There were notable qualitative differences in body maps between individuals who performance below vs. above average on the gait perception task (Fig. 11). There were no apparent qualitative differences in body maps between individuals with different degrees of alexithymia, schizotypy, or autism-spectrum quotient, after median splits.

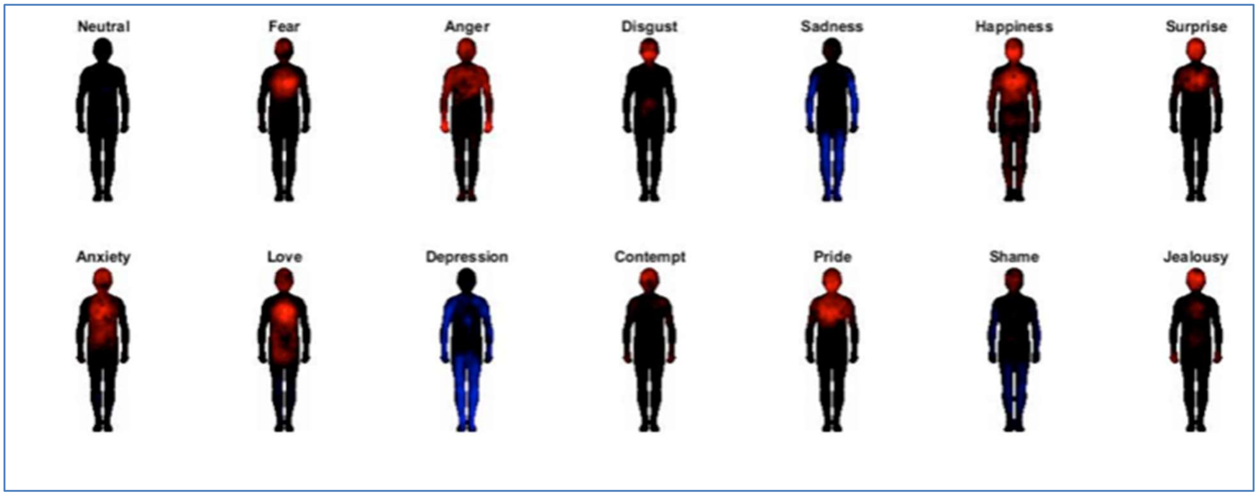

Figure 10. Composite Body Maps of Emotions across All Participants

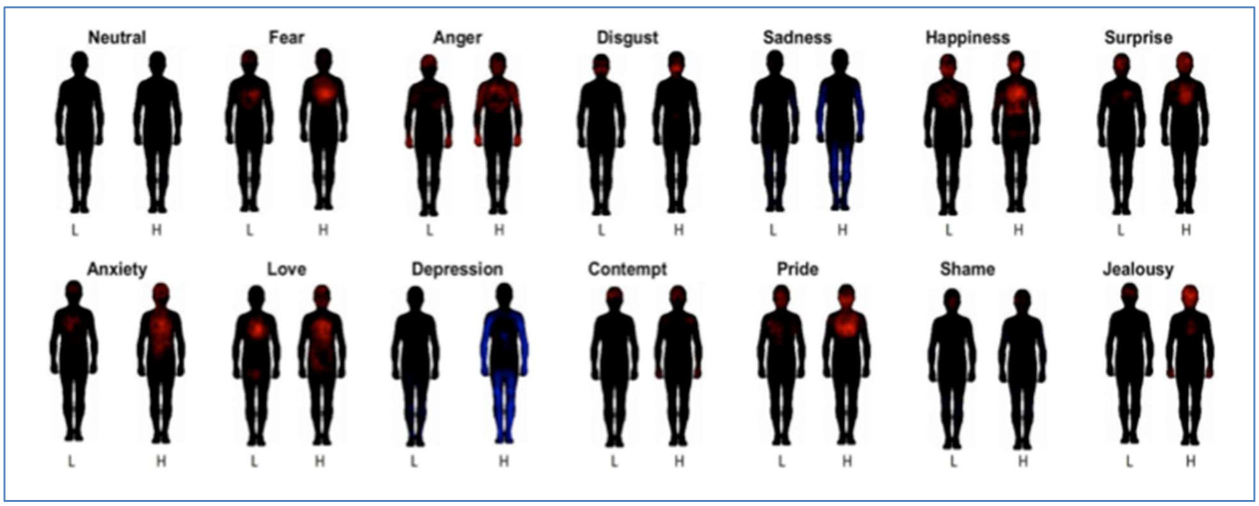

Figure 11. Body Maps of Emotions Split by Low vs. High Gait Perception Accuracy

Correlations among Personality Measures

Correlational analyses were conducted to examine the associations among alexithymia, schizotypy, and autism-spectrum quotient. Schizotypy correlated positively with autism-spectrum quotient ($\rho = 0.410$, $p < 0.001$; see Fig. 12). Alexithymia correlated positively with autism-spectrum quotient ($\rho = 0.280$, $p < 0.05$; see Fig. 13) and with Schizotypy ($\rho = 0.393$, $p < 0.001$; see Fig. 14). Figure 15 displays the correlations among the three personality measures, visualized in a three-dimensional Euclidean space.

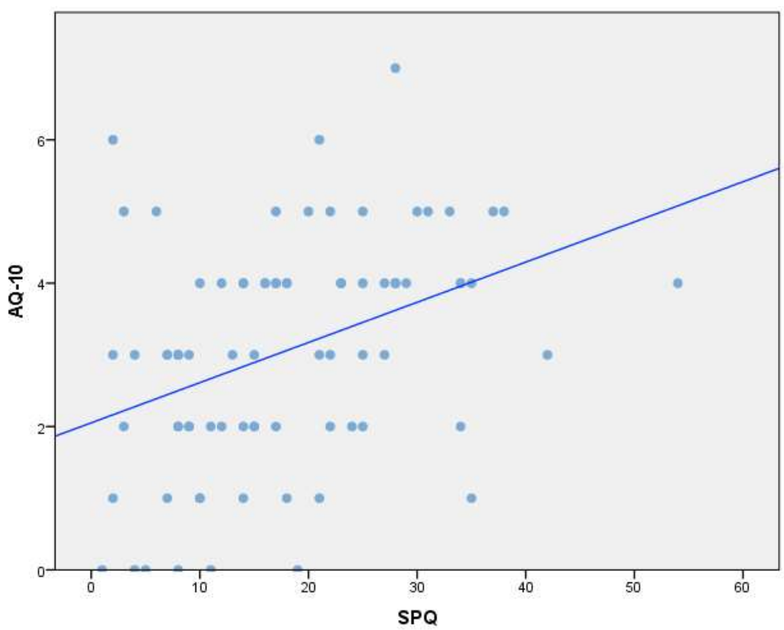

Figure 12. Association between Autism-spectrum Quotient and Schizotypy

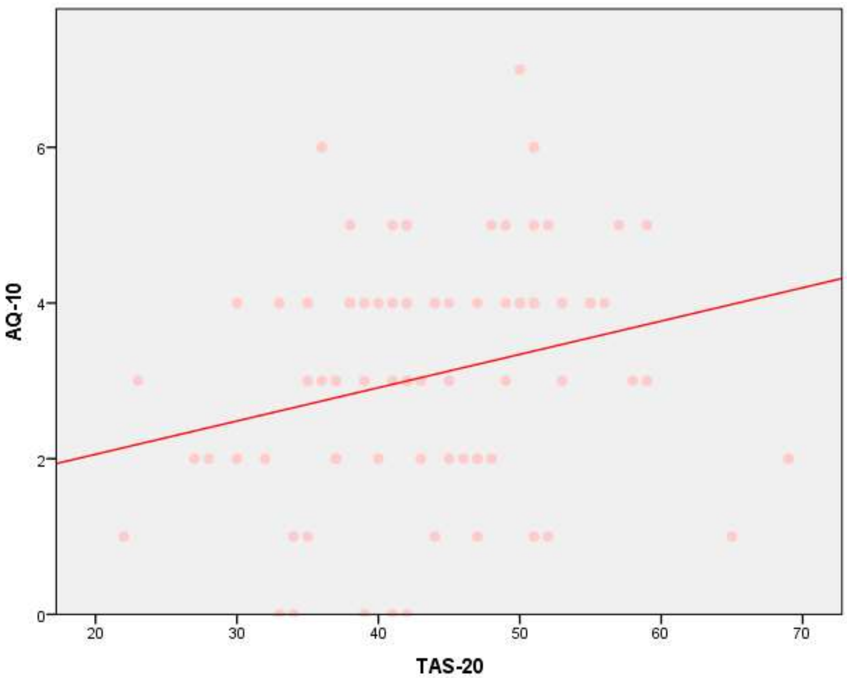

Figure 13. Association between Autism-spectrum Quotient and Alexithymia

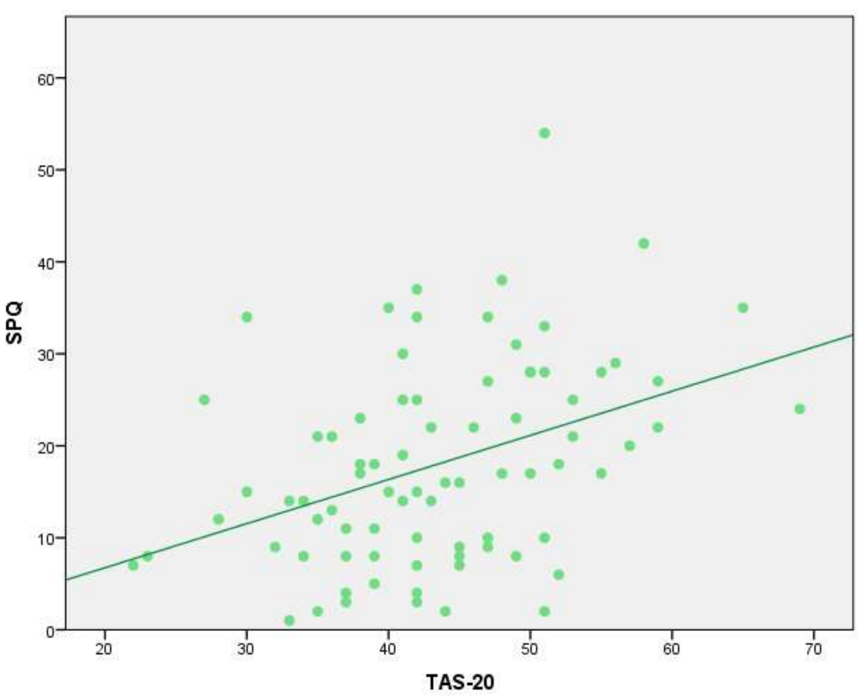

Figure 14. Association between Alexithymia and Schizotypy

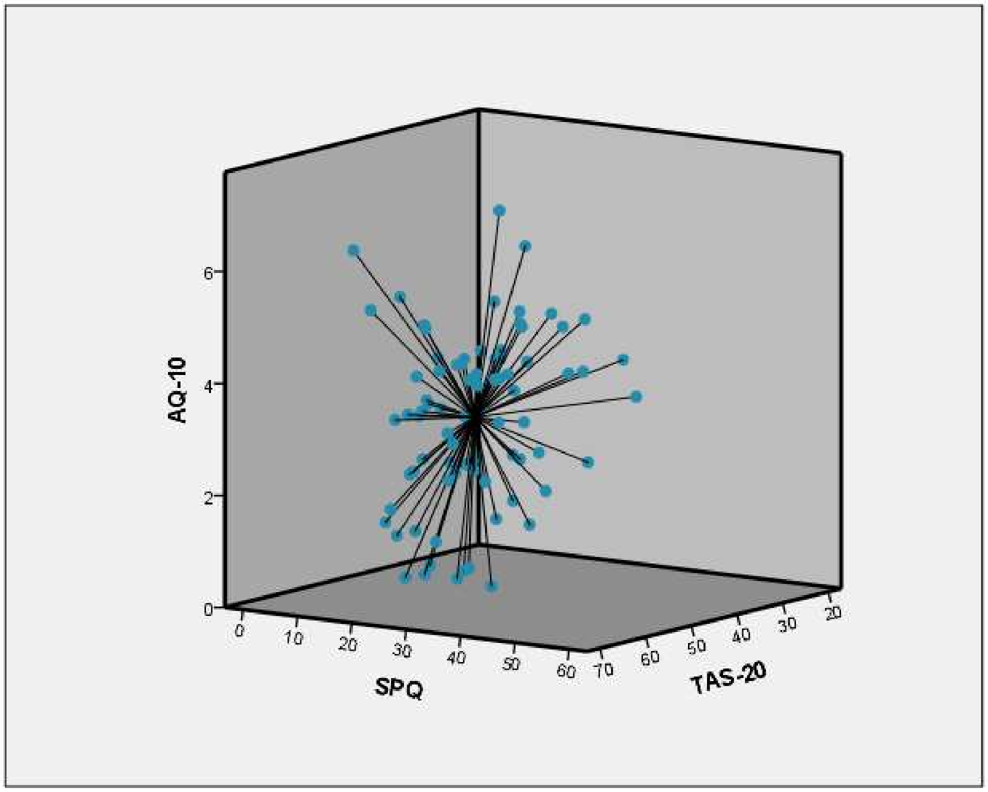

Figure 15. Visualization of Correlations among Alexithymia, Autism-spectrum Quotient, and Schizotypy

Moderation Analysis for Alexithymia, Schizotypy, and Autism-spectrum quotient

AQ-10 was examined as a moderator of the relation between SPQ and TAS-20. SPQ and AQ-10 were entered in the first step of the regression analysis. In the second step of the regression analysis, the interaction term between SPQ and AQ-10 was also entered, and it explained a significant increase in variance in labeling target emotions ($\Delta R2 = 0.045$, $F(1, 75) = 4.22$, $p < 0.05$). Thus, autism-spectrum quotient was a significant moderator of the relationship between schizotypy and alexithymia. This moderation relationship is visualized using AQ-10 quartiles in Figure 16. Post-hoc simple linear regression analyses were examined for the prediction of TAS-20 by SPQ, for each AQ quartile. SPQ was a significant predictor of TAS-20 for the bottom ($\beta = 0.573$, $t(12) = 2.42$, $p < 0.05$) and second quartile (β = 0.487, $t(28) = 2.95$, $p < 0.001$), but not for the third ($\beta = 0.252$, $t(20) = -0.19$, $p > 0.05$) or top quartiles ($\beta = -0.066$, $t(12) = -0.23$, $p > 0.05$).

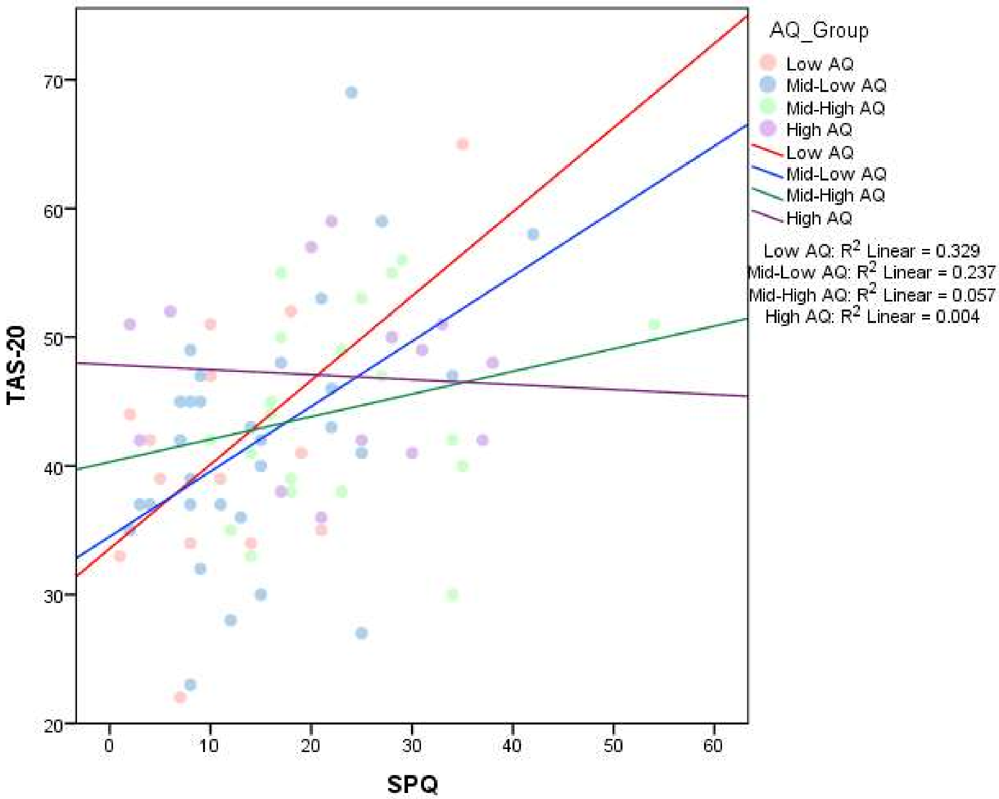

Figure 16. Moderation Analysis for Personality Measures

Discussion

Recent research demonstrated that perception of emotional cues in gait is impaired among individuals with schizophrenia (Peterman et al., 2014), adding to a growing body of work showing impaired emotion perception in individuals with schizophrenia- and autism- spectrum disorders (Couture et al., 2010; Hubert et al., 2007; Kohler et al., 2003; Lozier et al., 2014), as well as individuals with latent liability for these conditions (Mikhailova et al., 1996; Miller & Lenzenweger, 2012; Miller & Saygin, 2013; Platek et al., 2005; Poljac et al., 2013; Poreh et al., 1994). Recent theory and research suggest that alexithymia may serve to mediate the relationship between autistic/schizotypal traits and social-cognitive deficits (Aaron et al., 2015; Bird & Cook, 2013). Furthermore, interoceptive awareness and embodied emotion have emerged as promising mechanisms, theorized to explain socio-emotional deficits across alexithymia and clinical symptomatology (Herbert et al., 2011). Thus, the current study aimed to investigate how autistic/schizotypal traits, alexithymia, and embodied emotion may impact the perception of emotional cues in gait.

Autism Spectrum Quotient – Extending the Validity of the AQ-10

Building on research indicating negative associations between emotion perception and autism-spectrum quotient, the current study showed negative correlations between low-intensity gait perception accuracy and scores on the AQ-10. Previously, this relationship had been demonstrated using emotion perception stimuli sets consisting of emotional faces (Poljac et al., 2013) and eyes (Miller & Saygin, 2013). The current findings suggest that individuals with high autism spectrum traits may also have impaired ability to detect emotional cues in gait. This is in line with research demonstrating impaired recognition of emotional-biological motion among individuals with ASD (Hubert et al., 2007). It is important to note, however, that effects were only present for stimuli at the

50% intensity level. This indicates that autism spectrum traits may be associated with impaired perception of low-threshold emotions, despite intact ability to perceive and categorize higher intensity emotions. Nonetheless, this could be a significant detriment to adaptive social functioning, as perception of low-threshold emotions and expressions is particularly important for making initial social judgements (Bar, Neta, & Linz, 2006; Young, Rowland, Calder, Etcoff, Seth, & Perrett, 1997).

In addition to extending research on gait-based emotion perception and subclinical symptomatology, the current study serves to further validate the AQ-10, for use in non-clinical, individual difference research settings. The majority of previous studies showing correlations of autism-spectrum quotient with emotion perception, schizotypy, and alexithymia utilized the full 50-item version of the instrument (e.g., Aaron et al., 2015; Lockwood et al., 2013; Miller & Saygin, 2013; Poljac et al., 2013). Results of a recent study using advanced statistical modeling found that the AQ-10 is as valid as the original AQ for predicting whether an individual has a diagnosable autism spectrum disorder (Booth, Murray, McKenzie, Kuenssberg, O' Donnell et al., 2013); however, the AQ-10 had not been fully validated for measuring individual differences in autism-related traits among neurotypical individuals. The current study's replication of correlations of AQ with TAS-20 and SPQ, as well as emotion perception measures, suggest that the AQ-10 may also be useful as a less time-intensive measure of autism-spectrum traits, for utilization in social and personality psychology research. So while the original AQ may be ideal for studies utilizing clinical populations and for researchers desiring precise measures of personality and autism-related traits (including subdomains of the AQ), the AQ-10 may serve as a valid, time-efficient alternative in non-clinical studies of individual differences in socioemotional functioning.

On the other hand, however, the effect sizes—for associations involving AQ—demonstrated in the current study were relatively small, compared to the aforementioned studies using the full autism-spectrum Quotient. This may be due to the reduced amount of variability captured by the AQ-10 vs. the full 50-item version of the AQ. Alternatively, the small effect size may have been simply due to small variability in the range in autism-spectrum traits, for the current sample. Future studies could benefit from specifically recruiting participants with elevated autism-spectrum quotient, rather than simply exploring varying levels of these traits in the general population. Furthermore, future analyses could employ more fine-grained analytical techniques, rather than the dichotomous scoring used in the AQ-10's scoring guide; such analyses may reveal additional variability and thus increase the statistical power for examining associations of AQ with social-cognitive functioning.

Schizotypal Personality – Positive Symptomatology and Pattern Recognition

In addition to showing associations with AQ-10, gait perception accuracy was negatively correlated with positive schizotypy. This is in line with previous research indicating associations between elevated schizotypy and impaired emotion perception (Mikhailova et al., 1996; Miller & Lenzenweger, 2012; Platek et al., 2005; Poreh et al., 1994). Our findings extend evidence of negative associations between schizotypy and emotion perception beyond facial/eye stimuli to include perception of emotional cues in gait. Contrary to previous work that found emotion perception was disrupted in negative, but not positive schizotypy (Williams, Henry, & Green, 2007), in the current sample, impaired emotion perception was specifically correlated with positive schizotypy. Furthermore, the observed negative correlation between positive schizotypy and gait perception accuracy conflicted with our initial hypotheses; namely, we expected that gait perception would be negatively correlated with negative schizotypy, which is a sub-factor associated with constricted/flat affect (Cohen & Hong, 2011). Nonetheless, interpreting the results of mediation analyses from the current study may help rectify and clarify our initially surprising findings.

Post-hoc correlational analyses indicated positive associations between positive schizotypy and participants' tendency to label neutral and angry stimuli as happy. Moreover, the relation between positive schizoptypy and accuracy was partially mediated by a tendency of participants with high positive schizotypy to label neutral stimuli as happy. This is in line with previous research using facial affect stimuli, in which participants with high positive schizotypy were more likely to mislabel angry stimuli as happy (van't Wout, Aleman, Kessels, Larøi, & Kahn, 2004). Moreover, both the current data and van't Wout (2004) indicate associations between scores on the unusual perceptual experiences subscale of the SPQ and tendency to mislabel emotional stimuli. Despite the presence of strong correlations between positive schizotypy and incorrectly labeling stimuli as happy ($r = 0.53$) van't Wout and colleagues (2004) do not offer a clear interpretation of these specific findings or set forth hypothetical mechanistic explanations.

One possible explanatory mechanism for the observed correlations between positive schizotypy and gait-perception accuracy/happy-bias is the increased prevalence of apophenia among individuals with high levels of positive schizotypy (Brugger & Graves, 1997; Fyfe, Williams, Mason, & Pickup, 2008). Apophenia refers to a tendency to perceive meaning in unrelated events and patterns in noise (Brugger, 2001). Various attempts to quantify and measure this construct have been made including contingency tasks that measure participants' tendency to perceive intentionality/meaning in noise or randomness (Blakemore, Sarfati, Bazin, & Decety, 2003) and more recent efforts are underway to create self-report questionnaires of apophenia. Apophenia is a trait characteristic of psychosis, as well as positive schizotypy and loads onto the same personality simplex as openness/intellect (DeYoung, Grazioplene, & Peterson, 2012). Apophenia often manifests as a tendency toward Type I error, that is, finding meaning in patterns that can be adequately explained by chance (DeYoung et al., 2012). Apophenia may result in increased confidence in one's decisions and, in the extreme, can contribute to hallucinations and delusional beliefs.

In the current study (and in the aforementioned van't Wout study), elevated apophenia among participants with high positive schizotypy may have led to increased perception of positive and neutral stimuli as happy. Despite being instructed that both options (i.e., happy and angry) would be used equally, increased apophenia may have led individuals with high positive schizotypy to perceive a higher amount of non-happy stimuli as happy, contrary to experimenter instructions. This conclusion is indirectly supported by the fact that gait perception errors were most strongly correlated with the "odd beliefs" subscale of the SPQ. Presence of such a pattern-seeking tendency is further supported by the fact that higher positive-SPQ was correlated with a tendency to respond more quickly to happy and neutral stimuli, and by the fact that accuracy for happy stimuli was actually **positively correlated** with SPQ at some intensity levels (see Table A2). Nonetheless, while elevated apophenia may provide a convincing explanation for findings in the current study, it is important to note that no measure of apophenia was collected in the current sample, and thus, such explanations are merely conjecture. Future efforts may be made to quantify apophenia in the current sample of participants, and follow-up investigations involving SPQ and social cognition could certainly benefit from the inclusion of such instruments.

Alexithymia and Emotion Perception – Clarifying the Construct

While AQ-10 and SPQ were associated with impaired perception of emotional cues in gait, no such correlation was seen with alexithymia. This is contrary to a number of previous studies that suggest a negative relation between alexithymia and emotion perception abilities (Cook, Brewer, Shah, & Bird, 2013; Prkachin et al., 2008). Furthermore, these findings were in direct contrast to our hypotheses, which were grounded in findings that alexithymia mediated the relation between autistic/schizotypal traits and empathic deficits (Aaron et al., 2015). Nonetheless, a number of previous studies have also failed to show clear associations between alexithymia and lower-level social-cognitive processes such as emotion perception. For instance, Hsing and colleagues (2013) found that while alexithymia was associated with slower responding in an emotion perception task, basic lower-level ability to recognize and categorize facial emotions remained intact, in alexithymia.

Furthermore, the lack of mediational effect of alexithymia on the relationship between AQ and the current study's measure of social cognition (i.e., gait perception) could be related to the nature of the tasks in the current study vs. the tasks utilized by Aaron and colleagues (2015); namely, while the current study utilizes an experimental measure of social cognition, the former study used only a self-report metric of social cognition (i.e., empathy), in the form of the Interpersonal Reactivity Index (Davis, 1980). In line with this interpretation, Lockwood and colleagues (2013) found that alexithymia could not explain the relation between AQ and social cognition, as measured by an experimental task of cognitive perspective taking; specifically, in their study, the theory-of-mind "triangles playing tricks" task was utilized (Abell, Happe, & Frith, 2000). In addition to the differences in experimental vs. self-report nature of the tasks used in the current study, Aaron (2015), and Lockwood (2013), another important difference is worth noting—the specific social-cognitive domains which are being addressed. While Aaron (2015) investigated the relationship between alexithymia and empathy, Lockwood focused on theory-of mind, and the current study assesses the perception of lower-level emotional cues. This raises the important question of how exactly alexithymia may (or may not) relate to specific aspects of social-cognitive function (and dysfunction).

Although alexithymia has been shown to associate strongly with higher-level socioemotional processing and empathy (Aaron et al., 2015; Bird et al., 2010), similarly clear associations with theory-of-mind and perception of lower-level emotional cues have not been consistently demonstrated. This could be due to the distinct nature of these various aspects of social-cognitive processing, as well as the role of language and semantics in alexithymia. Some propose that alexithymia may be uniquely associated with impaired "affective resonance," while autism-spectrum traits are specifically associated with deficits in "cognitive empathy," theory-of-mind, and perspective taking (Lockwood et al., 2013). A similar dissociation between forms of social cognition may explain the discrepant results between the current data and Aaron (2015). Namely, a separate set of (sub-) clinical symptomatology, other than alexithymia, may be associated with deficits in the basic processing of lower-level emotional cues (in gait and otherwise). This finding is actually quite in line with original conceptualization of alexithymia as a deficit specific to the semantic and linguistic processing of emotional states (Lane et al., 1997; Lane, Lee, Reidel, Weldon, Kaszniak et al., 1996). It may be the case that, rather than a generalized deficit in the processing of emotions as recently conceptualized, alexithymia—at least as it is assessed using the TAS-20—is related specifically to deficits in higher-level emotional classification/categorization and the understanding of how affective/physiological states are conceptualized using language.

Moving forward, the formation and utilization of a new trans-diagnostic construct—paralleling alexithymia, but pertaining to the perception of lower-level emotional cues—could be beneficial for research in personality and clinical psychology. Such a psychometric construct would likely be positively correlated with schizotypy, autism-spectrum quotient, and perhaps alexithymia, but would provide a valuable new theoretical keystone in trans-diagnostic socioemotional symptomatology. The emergence of such a construct would forward the initiatives of RDoC (Insel, Cuthbert, Garvey, Heinssen, Pine et al., 2010) and other efforts to more fully elucidate the psychometric structure of psychopathology (Krueger & DeYoung, 2016), while perhaps paving the way for clinicians to better understand and intervene with dysfunctional emotion perception in neuropsychiatric populations such as autism and schizophrenia spectrum. Furthermore, such a construct could further explain the connections between self and other experience of emotion, much like Bird's alexithymia hypothesis has offered a convincing explanation of empathic deficits across various clinical and subclinical groups

(Aaron et al., 2015; Bird et al., 2010; Bird & Cook 2013). Despite the lack of correlation between alexithymia and lower-level emotion perception in the current study, we hypothesized that alexithymia might still be related to performance on the EMBODY task and report of embodied emotion.

Body Mapping – No Associations with Personality Measures?

Interestingly, while we hypothesized that alexithymia and subclinical symptomatology would be associated with decreased experience/report of embodied emotion, there were no noticeable associations of body mapping data with any of the self-report measures (see Figures C1-8, in Appendix C). If these associations are actually not present in the population, there could be major clinical/translational implications. Namely, if individuals with alexithymia actually have no dysfunction related to embodied emotion and interoceptive awareness, training these skills through mindfulness meditation and related therapies (Khalsa, Rudrauf, Damasio, Davidson, Lutz et al. 2008) may be futile. While literature does suggest impaired interoceptive awareness and altered connectivity of the interoceptive-cortex in ASD (Ebisch, Gallese, Willems, Mantini, D., Groen et al., 2011), these deficits may not extend to individuals with latent liability for ASD or high AQ. Alternatively, impairments in the experience and report of embodied emotion may be extant but much weaker in individuals with autistic traits, vs. those with an actual ASD diagnosis.

While results were contrary to our hypotheses, the literature involving embodied emotion and interoceptive awareness in schizophrenia, schizotypal personality, and alexithymia is far from definitive. For instance, our ongoing research suggests that interoceptive awareness, as measured by a heartbeat detection task, may not be linearly associated with alexithymia (Aaron, Snodgress, Blain, & Park, manuscript in preparation A). This further extends the idea that alexithymia, as measured by the TAS-20, may be associated uniquely with higher-level emotional processing and language-based categorization of emotional experiences. If this is the case, perhaps training emotion processing skills specific to semantical/linguistic processing through cognitive behavioral therapy (CBT) or emotional intelligence training could be most helpful for individuals with high levels of alexithymia (Elias, 1997).

Some might argue that alexithymia is, in fact, a result of impaired interoceptive awareness and embodied emotion (e.g., Bird & Cook, 2013); however, the TAS-20—as an imperfect self-report instrument—may not be accurately by capturing this aspect of the alexithymia construct. Nonetheless, our ongoing research suggests that mindfulness meditation does not significantly impact one's ability to label and describe emotions in an experimental emotion-induction task, relative to listening to a placebo recording; moreover, interoceptive awareness does not appear to significantly correlate with participants' ability to subjectively label and describe emotional experiences in this same task (Aaron et al., manuscript in preparation A). Thus, while mindfulness-/interoception- based interventions may be helpful for a subset of individuals with alexithymia and specific clinical diagnoses, interoceptive awareness may not provide a universal causal explanation or point of intervention. Similarly, if schizophrenia spectrum disorders are not associated with deficits in embodied emotion and interoceptive awareness, perhaps therapies specifically training social-cognitive skills such as theory-of-mind and the perception/categorization of basic emotional cues would be more beneficial than interventions targeting bodily awareness. Nonetheless, it is possible that—as with the perception of lower-level emotional cues—impaired embodied emotion and interoceptive awareness represent symptoms of yet another trans-diagnostic construct, overlapping with, but distinct from alexithymia as measured by the TAS-20. To determine whether is the case, further research into the mechanisms and dysfunction of embodied emotion and interoceptive awareness is vital.

Then again, another possible explanation for the lack of noticeable effects of personality on body mapping is the small size of the current sample, compared to sample size of the original study, which was over 700 (Nummenmaa et al., 2013). As seen below in Figure 17, qualitative visualizations of data were much more detailed and precise in the original study, because of the large difference in sample size vs. the current study, as well as the statistical nature of the body mapping analysis, which incorporates multiple comparisons with false discovery rate (FDR) correction. Given that the original study did not even conduct analyses pertaining to individual differences and still used such a large sample, it is likely that far more than 80 participants would be required to elucidate clear group differences. In the current study, effect sizes of AQ and SPQ on gait perception were relatively small, and for similar effect sizes to be observed on the body mapping data, larger samples may be required, due to the nature of the data and the FDR correction. It is worth noting that we attempted to compare top and bottom quartiles for these personality measures as well, but these body maps were severely under-powered and virtually no shaded areas appeared in the composite maps of either quartile. The problem of sample size in the current EMBODY data is of a similar nature to issues faced in "under-powered" neuroimaging studies that utilize voxel-wise comparison along with measures of individual difference measures (DeYoung, Hirsh, Shane, Papademetris, Rajeevan et al, 2010). Thus, moving forward, efforts should be made to collect additional body mapping data, along with various individual difference measures, across multiple sampling sites. Furthermore, as no direct equivalent to effect size currently exists for the EMBODY paradigm, efforts to create a quantitative equivalent of Cohen's d or Cohen's f^2 for use with the EMBODY data could facilitate more effective power analyses; this could allow for more effective a priori sample size estimation in future studies incorporating EMBODY with individual difference measures.

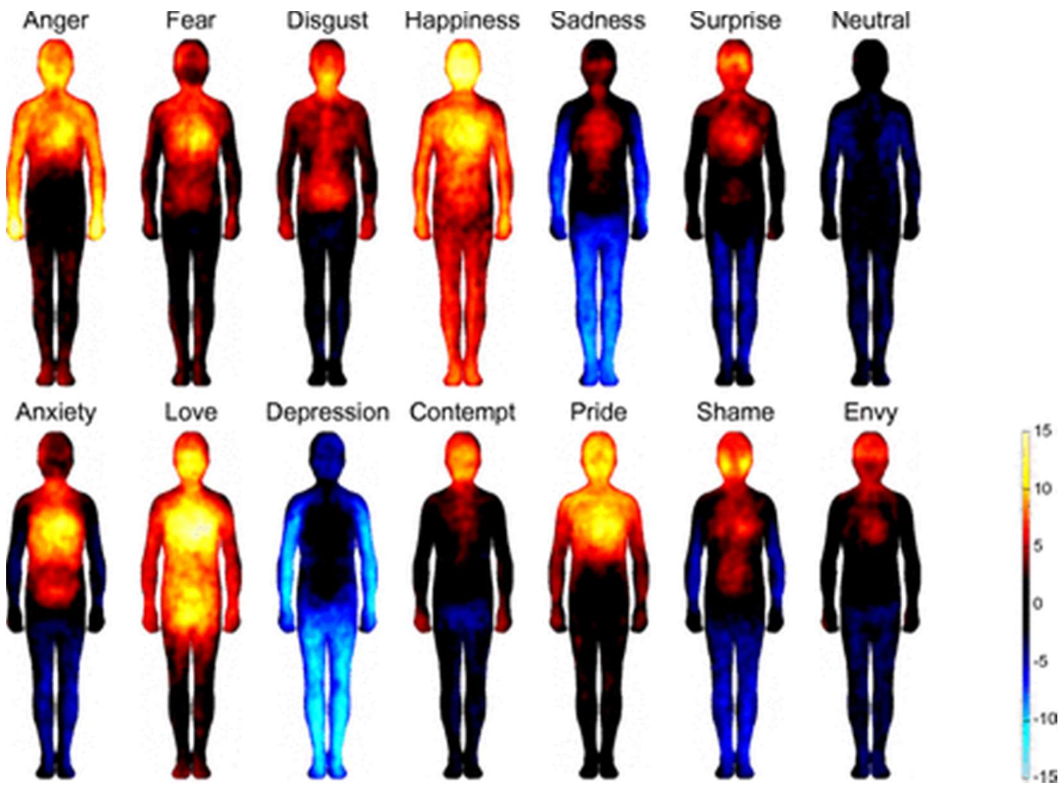

Figure 17. Results of the Original EMBODY Study, N=701 (Taken from Nummenmaa et al., 2013)

Body Mapping – Connections between Interpersonal and Intrapersonal Embodied Emotion

In line with the demonstrated connections between self and other processing of emotion that have been prominently forwarded through the alexithymia hypothesis, using both self-report (Bird & Cook, 2013) and experimental measures of alexithymia/empathy (Aaron, Blain, Snodgress, & Park, manuscript in preparation), current findings extend the ideas of self-other connections in the processing of emotion beyond higher-level cognitive domains such as emotional appraisal and empathy, to also include embodied emotion and the perception of lower-level emotional cues. In particular, the present study's body mapping data revealed that decreased ability to perceive emotional cues in gait was associated with decreased subjective report of embodied emotion. These findings are in line with research indicating connections between interoceptive awareness/embodied emotion and such phenomena as emotion reappraisal success (Füstös, Gramann, Herbert, & Pollatos, 2013), ease of intuitive decision making (Dunn, Galton, Morgan, Evans, Oliver et al., 2010), and strength of neural response to emotional stimuli (Pollatos, Kirsch, & Schandry, 2005). These findings are also in line with the "shared-network" hypothesis, which suggests areas of the brain responsible for processing one's own emotional experiences are also highly involved in processing the emotional experiences of others (Singer, 2006; Singer et al., 2009; Singer & Lamm, 2009). This notion is related to classical simulation theory (Davies, & Stone, 1995; Goldman, 1992; Gordon, 1992) and the more recent emergence of research on mirror-neurons, which activate either when an individual performs and action, or when they observe the same action (Gallese & Goldman, 1998; Rizzolatti & Craighero, 2004). In addition to backing-up general notions of simulation theory and mirror neuron activation, the current findings are particularly important for better understanding self-other connections specific to embodied emotion.

Our findings that increased report of embodied emotion is associated with more accurate perception of emotional cues in others are in line with previous theory and research suggesting that the activation of relevant somatic states associated with specific emotions may serve to facilitate more effective perception and categorization of emotions in the social environment (Decety & Jackson, 2004; Keysers et al., 2010; Niedenthal, 2007). Furthermore, our findings correspond with research indicating that emotion perception and affective resonance are associated with neural activation of the somatosensory cortex (Nummenmaa, Glerean, Viinikainen, Jääskeläinen, Hari et al. 2012; Nummenmaa, Hirvonen, Parkkola, & Hietanen, 2008) and that damage to/disruption of somatosensory areas in the brain can impair emotion perception (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Pourtois, Sander, Andres, Grandjean, Reveret et al., 2004). These connections between embodied emotion and emotion perception are also supported by facial mimicry studies, which indicate that observing prototypical emotional faces results in the activation of facial muscles associated with those emotions (Hofree, Ruvolo, Bartlett, & Winkielman, 2014; Oberman, Winkielman, & Ramachandran,

2009) and that temporarily blocking facial movement can lead to impaired emotion perception (Oberman, Winkielman, & Ramachandran, 2007). While the aforementioned studies show effects related to those of the current investigation, our findings provide more robust evidence of self-other connections in embodied emotion, by incorporating experimental measures of both embodied emotion and emotion perception; furthermore, the current study was the first to utilize measures of embodied emotion and gait perception in conjunction. Moving forward, more research is needed to clarify whether perception of emotions in various channels (e.g., faces, voices, and gait) show similarly strong associations with embodied emotion.

On top of reinforcing the embodied emotion literature at large, findings in the current sample extend the original EBMODY study's findings regarding social cognition. In the original study, Nummenmaa and colleagues (2013) employed a variety of experimental conditions in which participants completed the EMBODY task after either seeing emotional faces, reading emotion words, or being presented with emotion-induction videos. Their findings showed that body maps provided after being prompted with facial expressions of others were significantly correlated with body maps for emotion words and induction videos, using independent samples of participants. Participants in the original study were also readily able to categorize emotions corresponding to the mean body maps of other subjects (Nummenmaa et al., 2013). While these findings are important in their own right, the current study uses a stronger, within-subjects design and establishes connections between report of embodied emotion and the perception of embodied emotional cues in others.

If experience of and ability to subjectively report embodied emotion is, in fact, related to accurate emotion perception, this could have significant implications for therapy and clinical applications. Namely, clinicians may be able to enhance perception of emotional cues in gait and other full body stimuli by training patients' abilities to interpret and process emotional experiences in their own bodies. Meditation and mindfulness-based therapies already show promise for improving interoceptive and bodily awareness (Silverstein; Brown, Roth, & Britton, 2011; Khalsa et al. 2008), as well as changing the neural architecture associated with interoceptive/bodily awareness (Farb, Segal, & Anderson, 2012; Hölzel, Ott, Gard, Hempel, Weygandt et al., 2007; Lazar, Kerr, Wasserman, Gray, Greve et al., 2005). In light of the current findings, such mindfulness-based interventions may also help individuals more effectively perceive emotional cues in the bodies of others. Such translational applications could have broad applicability in both clinical and neurotypical populations. Furthermore, these connections between interpersonal and intrapersonal embodied emotion might inform future research on body-specific domains of social-cognitive dysfunction, in a variety of clinical populations.

EMBODY – Proliferating and Validating a Novel Psychological Instrument

The current study marks the first known use of the EMBODY task to assess individual differences in interoceptive awareness and the subjective experience/report of embodied emotion. Building on the original study, the current investigation shows that the EMBODY task can serve as an effective measure for measuring individual differences in the subjective report of embodied emotion. Furthermore, qualitative group differences in body mapping can be demonstrated, as seen by the current study's demonstrated associations between body mapping and gait perception. In the future, EMBODY could be used to also measure possible alternations of embodied emotion in clinical populations (e.g., schizophrenia, ASD, and eating disorders).

In addition to providing insight into how individuals subjectively represent the embodiment of emotion, the EMBODY task may serve as a valuable tool for assessing some elements of interoceptive awareness. The current most common method of assessing interoceptive awareness—heartbeat detection/counting tasks—poses many methodological issues and confounds, including lack of a validated statistical measure (Khalsa et al., 2008), the failure to properly account for changes in heartrate (Windmann, Schonecke, Frohlig, & Maldener, 1999), and possible influence of counting ability and prior knowledge of one's heartrate (Phillips, Jones, Rieger, & Snell, 1999; Ring & Brener, 1996). Thus, moving forward, the EMBODY task may serve as a valid alternative to the heartbeat detection task to assess interoceptive awareness, or at least as a valuable supplement to other metrics.

Despite the promise of EMBODY for providing insight into interoceptive awareness and the subjective experience of embodied emotion, it cannot provide a full picture of the physiological and neural mechanisms that embodied emotion entails. Thus, EMBODY would ideally be complimented with objective measures of how the body changes when various emotions are experienced. For instance, whole body activation could be measured using full-body 15O-H_2O PET imaging during emotion induction paradigms, which could then be compared to subjective report of bodily activation via EMBODY. Such use of EMBODY—paired with emotion induction paradigms and psychophysiological measures—could provide strong insight into how the body changes during emotional experience, individuals' interoceptive awareness of these changes, and how clinical disorders and symptomatology may disrupt the link between these phenomena.

Inter-correlated Personality Measures – Replicating and Forwarding Previous Associations

In addition to revealing novel insight into individual differences in emotion perception and embodied emotion, the current study replicated previously found correlations between alexithymia, autism-spectrum quotient, and schizotypy. Thus, our results add to a large yet ever-growing body of literature showing positive associations of alexithymia with ASD, schizophrenia, and their extended phenotypes (Aaron et al., 2015; Berthoz & Hill, 2005; Bird et al., 2010; Cedro, Kokoszka, Popiel, & Narkiewicz-Jodko, 2001; Hill, Berthoz, & Frith, 2004; Lockwood et al., 2013; Seghers et al., 2011; Silani et al., 2008; Stanghellini & Ricca, 1995; van't Wout et al., 2007). Results also further the idea that alexithymia may be contributing to some (but certainly not all) socioemotional impairments in schizophrenia- and autism- spectrum disorders.

In addition to replicating previously demonstrated correlations, moderation analyses indicated significant interactions between the measures, in the prediction of each other, as well as the prediction of gait perception accuracy. These interactions indicate the complex, inter-related nature of the constructs and their sub-factors. For instance, it appears that these traits may serve a compensatory function (in the statistical sense) when one predicts another; namely, high levels of one measure appear to “make up for” lower scores on another one of these measures, when either predicting gait perception or the third personality measure. This is in contrast to the other possible form of moderation, in which two measures have additive effects. In future studies utilizing these measures (i.e., TAS-20, AQ, and SPQ), heightened attention should be given to the calculation and interpretation of moderation analyses.

Moving forward, the use of more complex statistical methods such as factor analysis, structural equation modeling, and item response theory could facilitate a more comprehensive characterization of the relationship between alexithymia, schizotypy, and autism-spectrum quotient, as well as the (often overlapping, yet sometimes distinct) impact of these traits on socioemotional functioning across the spectrum of mental health and wellness. The use of such statistical approaches—paired with the incorporation of measures for apophenia, embodied emotion, and a novel trans-diagnostic construct pertaining to impaired emotion-perception—would facilitate fuller characterization of social-cognitive deficits, as well as the connections between self and other experience of emotion, in clinical and neurotypical populations alike. This approach could serve to integrate the perspectives espoused by RDoC (Insel et al., 2010), recent efforts to illuminate the psychometric structure of psychopathology (Krueger & DeYoung, 2016; Wright, Krueger, Hobbs, Markon, Eaton et al., 2013), and Bird’s alexithymia hypothesis (2010), thus leading to a more complete, nuanced view of social-cognitive functioning, as well as its relationship with psychopathology and personal experience of emotion.

Limitations/Future Directions

While the current study revealed many interesting findings, there were some obvious limitations, which should be addressed moving forward. First, the current task relied upon participants' ability to indicate which of two discrete emotions were communicated through the gait stimuli. While the discrete emotion labels "happy" and "angry" were used, these labels and their connotations could have influenced task performance (Barrett, Lindquist, & Gendron, 2007). In follow-up studies, it may be more valid to replace such labels with the more basic components of emotion, such as "positive" and "negative" affect.

Perhaps more importantly, an ongoing issue in studies involving alexithymia, autism-spectrum quotient, and schizotypy is the reliance upon metrics that use verbal surveys to assess characteristics associated with verbal deficits. While the current study was valuable in utilizing experimental (rather than only) self-report/questionnaire measures of embodied emotion and emotion perception, more work in this direction is needed still. Thus, moving forward, it is essential to create more objective measures of alexithymia and sub-clinical traits that place less reliance on verbal/language ability. Current work is underway to create a more objective, behavioral (rather than purely questionnaire-based) measure of alexithymia to supplement the TAS-20 (Aaron, Snodgress, Blain, & Park, manuscript in preparation B).

Conclusion

The current study sought to expand upon previous research showing impaired emotion perception in the extended phenotypes of autism and schizophrenia, while also investigating the possible contributions of alexithymia and embodied emotion. Findings indicate that latent liability for autism and schizophrenia may lead to impaired perception of low-threshold emotional cues from gait. In particular, positive schizotypy and associated pattern-seeking tendencies may be associated with altered perceptual patterns. Impaired low-threshold gait perception was also associated with decreased report of embodied emotion. Contrary to our hypotheses, alexithymia was not associated with impaired emotion perception, suggesting that perception of basic, lower-level emotional cues may be in-tact in alexithymia, despite the presence of higher-level socioemotional deficits. Nonetheless, alexithymia was highly correlated with both autism-spectrum quotient and schizotypy, replicating previous findings. In addition to providing novel insights into individual differences in embodied emotion, the current study serves to further validate and expand the use of the AQ-10 as a valid alternative to the full 50-item version of the AQ. The study also marks the first usage of the EMBODY task in an individual difference research setting and serves to expand the use of EMBODY as a novel, powerful measure of interoceptive awareness and subjective experience of embodied emotion. In summary, the present research serves to further the growing field of gait-based emotion perception and embodied emotion, while also providing substantial contributions to the study of individual differences and subclinical socioemotional symptomatology. Moreover, our findings demonstrate connections between personal and interpersonal experience of embodied emotion, paving the way for future research on the mechanisms of socio-emotional deficits in autism, schizophrenia, and extended phenotypes of these disorders.

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Appendix A: Correlation Matrixes

Table A1. Spearman Correlations between Gait Perception (Overall) and Personality Measures

	AQ-10	SPQ	TAS-20
Total Accuracy	0.03	-0.05	-0.10
Happy Accuracy	0.13	0.07	-0.07
Angry Accuracy	-0.04	-0.07	-.009

** p < .05, * p < .05, + p < .1

Table A2. Spearman Correlations between Gait Perception (High-Intensity) and Personality Measures

	AQ-10	SPQ	TAS-20
Total Accuracy 150%	-0.04	-0.06	-0.08
Total Accuracy 100%	-0.04	-0.01	0.04
Happy Accuracy 150%	0.07	0.04	-0.11
Happy Accuracy 100%	0.02	0.16	-0.02
Angry Accuracy 150%	0.07	-.12	-0.07
Angry Accuracy 100%	-0.06	-0.08	0.03

** p < .05, * p < .05, + p < .1

Table A3. Spearman Correlations between Gait Perception (Low-Intensity) and Personality Measures

	AQ-10	SPQ	TAS-20
Total Accuracy 50%	-0.23*	-0.16	-0.01
Happy Accuracy 50%	0.07	0.11	0.06
Angry Accuracy 50%	-0.23*	-0.17	-0.02

** p < .05, * p < .05, + p < .1

Appendix B: Visualizations of Key Correlations

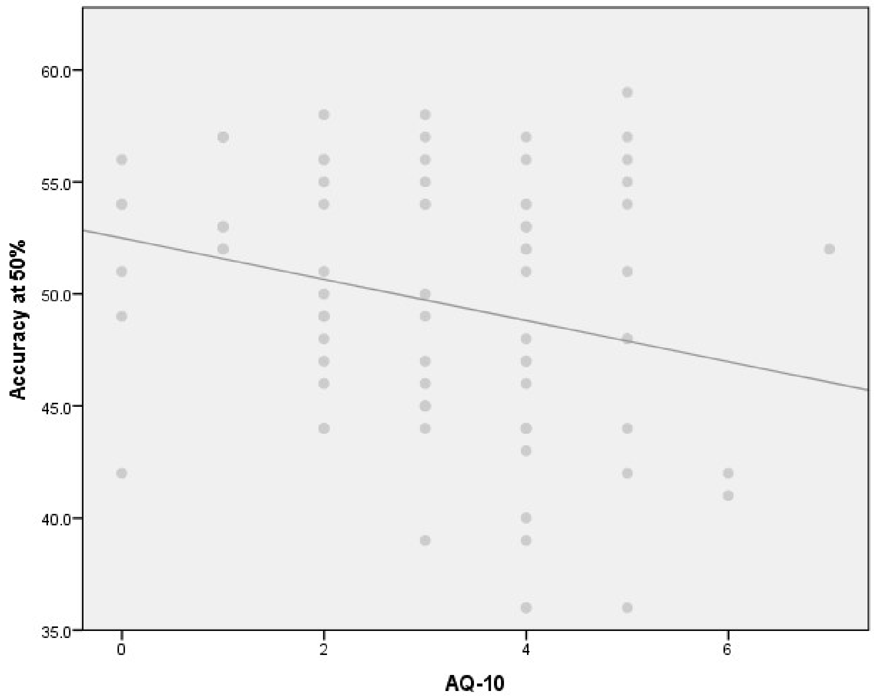

Figure B1. Association between Gait Perception Accuracy and Autism-spectrum quotient

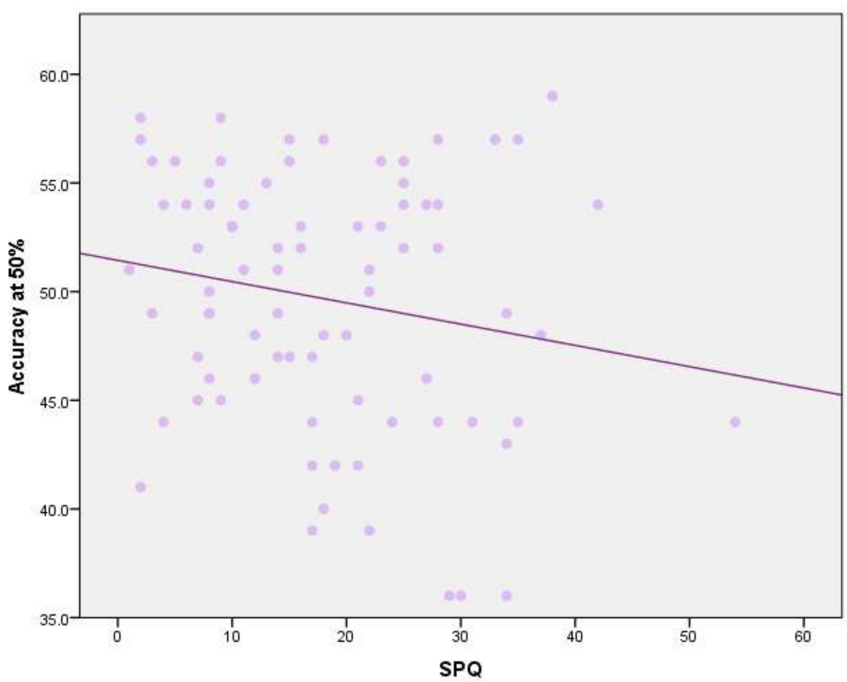

Figure B2. Association between Gait Perception Accuracy and Schizotypy

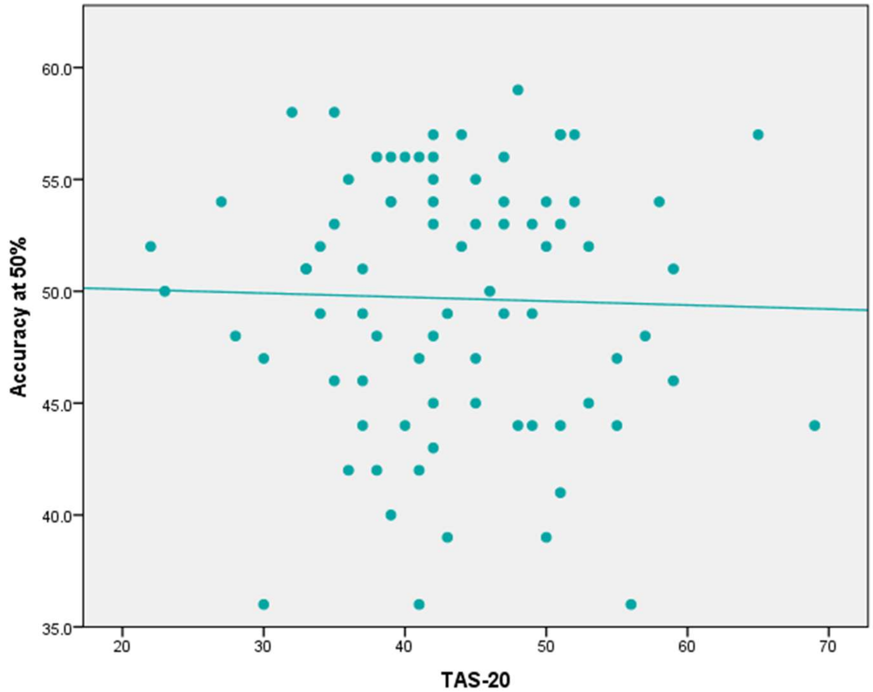

Figure B3. Association between Gait Perception Accuracy and Alexithymia

Figure Legends

Figure B1. Association between Gait Perception Accuracy and Autism-spectrum quotient

Regression line indicates a significant negative correlation between AQ-10 scores and raw scores (out of 64) for total gait perception accuracy at 50% intensity ($\rho = -0.233$, $p < 0.05$).

Figure B2. Association between Gait Perception Accuracy and Schizotypy

Regression line indicates a negative trend between SPQ scores and raw scores (out of 64) for total gait perception accuracy at 50% intensity ($r = -0.184$, $p = 0.1$).

Figure B3. Association between Gait Perception Accuracy and Schizotypy

Regression line indicates no correlation between TAS-20 scores and raw scores (out of 64) for total gait perception accuracy at 50% intensity (alexithymia $r = -.027$, $p = .81$).

Appendix C: Additional Body Mapping Visualizations

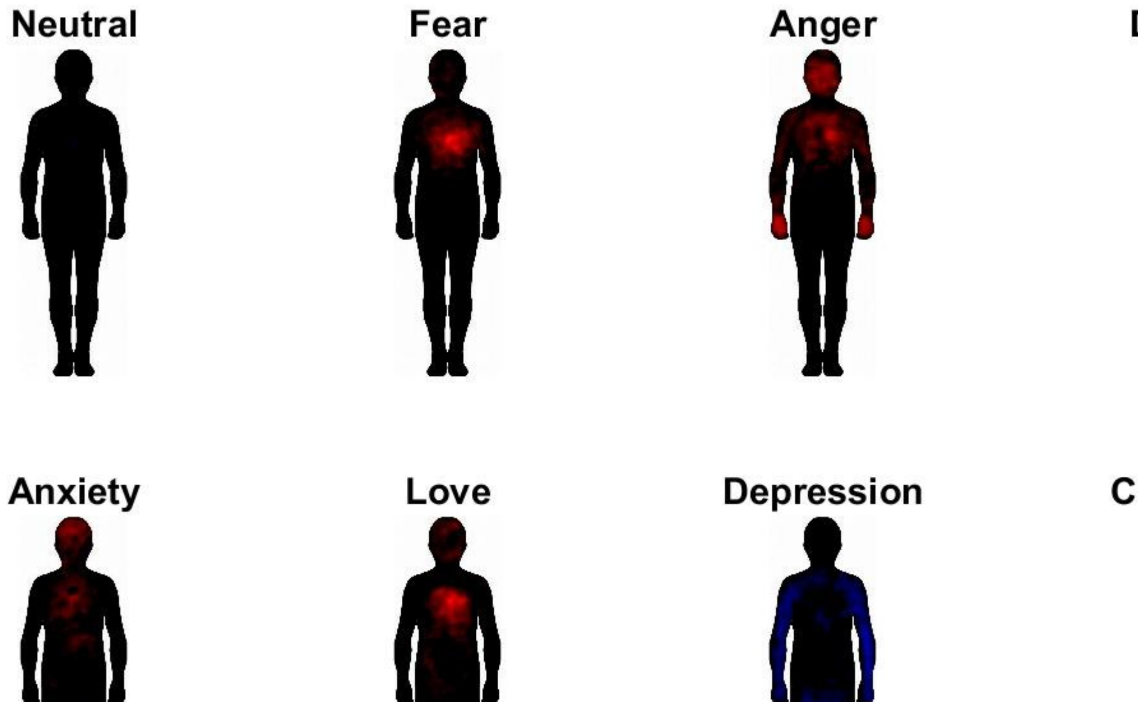

Figure C1. Body Mapping for Individuals with Bottom Half Positive SPQ

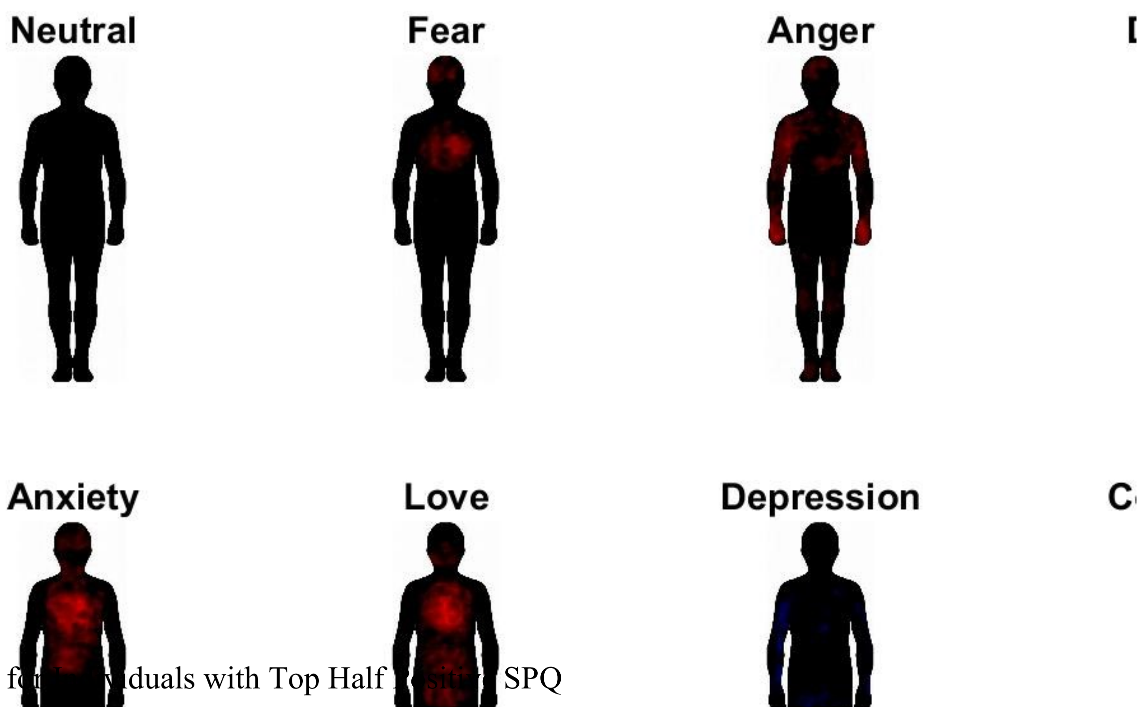

Figure C2. Body Mapping for Individuals with Top Half Positive SPQ

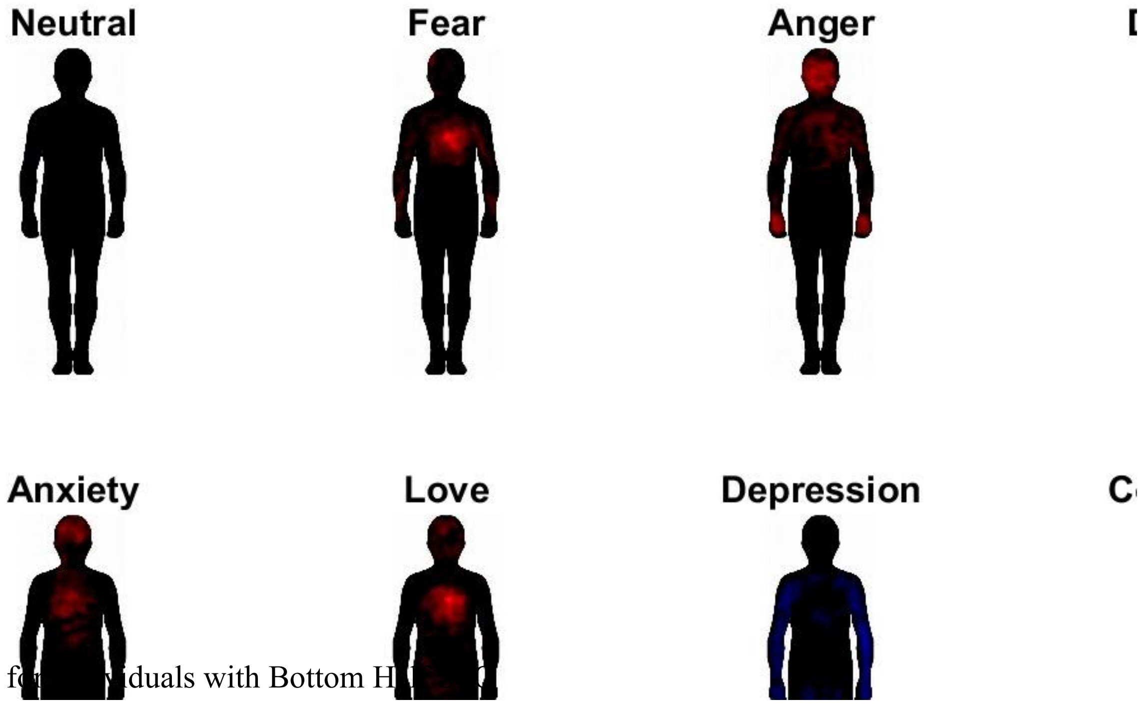

Figure C3. Body Mapping fo[illegible]iduals with Bottom H[illegible]

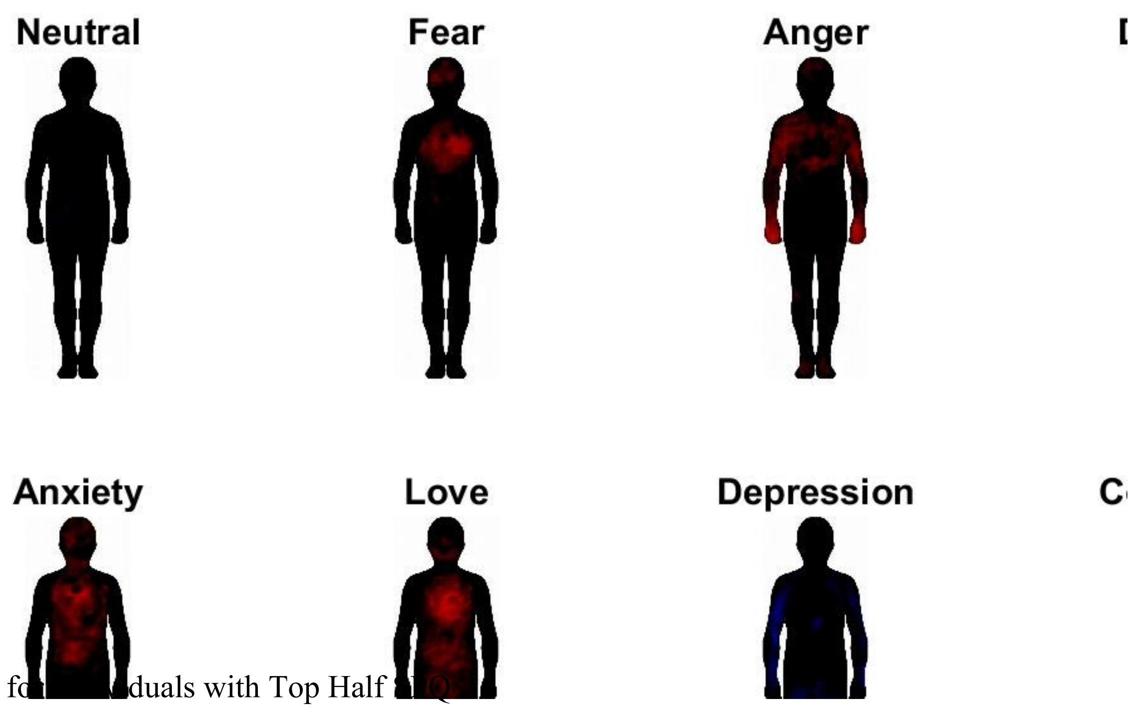

Figure C4. Body Mapping fo[illegible]duals with Top Half [illegible]Q

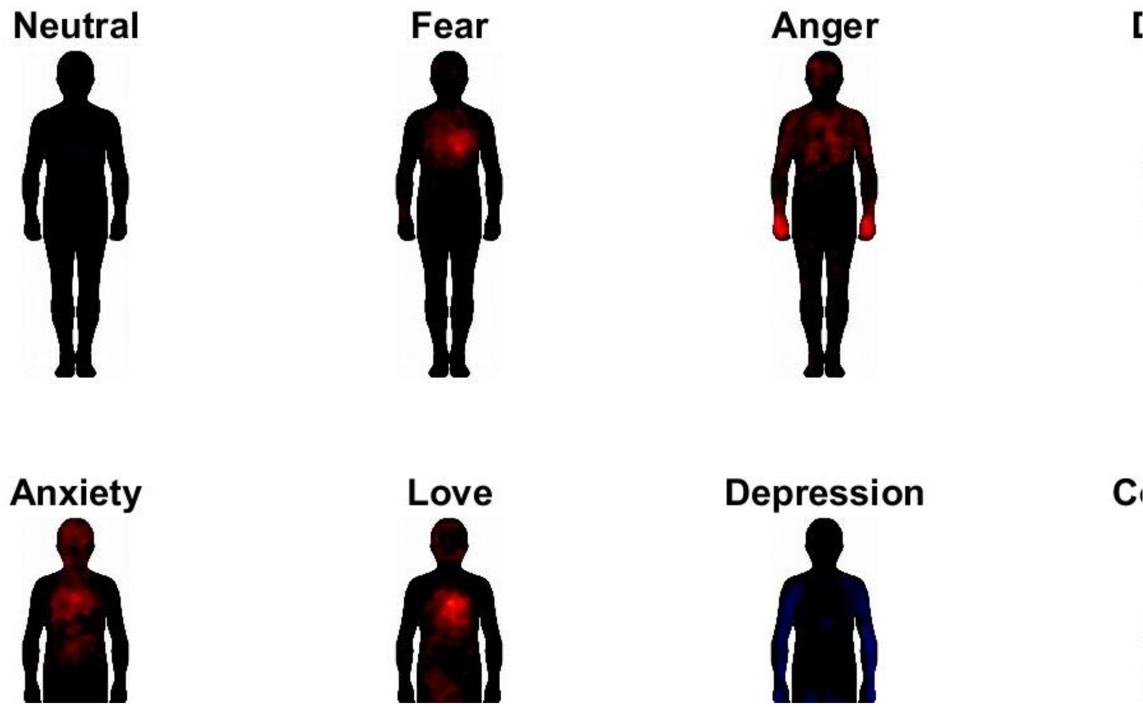

Figure C5. Body Mapping for Individuals with Bottom Half AQ-10

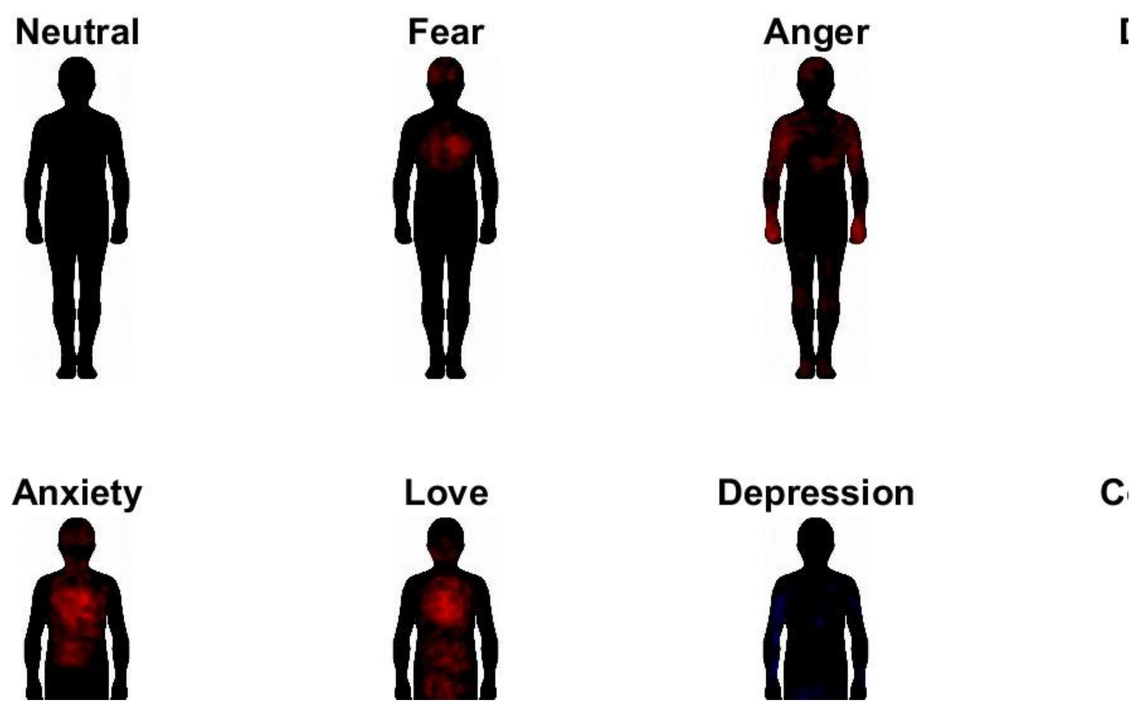

Figure C6. Body Mapping for Individuals with Top Half AQ-10

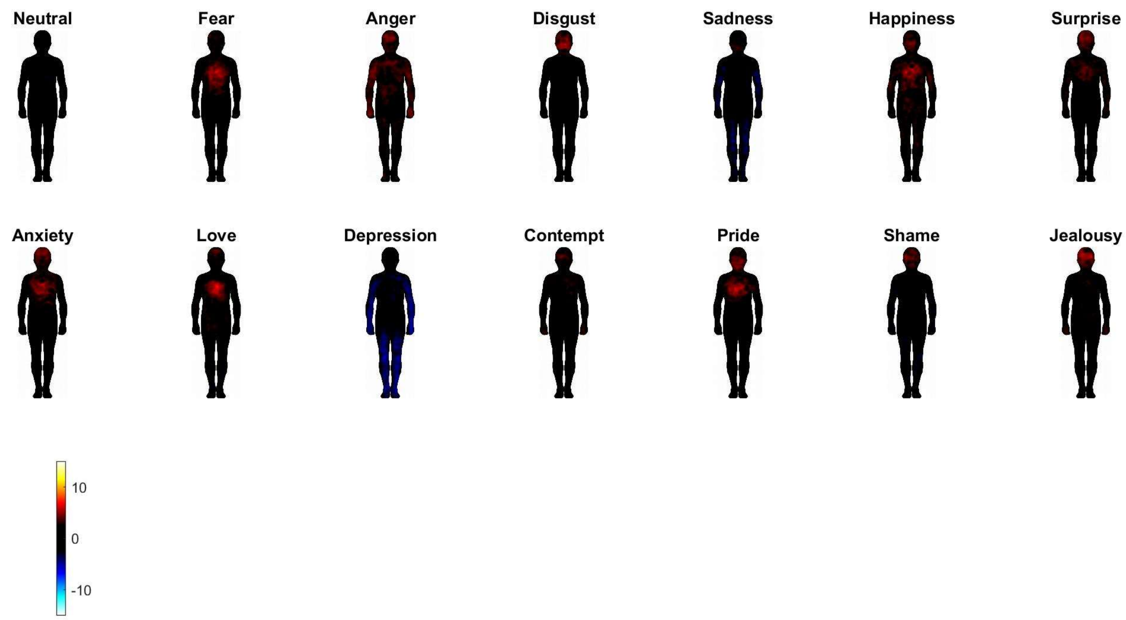

Figure C7. Body Mapping for Individuals with Bottom Half TAS-20

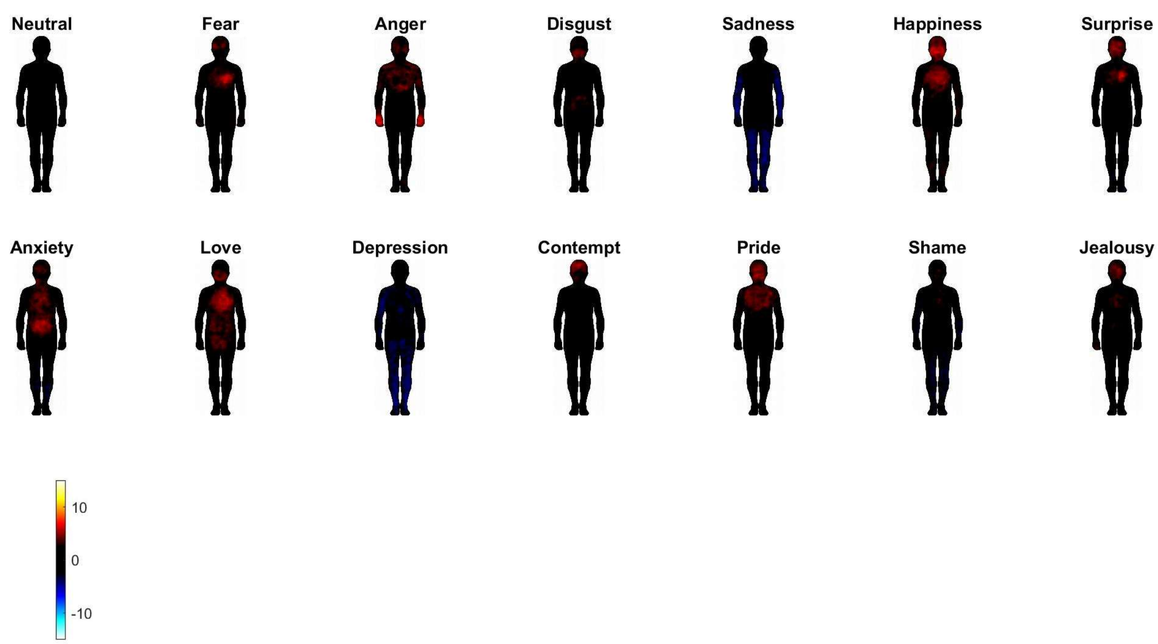

Figure C8. Body Mapping for Individuals with Top Half TAS-20

Appendix D: Personality Measures

AQ-10 (Allison et al., 2012)

National Institute for Health Research

AQ-10

Autism Spectrum Quotient (AQ)

A quick referral guide for adults with suspected autism who do not have a learning disability.

	Please tick one option per question only:	Definitely Agree	Slightly Agree	Slightly Disagree	Definitely Disagree
1	I often notice small sounds when others do not				
2	I usually concentrate more on the whole picture, rather than the small details				
3	I find it easy to do more than one thing at once				
4	If there is an interruption, I can switch back to what I was doing very quickly				
5	I find it easy to 'read between the lines' when someone is talking to me				
6	I know how to tell if someone listening to me is getting bored				
7	When I'm reading a story I find it difficult to work out the characters' intentions				
8	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant etc)				
9	I find it easy to work out what someone is thinking or feeling just by looking at their face				
10	I find it difficult to work out people's intentions				

SCORING: Only 1 point can be scored for each question. *Score 1 point for Definitely or Slightly Agree on each of items 1, 7, 8, and 10. Score 1 point for Definitely or Slightly Disagree on each of items 2, 3, 4, 5, 6, and 9.* If the individual scores **more than 6 out of 10**, consider referring them for a specialist diagnostic assessment.

This test is recommended in 'Autism: recognition, referral, diagnosis and management of adults on the autism spectrum' (NICE clinical guideline CG142). www.nice.org.uk/CG142

Key reference: Allison C, Auyeung B, and Baron-Cohen S, (2012) *Journal of the American Academy of Child and Adolescent Psychiatry* 51(2):202-12.

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autism research centre arc

TAS-20 (Bagby et al., 1994)

Please answer the following questions, using the scale provided:

(1) Completely disagree
(2) Disagree
(3) Neutral
(4) Agree
(5) Completely agree

1. I am often confused about what emotion I am feeling.	1 – 2 – 3 – 4 – 5
2. It is difficult for me to find the right words for my feelings.	1 – 2 – 3 – 4 – 5
3. I have physical sensations that even doctors don't understand.	1 – 2 – 3 – 4 – 5
4. I am able to describe my feelings easily.	1 – 2 – 3 – 4 – 5
5. I prefer to analyze problems rather than just describe them.	1 – 2 – 3 – 4 – 5
6. When I am upset, I don't know if I am sad, frightened, or angry.	1 – 2 – 3 – 4 – 5
7. I am often puzzled by sensations in my body.	1 – 2 – 3 – 4 – 5
8. I prefer to just let things happen rather than to understand why they turned out that way.	1 – 2 – 3 – 4 – 5
9. I have feelings that I can't quite identify.	1 – 2 – 3 – 4 – 5
10. Being in touch with emotions is essential.	1 – 2 – 3 – 4 – 5
11. I find it hard to describe how I feel about people.	1 – 2 – 3 – 4 – 5
12. People tell me to describe my feelings more.	1 – 2 – 3 – 4 – 5
13. I don't know what's going on inside me.	1 – 2 – 3 – 4 – 5
14. I often don't know why I am angry.	1 – 2 – 3 – 4 – 5
15. I prefer talking to people about their daily activities rather than their feelings.	1 – 2 – 3 – 4 – 5
16. I prefer to watch "light" entertainment shows rather than psychological dramas.	1 – 2 – 3 – 4 – 5
17. It is difficult for me to reveal my innermost feelings, even to close friends.	1 – 2 – 3 – 4 – 5
18. I can feel close to someone, even in moments of silence.	1 – 2 – 3 – 4 – 5
19. I find examination of my feelings useful in solving personal problems.	1 – 2 – 3 – 4 – 5
20. Looking for hidden meanings in movies or plays distracts from their enjoyment.	1 – 2 – 3 – 4 – 5

TAS

SPQ (Raine, 1991)

VOL. 17, NO. 4, 1991 557

Table 1. Items for the nine subscales in the final 74-item version of the Schizotypal Personality Questionnaire

Ideas of Reference

1. Do you sometimes feel that things you see on the TV or read in the newspaper have a special meaning for you?
10. I am aware that people notice me when I go out for a meal or to see a film.
19. Do some people drop hints about you or say things with a double meaning?
28. Have you ever noticed a common event or object that seemed to be a special sign for you?
37. Do you sometimes see special meanings in advertisements, shop windows, or in the way things are arranged around you?
45. When shopping do you get the feeling that other people are taking notice of you?
53. When you see people talking to each other, do you often wonder if they are talking about you?
60. Do you sometimes feel that other people are watching you?
63. Do you sometimes feel that people are talking about you?

Excessive Social Anxiety

2. I sometimes avoid going to places where there will be many people because I will get anxious.
11. I get very nervous when I have to make polite conversation.
20. Do you ever get nervous when someone is walking behind you?
29. I get anxious when meeting people for the first time.
38. Do you often feel nervous when you are in a group of unfamiliar people?
46. I feel very uncomfortable in social situations involving unfamiliar people.
54. I would feel very anxious if I had to give a speech in front of a large group of people.
71. I feel very uneasy talking to people I do not know well.

Odd Beliefs or Magical Thinking

3. Have you had experiences with the supernatural?
12. Do you believe in telepathy (mind-reading)?
21. Are you sometimes sure that other people can tell what you are thinking?
30. Do you believe in clairvoyancy (psychic forces, fortune telling)?
39. Can other people feel your feelings when they are not there?
47. Have you had experiences with astrology, seeing the future, UFOs, ESP, or a sixth sense?
55. Have you ever felt that you are communicating with another person telepathically (by mind-reading)?

Unusual Perceptual Experiences

4. Have you often mistaken objects or shadows for people, or noises for voices?
13. Have you ever had the sense that some person or force is around you, even though you cannot see anyone?
22. When you look at a person, or yourself in a mirror, have you ever seen the face change right before your eyes?
31. I often hear a voice speaking my thoughts aloud.
40. Have you ever seen things invisible to other people?
48. Do everyday things seem unusually large or small?
56. Does your sense of smell sometimes become unusually strong?
61. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
64. Are your thoughts sometimes so strong that you can almost hear them?

Odd or Eccentric Behavior

5. Other people see me as slightly eccentric (odd).
14. People sometimes comment on my unusual mannerisms and habits.
23. Sometimes other people think that I am a little strange.
32. Some people think that I am a very bizarre person.
67. I am an odd, unusual person.
70. I have some eccentric (odd) habits.
74. People sometimes stare at me because of my odd appearance.

No Close Friends

6. I have little interest in getting to know other people.
15. I prefer to keep myself to myself.
24. I am mostly quiet when with other people.

Table 1. Items for the nine subscales in the final 74-item version of the Schizotypal Personality Questionnaire—*Continued*

No Close Friends—*Continued*

33. I find it hard to be emotionally close to other people.
41. Do you feel that there is no one you are really close to outside of your immediate family, or people you can confide in or talk to about personal problems?
49. Writing letters to friends is more trouble than it is worth.
57. I tend to keep in the background on social occasions.
62. I attach little importance to having close friends.
66. Do you feel that you cannot get "close" to people?

Odd Speech

7. People sometimes find it hard to understand what I am saying.
16. I sometimes jump quickly from one topic to another when speaking.
25. I sometimes forget what I am trying to say.
34. I often ramble on too much when speaking.
42. Some people find me a bit vague and elusive during a conversation.
50. I sometimes use words in unusual ways.
58. Do you tend to wander off the topic when having a conversation?
69. I find it hard to communicate clearly what I want to say to people.
72. People occasionally comment that my conversation is confusing.

Constricted Affect

8. People sometimes find me aloof and distant.
17. I am not good at expressing my true feelings by the way I talk and look.
26. I rarely laugh and smile.
35. My "nonverbal" communication (smiling and nodding during a conversation) is not very good.
43. I am poor at returning social courtesies and gestures.
51. I tend to avoid eye contact when conversing with others.
68. I do not have an expressive and lively way of speaking.
73. I tend to keep my feelings to myself.

Suspiciousness

9. I am sure I am being talked about behind my back.
18. Do you often feel that other people have it in for you?
27. Do you sometimes get concerned that friends or co-workers are not really loyal or trustworthy?
36. I feel I have to be on my guard even with friends.
44. Do you often pick up hidden threats or put-downs from what people say or do?
52. Have you found that it is best not to let other people know too much about you?
59. I often feel that others have it in for me.
65. Do you often have to keep an eye out to stop people from taking advantage of you?

Note.—The response format is "yes/no." All items endorsed "yes" score 1 point.