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ORIGINAL PAPER

The Relationship Between Autistic Traits and Social Anxiety, Worry, Obsessive–Compulsive, and Depressive Symptoms: Specific and Non-specific Mediators in a Student Sample

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Abstract The high prevalence of anxiety symptoms in individuals with autism spectrum disorders has now been well documented. There is also a positive relationship between autistic traits and anxiety symptoms in unselected samples and individuals with anxiety disorders have more autistic traits compared to those without. Less is known, however, regarding which elements of autistic traits (i.e., social versus non-social/behavioral) or which other variables may mediate this relationship. This study investigated the shared and specific role of five autistic-trait related mediators (social problem-solving, social competence, teasing experiences, prevention from/punishment for preferred repetitive behaviors and aversive sensory experiences) in a non-clinical sample of 252 university students. Autistic traits positively correlated with both anxiety and depressive symptoms. Social competence mediated the relationship between autistic traits and social anxiety symptoms only, while only prevention from preferred repetitive behaviors and frequent aversive sensory experiences mediated the relationship between autistic traits, worry and obsessive–compulsive symptoms. Replication of these findings is required in longitudinal studies and with clinical samples. Limitations of the study are discussed and possible implications for intervention are tentatively suggested.

Keywords Autism · Autistic traits · Anxiety · Depression · Mediator · Relationship · Predictor

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Introduction

Autism spectrum disorder (ASD) is a heterogeneous lifelong neurodevelopmental condition characterized by impairments in reciprocal social interaction and communication as well as a pattern of restricted and circumscribed behaviors and interests (APA 2013). Individuals with ASD are now understood to be at the extreme end of a continuum of social, communication and behavioral autistic-related traits, which have been found to be higher, albeit below clinical threshold, in relatives of those with ASD and normally distributed in the general population (the "Broader Autism Phenotype", BAP; Constantino and Todd 2003; Ronald et al. 2006; Skuse et al. 2009). There is also graving empirical evidence that the magnitude of inherited influence of autistic traits (80 %) is similar to that of ASD (Constantino 2013) and that autistic traits in the general population and at the quantitative extremes likely show the same etiology as ASD (Robinson et al. 2011; Lundstrom et al. 2012; see Ronald and Hoekstra 2011). Understanding ASD dimensionally has led to a considerable increase in family, twin, sibling and general population BAP studies, as it is thought that understanding the etiology of individual differences in autistic traits in the general population may aid our understanding of the causes of clinically diagnosed ASD, the relationships

between ASD and other comorbid conditions or symptoms and the potential mechanisms explaining these relationships (Ronald and Hoekstra 2014; Sucksmith et al. 2011; Gerdts and Beriner 2011).

High rates of anxiety difficulties or disorders are common in individuals with ASD, often much higher than in those without ASD or those with other neurodevelopmental disabilities (Green et al. 2000; Gadow et al. 2009; see White et al. 2009; MacNeil et al. 2009, for reviews). Relatives of children with ASD also show a higher prevalence of psychiatric disorders, including anxiety, compared to relatives of children without ASD (Micali et al. 2004; Piven et al. 1991).

The Relationship Between ASD, Autistic Traits and Anxiety Symptoms or Disorders

In clinical samples of individuals with ASD, more anxiety symptoms have been associated with greater autism-related symptomatology (i.e., Mayes et al. 2011; Hallett et al. 2012a, b; Kelly et al. 2008) or with specific autism-related characteristics, such as poorer social responsiveness (Sukhodolsky et al. 2008) and social skills (Bellini 2004), but increased loneliness (White and Roberson-Nay 2009), sensory symptoms (Green et al. 2012), and repetitive behaviors (Sukhodolsky et al. 2008).

In studies of individuals with anxiety and/or mood disorders but without ASD, high rates of autistic traits and symptoms have been reported (Pine et al. 2008; van Steensel et al. 2013). Clinically anxious adolescents with higher levels of autistic traits but no ASD diagnosis have more diagnoses of anxiety disorders, social phobia, interpersonal worries and are more resistant to "traditional" cognitive behavioral interventions for anxiety compared to clinically anxious adolescents with fewer autistic traits (Settipani et al. 2012; Puleo and Kendall 2011).

In non-clinical community or student samples too, using self-report or informant-based screening measures assessing autistic traits dimensionally, participants with higher reported autistic traits also report more depressive and anxious symptoms (Kanne et al. 2009; Scherff et al. 2014), higher frequency of being bullied (Kunihira et al. 2006), increased sensory sensitivity (Robertson and Simmons 2013) and lower relationship satisfaction (Pollmann et al. 2010).

Taken together, these findings provide consistent evidence that there is a strong positive relationship between autistic traits and anxiety symptoms in both clinical and non-clinical samples. There is currently very little evidence regarding the direction of this relationship, as there have been extremely few longitudinal studies (Kerns and Kendall 2012). Hallett et al. (2012a, b) provided preliminary evidence for a bidirectional association between autistic-like and internalizing traits over time in a population-based twin sample, with earlier autistic traits being stronger predictors of later internalizing traits than vice versa. There is also considerably little evidence as to whether this relationship is specific to anxiety or also applies to other internalizing (i.e. depressive) symptoms. Moreover, much less is understood about *how* anxiety and autistic traits may be related and which specific parts or dimensions of autistic symptoms may differentially explain the relationship between broad autistic traits and certain anxiety subtypes (i.e., obsessive–compulsive, social, general worry).

Mediators Between Autistic Traits and Anxiety/Depressive Symptoms

To our knowledge, only one study has so far empirically examined a number of autism-trait related mediators together between broad autistic traits and anxiety and depressive symptoms in the general population adopting a dimensional approach. In a cross-sectional study, Rosbrook and Whittingham (2010) explored the role of social problem-solving, social competence, and teasing experiences in mediating the relationship between autistic traits and anxious and depressive symptoms in 231 university students from Australia and the United Kingdom. These mediators were purposefully selected due to past evidence of their association with anxiety or depressive symptoms. For example, better social competence has been found to predict fewer depressive symptoms (Vickerstaff et al. 2007) and better social problem-solving or fewer social difficulties have been associated with decreased depressive and anxious symptomatology (e.g., Anderson et al. 2007; Hallett et al. 2012a, b). They found that social problem-solving ability and past teasing experiences were significant partial mediators between autistic traits and anxiety, but this also applied to depressive symptoms. Social competence was not a significant mediator in explaining depressive symptoms, but the mediation analysis of social competence in relation to anxiety symptoms was not reported.

Theoretically, Wood and Gadow's proposed hypothetical model (2010) of anxiety in ASD postulated that (1) social confusion and unpredictability, (2) peer rejection and victimization relating to autism symptoms, (3) prevention from or punishment for preferred repetitive behaviors, and (4) frequent aversive sensory experiences in daily life may be specific autism-related factors contributing to mood dysregulation and anxiety. Again, these variables appear to have been purposefully selected, given evidence that individuals with ASD are particularly prone to being teased and bullied due to their deviant social and behavioral features (i.e., Shtayermman 2007). Repetitive behaviors and interests often generate negative or even punishing

reactions from others (Bellini 2004; Gillott and Stranden 2007). Sensory oversensitivity can be overwhelming to many people with ASD, potentially contributing to more anxiety (Wood and Gadow 2010; Spiker et al. 2011). In this model, social confusion and peer victimization were proposed to contribute to social and non-social (e.g., obsessive–compulsive or worry) anxiety, negative affectivity and/or depressive symptoms. However, prevention of/punishment from circumscribed behaviors and aversive sensory experiences were conceptualized as variables contributing to overall depressive and anxiety symptoms, but *not* social anxiety. There is currently little empirical evidence to support this proposed model.

The Present Study: Aims and Research Hypotheses

The present study aimed to replicate and extend the work of Rosbrook and Whittingham (2010) and to validate some of the variables and relationships proposed by Wood and Gadow (2010) in an unselected sample.

Barlow's (2000) triple vulnerabilities model of anxiety was adopted, which postulates that broad, largely biologically determined, dispositions (in this study, autistic traits) may predict anxiety through the effect of more specific, proximal vulnerabilities (the proposed mediators). The five mediators examined in the present study were purposefully selected given preliminary empirical evidence by Rosbrook and Whittingham (2010) and guided by the theoretical model by Wood and Gadow (2010). Further to the three socially-focused autism-related mediators in Rosbrook and Whittingham (2010; social problem-solving, social competence, teasing experiences), two additional non-social autism-related constructs proposed by Gadow and Wood (2010; i.e., prevention from/punishment for stereotyped behaviors; and frequent adverse sensory experiences) were included, as recent evidence suggests autistic-related symptoms are "fractionable" (Happé and Ronald 2008; Mandy and Skuse 2008; Robinson et al. 2012; Shuster et al. 2014). For this reason, it was considered important to investigate the potential specific mediating role of both social (competence, problem solving, teasing) and non-social/behavioral autism-symptom related vulnerabilities (sensory, repetitive behavior symptoms). Their role as mediators was examined with anxiety as well as depressive symptoms, in order to establish whether these mediators are specific to anxiety or explain negative affect more broadly. We specifically examined social anxiety, worry and obsessive–compulsive symptoms, because these have been found to be increased in those with a diagnosis of ASD (van Steensel et al. 2011).

The present study, thus, examined the following hypotheses:

Hypothesis 1 Autistic traits will be positively correlated with both anxiety and depressive symptoms.

Hypothesis 2 To explore the potential specificity of the five proposed mediators, it was further hypothesized that:

(a) Social problem-solving, social competence, and teasing experiences will mediate the relationship between broad autistic traits and social anxiety as well as depressive symptoms, but *not* other anxiety (i.e., obsessive–compulsive, worry) symptoms.
(b) Prevention from/punishment for preferred repetitive behaviors and frequent aversive sensory experiences will mediate the relationship between autistic traits and non-social anxiety symptoms (i.e., obsessive–compulsive, worry symptoms) as well as depressive, but *not* social anxiety, symptoms.

Adopting a dimensional approach, this study was carried out with a university student sample in Singapore, providing an opportunity to replicate earlier findings in an Asian country. Although findings have been mixed, there is evidence that anxiety symptoms may be higher and symptom presentation may be different in non-Caucasians as compared to Caucasian participants largely from the US and the UK (see Anderson and Mayes 2010; for a review). Similarly, there may be differences in the expression or reporting of autistic traits in different countries or ethnic groups (e.g., Wakabayashi et al. 2006; Freeth et al. 2013b). Thus, examining the relationship of these two constructs, which may at least to some extent be influenced by cultural or ethnic group membership, in a non-Caucasian sample would strengthen the ecological validity of existing findings from studies carried out with predominantly Caucasian participants.

Method

Participants and Recruitment

Two hundred and fifty two university students (88 males) from the National University of Singapore with a mean age of 20.6 years ($SD = 1.73$, range 18–29 years) participated. Of those, 223 were Chinese (89 %), 11 Malay (4 %), 12 Indian (5 %) and 6 from other ethnic groups (2 %). Just over half (53 %) were students from various departments/degrees taking an introductory psychology module who received course credit for their participation, while the remaining participants were recruited from other departments and received a small voucher. The breakdown of students from the various faculties was: Arts (36 %); Engineering (24 %); Sciences (25 %); Computing (5 %); Business (1 %); not yet decided on their major (9 %).

Measures

Autism Spectrum Quotient (AQ; Baron-Cohen et al. 2001)

AQ is a brief, self-completed 50-item scale designed to measure the degree to which adults with normal intelligence have ASD-associated traits. It provides a Total score (range 0–50; higher scores indicate more autistic traits) and five a priori derived subscale scores. The AQ has good test–retest reliability ($r = .70$) and adequate internal consistency (Baron-Cohen et al. 2001). Aside from its use as a screening tool (i.e. Allison et al. 2012), a large number of studies have used the AQ to measure quantitative autistic traits in student and non-clinical populations, reporting similar score patterns in different countries (i.e., Freeth et al. 2013b; Ruta et al. 2012; Wakabayashi et al. 2006), while different factor structures has been proposed (e.g., Hurst et al. 2007; Hoekstra et al. 2008; Lau et al. 2013).

Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al. 2007)

The 64-item IDAS self-report scale measures symptoms associated with major depression and related anxiety disorders. Items are rated on a 5-point Likert scale (total score range 0–320) and organized in ten specific and two broad symptom scales. The IDAS has excellent short-term stability, good internal consistency, excellent convergent validity with other well-established measures, good discriminant validity and good test–retest reliability (Watson et al. 2007). In this study, the 20-item IDAS General Depression subscale (score range 0–100) was used to measure depressive symptoms.

Penn State Worry Questionnaire (PSWQ; Meyer et al. 1990)

The 16-item PSWQ (total score range 0–80) has been completed by clinical and non-clinical populations to specifically measure self-reported worry/generalized anxiety symptoms (Meyer et al. 1990; Pallensen et al. 2006; Titov et al. 2010). It has high internal consistency ($\alpha = .93$), good test–retest reliability and good convergent, divergent and discriminant validity (Meyer et al. 1990).

Obsessive–Compulsive Inventory Revised (OCI-R; Foa et al. 2002)

The OCI-R is an 18-item factor-analysis derived shortened version of the OCI (total score 0–72) and comprising six factors measuring a range of obsessive–compulsive symptoms. It has good internal consistency ($.63 < \alpha < .80$) and test–retest reliability ($.74 < r < .91$). It has been used to screen for OCD (Foa et al. 2002) and has been found to be valid in the Chinese culture (Peng et al. 2011).

Social Interaction Anxiety Scale (SIAS; Mattlick and Clarke 1998)

The widely used 20-item SIAS was used to assess self-reported fears and avoidance concerning social interactions (score range 0–80). It has very good internal consistency ($.88 < \alpha < .93$), test–retest reliability ($r = .92$; Mattlick and Clarke 1998) and strong convergent and discriminant validity (Heimberg et al. 1992; Brown et al. 1997; Rodebaugh et al. 2006).

Social Skills Inventory (SSI; Riggio 1989)

The 90-item SSI (score range 0–450) was employed to assess participants' self-reported basic social communication skills and to provide an overall social competence score. It comprises six scales measuring social, communication and emotional verbal and non-verbal skills. It has favorable psychometric properties and predicts real world social behavior (Riggio 1989).

Social Problem Solving Inventory-Revised Short Form (SPSI-R-SF; D'Zurilla and Nezu 1990)

The SPSI-R-SF is a 25-item shortened version of the SPSI-R measuring five major dimensions of participants' perceived ability to solve "real-life" social problems (i.e., Positive Problem Orientation, Rational Problem Solving, Impulsivity/Carelessness Style, Avoidance Style; score range 0–100). It has reasonable internal consistency ($\alpha = .69$; Rosbrook and Whittingham 2010) and excellent test–retest reliability in an adult university sample (Haugh 2006).

Teasing Questionnaire-Revised (TQ-R; Storch et al. 2004)

The 35-item TQ-R measures childhood memories of teasing. It has five constructs (i.e., teasing about performance, academics, social behavior, family background, and appearance). Its internal consistency is high ($\alpha = .87$; Ledley et al. 2005). An adapted version was used in this study following authors' permission: all items were included in their original wording in the past tense, but we also added a "present tense" version to also obtain information about current experiences of teasing. The total score (0–350; 35 "past" and 35 "present" items) was used to measure overall teasing experiences.

Repetitive Behaviors Scale-Revised (RBS-R; Bodfish et al. 2000)

The RBS-R is a caregiver-report measure assessing observable repetitive behaviours in individuals with ASD. The original RBS-R demonstrates good internal consistency and validity (Lam 2004). There is, to our knowledge, no existing measure assessing self-reported repetitive behaviors in adults without ASD. Thus, with the authors' permission, the items from five of the RBS-R subscales (Stereotyped, Compulsive, Routine, Sameness and Restricted; the original Self-injurious subscale was excluded due to low incidence in non-clinical samples) were all retained verbatim, but changed to first person. In addition, two items were added at the end of each subscale: participants rated the extent to which they have been (a) prevented from or (b) punished for engaging in their preferred repetitive behaviors on a scale of 0 (never/rarely) to 3 (very often). The total scores of these ten added items (0–30) were calculated to measure prevention from or being punished for preferred repetitive behaviors in this study.

Adolescent/Adult Sensory Profile (AASP; Brown and Dunn 2002)

AASP is an ecologically valid 60-item self-report questionnaire (score range 0–300) measuring an individual's responsiveness to varying sensory stimuli (i.e., taste/smell, movement, visual, touch, activity level, and auditory) and the effect of sensory processing on functional performance in daily life (Brown and Dunn 2002). It has good test–retest reliability, discriminant, convergent and external validity in clinical and non-clinical samples (Brown and Dunn 2002). In this study, the 15-item AASP Sensory Sensitivity subscale (score range 0–75) was used to measure discomfort with sensory stimuli in daily life.

Procedure

Ethical approval was obtained from the National University of Singapore, Institutional Review Board. Following informed consent, participants completed the questionnaires in a single 1-h long session in a psychology lab. Written instructions were provided and the first or second authors were present to guide the participants and answer any queries. All data were anonymous. After completing the questionnaires, participants were given a written debriefing summary, which included the study rationale, past findings, and contact details of the researchers for any future queries.

Missing Data and Statistical Analyses

Less than 5 % of data were missing, which were substituted as recommended by the measures' manuals.

To examine Hypothesis 1, the correlation coefficients between autistic traits, anxiety and depressive symptoms were calculated. Due to the large number of correlations, a Bonferroni correction was applied (p value of .05 divided by 45 correlations = .001). Thus, only statistically significant correlations of $p < .001$ and those of at least a medium effect size ($r > .3$; Cohen 1988) were interpreted as significant.

For Hypotheses 2a and 2b, four multiple mediation analyses were carried out using the bootstrapping method (Preacher and Hayes 2008) to examine the five proposed mediators simultaneously. The outcome variables were social anxiety, obsessive–compulsive, worry and depressive symptoms respectively. Biased corrected and accelerated confidence intervals (BCa 95 % CI) were examined to determine the significance of the mediators' specific indirect effects on the outcome variable (Preacher and Hayes 2008). If the BCa 95 % CIs do not include zero, the indirect effect is considered to be statistically significant (Shrout and Bolger 2002). Bootstrapping was chosen, as it is a robust, superior, yet simple analysis, with high statistical power and lower probability of making Type I errors (MacKinnon et al. 2002). The assumption of multivariate normality for indirect effects in small samples is often untenable and thus bootstrapping offers a solution by yielding empirical-based sampling distributions of the indirect effects (Preacher and Hayes 2008).

Results

Preliminary Analyses and Descriptive Statistics

The means, standard deviations, internal consistency and inter-correlations for all variables in this study are summarized in Table 1.

Kenny (2014) advises that the different mediators need to be conceptually distinct and not too highly correlated. Field (2009) also recommends that variables that are too highly correlated ($r > .80$) are strongly suggestive of multi-collinearity and should be removed. In Table 1, most inter-correlations between the predictor, mediator and outcome variables were statistically significant at the $p < .001$ level, but most were of small or medium effect sizes and none exceeded $r = .59$. The inter-correlations between the five mediators were either non-significant or of small to medium effect sizes and none exceeded $r = .33$ (Table 1). Thus, although the variables in this study were in most cases significantly associated with one another, as is expected and necessary for mediation analyses (Baron and Kenny 1986), they were conceptually distinct constructs with some, but generally little, overlap and there were no concerns regarding serious multi-collinearity.

Table 1 Inter-correlations, means, standard deviations, and internal consistency for all variables

Variables	Autistic traits	Social anxiety symptoms	Obsessive–compulsive symptoms	Worry symptoms	Depressive symptoms	M1 SPS	M2 SC	M3 T	M4 RB	M5 AS
Social anxiety symptoms	**.59*****									
Obsessive–compulsive symptoms	**.34*****	**.34*****								
Worry symptoms	**.34*****	**.39*****	**.29*****							
Depressive symptoms	**.27*****	**.48*****	**.27*****	**.56*****						
Social problem solving (M1-SPS)	**−.24*****	**−.46*****	−.13*	**−.24*****	**−.34*****					
Social competence (M2-SC)	**−.56*****	**−.56*****	−.02	−.09	−.13*	**.31*****				
Teasing experiences (M3-T)	**.23*****	**.41*****	**.28*****	**.25*****	**.33*****	−.14*	−.08			
Prevented from and punished for repetitive behaviors (M4-RB)	.19**	.20**	**.50*****	**.29*****	**.34*****	−.17*	.03	**.30*****		
Aversive sensory experiences (M5-AS)	**.35*****	**.45*****	.33**	**.38*****	**.42*****	**−.33*****	−.09	**.28*****	**.24*****	
Mean	20.03	32.25	19.33	50.12	43.38	12.17	273.38	35.88	5.14	38.70
SD	5.97	13.15	11.6	12.46	11.21	2.35	30.26	24.98	6.29	7.95
Cronbach's α	.72	.92	.89	.81	.92	.74	.88	.94	.91	.74

SD standard deviation, *M1–M5* mediators 1 to 5

* $p < .05$; ** $p < .01$; *** $p < .001$ in bold

Independent samples *t*-tests, with a Bonferroni corrected significance level of < .004 due to multiple comparisons, showed no statistically significant gender differences in self-reported autistic traits ($t(246) = 1.55$, $p = .12$, $d = .20$) and no other gender differences in any of the variables assessed in this study (all *p*s > .05, all effect sizes were small; $.01 < d < .20$).

Relationship Between Autistic Traits, Anxiety and Depressive Symptoms

Autistic traits were positively associated with social anxiety ($r = .59$), obsessive–compulsive ($r = .34$), worry ($r = .34$), and depressive ($r = .27$) symptoms (all *p*s < .001) with medium to large effect sizes (see Table 1). Thus, Hypothesis 1 was supported.

Mediators Between Autistic Traits and Social Anxiety Symptoms

Fifty-eight percent of the variance in social anxiety symptoms was predicted by autistic traits and the five mediators [F (6,224) = 54.91, $p < .001$; see Table 2; Fig. 1]. All five partial mediators were significant, except one (prevented from/punished for preferred repetitive behaviors). Contrast analyses showed that social competence had the largest mediation effect compared to the other mediators (see Table 3).

Mediators Between Autistic Traits and Obsessive–Compulsive Symptoms

Autistic traits and the five mediators predicted 35 % of the variability in obsessive–compulsive symptoms [F (7,223) = 18.98, $p < .001$; see Table 2; Fig. 2]. Only prevention from/punishment for repetitive behaviors and aversive sensory experiences were significant partial mediators, while the other three were not. Contrast analyses showed that none of the two significant mediators had a larger mediation effect than the other (see Table 3).

Mediators Between Autistic Traits and Worry Symptoms

Twenty-four percent of the variance in worry symptoms was predicted by autistic traits and the five mediators [$F(6,224) = 12.86$, $p < .001$; see Table 2; Fig. 3]. Only aversive sensory experiences and prevention from/punishment for repetitive behaviors were significant partial mediators, while none of the two had a larger mediation effect compared to the other one (Table 3).

Table 2 Indirect effects of the four multiple mediator models examining the effect of autistic traits on three anxiety subtypes and depressive symptoms

Mediators	Social anxiety symptoms		Obsessive–compulsive symptoms		Worry symptoms		Depressive symptoms	
	b (SE)	95 % CI	*b* (SE)	95 % CI	*b* (SE)	95 % CI	*b* (SE)	95 % CI
Total indirect effects	**.80 (.11)**	(.59, .99)	.09 (.11)	(−.13, .29)	.22 (.12)	(−.04, .44)	**.37 (.12)**	(.15, .63)
Social problem solving	**.11 (.04)**	(.05, .20)	−.01 (.03)	(−.06, .06)	.05 (.04)	(−.02, .15)	**.10 (.04)**	(.04, .20)
Social competence	**.41 (.07)**	(.25, .55)	−.16 (.09)	(−.34, .004)	−.08 (.09)	(−.30, .09)	−.01 (.07)	(−.15, .14)
Teasing experiences	**.13 (.05)**	(.05, .24)	.02 (.03)	(−.04, .10)	.05 (.03)	(−.02, .12)	**.06 (.03)**	(.01, .15)
Repetitive behaviors	−.01 (.03)	(−.08, .05)	**.15 (.08)**	(.01, .31)	**.06 (.03)**	(.01, .14)	**.06 (.03)**	(.02, .16)
Sensory experiences	**.16 (.05)**	(.08, .27)	**.08 (.05)**	(.01, .21)	**.14 (.06)**	(.03, .26)	**.15 (.06)**	(.04, .28)
R^2 accounted for	.58		.35		.24		.28	

Repetitive behaviors = prevented from or punished for repetitive behaviors; Sensory experiences = aversive sensory experiences in daily life; Coefficients were derived with a bootstrapping re-sampling rate of 1,000 (N = 231). The 95 % CI were Bias Corrected (BCa). Coefficients in bold typeface are significant (i.e., the BCa 95 % CI does *not* include zero)

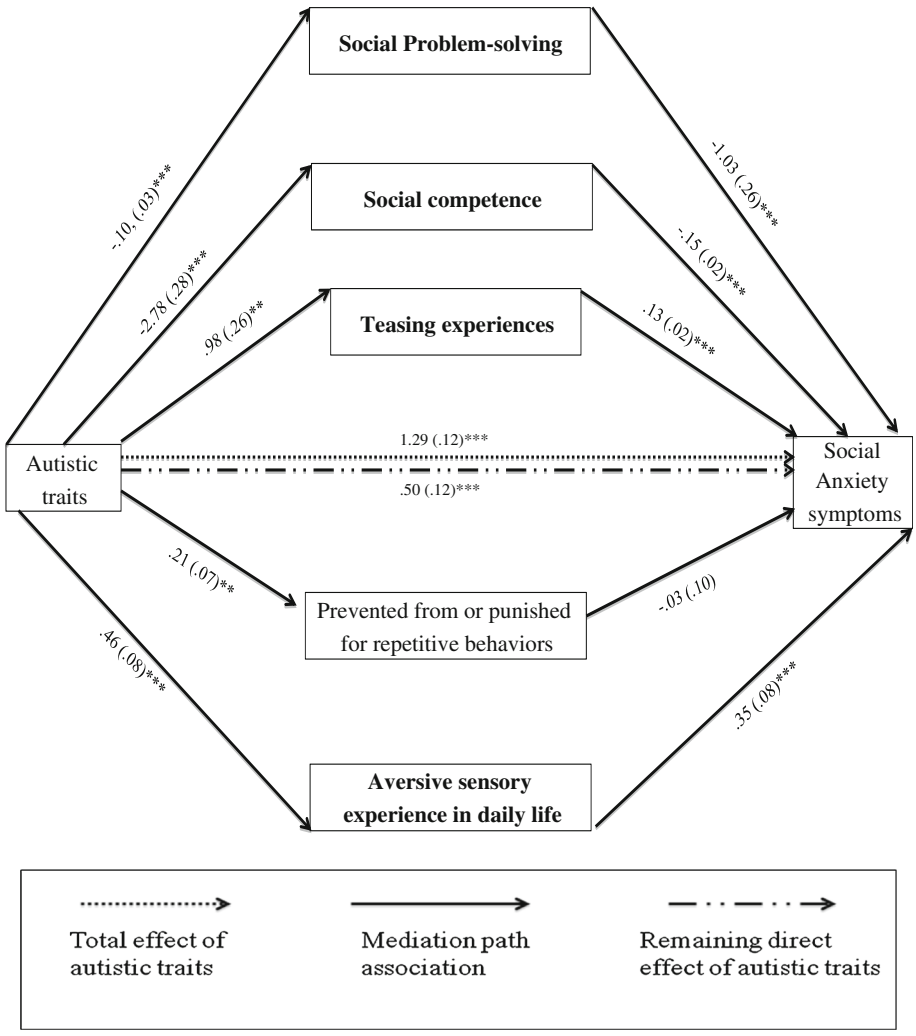

Fig. 1 Unstandardized *b* coefficients and standard errors (SE in *brackets*) of the multiple mediation bootstrap analysis examining the relationship of autistic traits and social anxiety symptoms as mediated by the five proposed variables. Significant mediators are in *bold typeface*

Table 3 Analyses of contrasts from the four multiple mediator models examining the effect of autistic traits on the three anxiety subtypes and depressive symptoms

Contrasts	Social anxiety symptoms		Obsessive–compulsive symptoms		Worry symptoms		Depressive symptoms	
	b (SE)	95 % CI	*b* (SE)	95 % CI	*b* (SE)	95 % CI	*b* (SE)	95 % CI
M1 versus M2	**−.30 (.08)**	(−.46, −.12)	.16 (.10)	(−.04, .36)	.14 (.12)	(−.10, .39)	.11 (.09)	(−.07, .30)
M1 versus M3	−.02 (.06)	(−.14, .09)	−.03 (.05)	(−.12, .06)	.01 (.05)	(−.10, .11)	.04 (.05)	(−.06, .16)
M1 versus M4	**.11 (.05)**	(.03, .23)	−.16 (.09)	(−.33, .01)	−.01 (.05)	(−.13, .08)	.04 (.05)	(−.07, .14)
M1 versus M5	−.05 (.06)	(−.18, .06)	−.09 (.06)	(−.21, .01)	−.09 (.07)	(−.24, .05)	−.04 (.08)	(−.21, .10)
M2 versus M3	**.28 (.08)**	(.11, .45)	**−.18 (.09)**	(−.36, −.01)	−.13 (.10)	(−.36, .06)	−.07 (.08)	(−.24, .08)
M2 versus M4	**.41 (.08)**	(.28, .58)	**−.32 (.13)**	(−.52, −.004)	−.15 (.09)	(−.36, .02)	−.07 (.08)	(−.22, .07)
M2 versus M5	**.25 (.09)**	(.07, .41)	**−.25 (.09)**	(−.44, −.08)	**−.23 (.11)**	(−.45, −.02)	−.15 (.08)	(−.30, .02)
M3 versus M4	**.14 (.06)**	(.04, .27)	−.13 (.10)	(−.31, .06)	−.02 (.05)	(−.13, .07)	−.003 (.05)	(−.10, .09)
M3 versus M5	−.03 (.06)	(−.15, .08)	−.06 (.06)	(−.20, .04)	−.10 (.07)	(−.23, .05)	−.08 (.07)	(−.23, .05)
M4 versus M5	**−.17 (.06)**	(−.33, −.06)	−.07 (.10)	(−.20, .24)	−.08 (.07)	(−.21, .08)	−.08 (.07)	(−.23, .06)

b Coefficients were derived with a bootstrapping re-sampling rate of 1,000 ($N = 231$). The 95 % CI were bias corrected (BCa). Contrasts in bold typeface are significant (i.e., the BCa 95 % CI does *not* include zero)

b unstandardized beta coefficient, *SE* standard error, *M* mediator, *M1* social problem solving, *M2* social competence, *M3* teasing experiences, *M4* prevented from or punished for repetitive behaviors, *M5* aversive sensory experiences in every-day life

Mediators Between Autistic Traits and Depressive Symptoms

Autistic traits and the five mediators predicted 28 % of the variance in depressive symptoms [$F(6,224) = 16.22$, $p < .001$; see Table 2; Fig. 4]. Only social competence was not a significant mediator. None of the significant mediators differed significantly from one another in their mediation effect in this model (see Table 3). The four variables (all except social competence) fully mediated the relationship between autistic traits and depressive symptoms (Fig. 4).

Discussion

The present study examined five empirically or theoretically selected possible specific mediators in their role in explaining the cross-sectional relationship between broad autistic traits, social anxiety, worry, obsessive–compulsive and depressive symptoms in an Asian student sample. The relationships between autistic traits and anxiety and depressive symptoms were positive with medium to large effect sizes, supporting Hypothesis 1. The "social" mediators (social problem-solving, social competence and teasing experiences) significantly mediated the relationship of autistic traits with social anxiety, but not with worry or obsessive–compulsive symptoms. Among these "social" mediators, social competence appears to be the most influential mediator between autistic traits and social anxiety. Prevention from/punishment for repetitive behaviors mediated the relationship between autistic traits and worry, obsessive–compulsive and depressive, but not social anxiety symptoms, supporting hypothesis 2b. However, hypothesis 2b was only partially supported, as aversive sensory experiences were also a significant mediator in the relationship between autistic traits and social anxiety symptoms, contrary to our prediction that they would only mediate the relationship between autistic traits and non-social anxiety or depressive symptoms.

All proposed mediators except social competence were significant mediators in explaining the relationship between autistic traits and depressive symptoms, replicating and generalizing the findings of Rosbrook and Whittingham (2010) in an Asian student sample. On the other hand, all mediators, except prevention/punishment for repetitive behaviors, were significant partial mediators in the social anxiety model. Only two mediators (aversive sensory experiences and prevention/punishment for repetitive behaviors) were significant in explaining the relationship between autistic traits and worry as well as obsessive–compulsive symptoms. These preliminary results suggest that some of the mechanisms explaining the relationship between autistic traits and anxiety and depressive symptoms are likely to be shared, which also suggests that these autism-trait related mediators may contribute more generally to increased global negative affect, rather than specific anxiety or depressive symptoms per se (Wood and Gadow 2010). However, the five mediators explained more variance in the social anxiety and obsessive–compulsive symptom models compared to the depressive or worry mediation models.

In the present study, social problem-solving appeared to be a stronger mediator compared to social competence, which was only significant in social anxiety symptoms. This finding, also found in Rosbrook and Whittingham

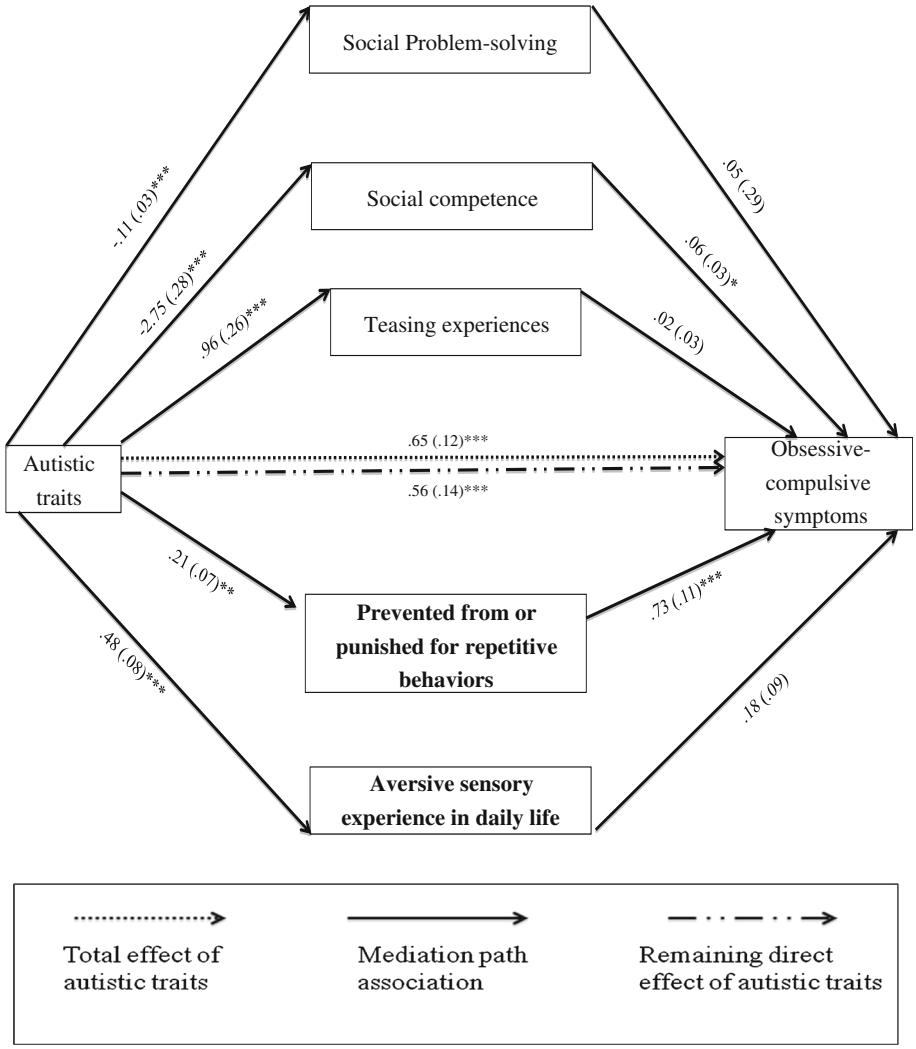

Fig. 2 Unstandardized *b* coefficients and standard errors (SE in *brackets*) of the multiple mediation bootstrap analysis examining the relationship of autistic traits and obsessive–compulsive symptoms as mediated by the five proposed variables. Significant mediators are in *bold typeface*

(2010), suggests that it may be the less well developed abilities in addressing encountered social difficulties that influence overall anxiety and depressive symptoms, rather than the social limitations or challenges per se. In contrast, social competence was the largest and most significant mediator in the relationship between autistic traits and social anxiety symptoms, providing preliminary evidence for a potentially unique mediating role of social competence in this relationship in a non-clinical student sample. Poorer social skills were also a sound predictor of social anxiety symptoms in adult male students in another study (Freeth et al. 2013a).

Only aversive sensory experiences in daily life and prevention from/punishment for repetitive behaviors were significant in explaining the cross-sectional relationship between autistic traits, worry and obsessive–compulsive symptoms, while none of the "socially loaded" mediators were significant in these two models. Others have also found that hyper- or hypo-sensitivity to environmental stimuli and sensory modulation difficulties can contribute to heightened anxiety (Pfeiffer et al. 2005). Our findings also seem to agree with those by Hallett et al. (2012a, b) who showed that autistic-like repetitive behaviors were strongly correlated with generalized anxiety symptoms phenotypically and genetically. These findings tentatively suggest that sensory sensitivity and aversive sensory experiences in the general population might lead to increased symptoms of worry, possibly through avoidance, hyper-vigilance, hyper-arousal and contextualized conditioning (see Grillon 2008; Green and Ben-Sasson 2010).

Prevention from/punishment for preferred repetitive behaviors and aversive sensory experiences in daily life could co-exist in many anxiety contexts, including social ones, because sensory sensitivity may contribute to general worry symptoms and overall behavioral disorganization (Kimball 1999). This could explain why these two mediators were also implicated in explaining the relationship between autistic traits and depressive as well as social

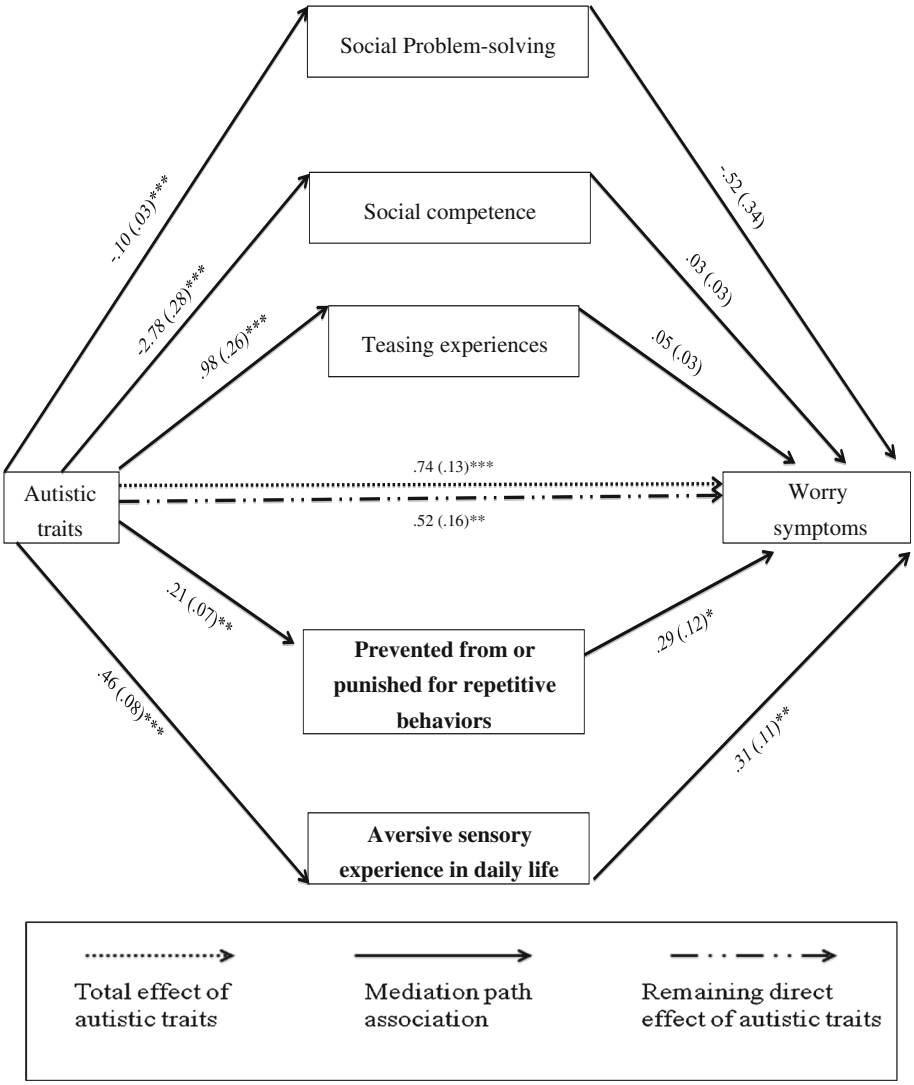

Fig. 3 Unstandardized *b* coefficients and standard errors (SE in *brackets*) of the multiple mediation bootstrap analysis examining the relationship of autistic traits and generalized anxiety symptoms as mediated by the five proposed variables. Significant mediators are in *bold typeface*

anxiety symptoms. Recent findings in unselected samples (Robertson and Simmons 2013) also suggest that sensory issues may be linked to social behavior and social responsiveness and participation. However, the direction of this relationship remains unclear, as there are currently no longitudinal studies. There are also a number of similarities in the presentation of symptoms of OCD and ASD (Zandt et al. 2007; Kerns and Kendall 2012). It would be worth further examining the type(s) of repetitive behaviors which were prevented/punished in order to examine whether symptom overlap may, at least in part, account for some of these findings.

Limitations of the Present Study

The findings need to be interpreted in the context of the study's limitations. Firstly, our mediation models were proposed based on empirical findings by Rosbrook and Whittingham (2010) and Wood and Gadow's (2010) hypothetical model of anxiety in ASD. Other mediating models not examined in the present study may also be plausible or consistent with our data or the data of others. It is also possible that other variable(s) not measured in the present study may confound the relationship between autistic traits and anxiety symptoms. Secondly, this was a cross-sectional study. Examining these relationships in this large sample cross-sectionally was a first step towards "narrowing" down potentially important mediators, which can then be investigated more purposefully in longitudinal studies. To establish whether the effects are stable across time and whether there is temporal precedence, prospective longitudinal data are needed (MacKinnon et al. 2007). Thirdly, the extent to which the higher female to male ratio in this study might have affected the findings cannot be ascertained, although no gender differences were found. Fourthly, minor modifications were carried out in two of

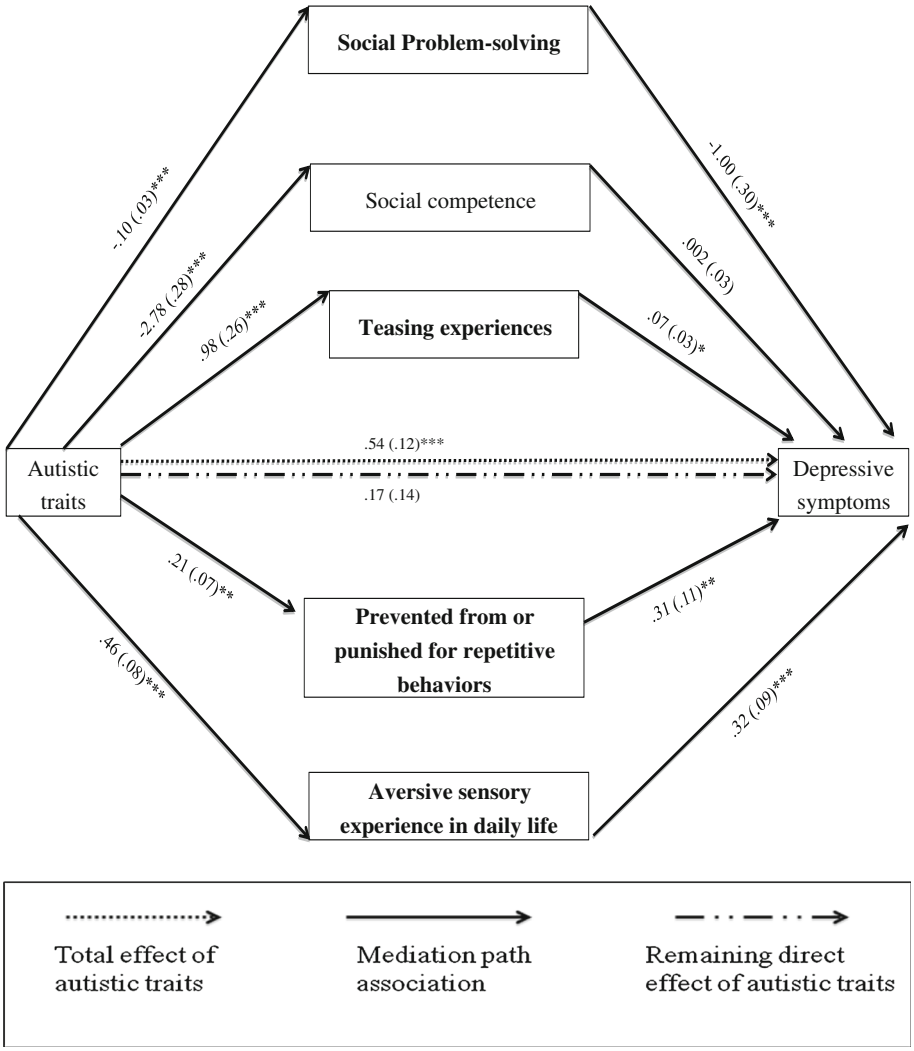

Fig. 4 Unstandardized *b* coefficients and standard errors (SE in *brackets*) of the multiple mediation bootstrap analysis examining the relationship of autistic traits and depressive symptoms as mediated by the five proposed variables. Significant mediators are in *bold typeface*

the ten self-report measures (i.e., teasing and prevented from/punished for repetitive behaviors). Despite the modifications, the internal consistency of both measures was very high (.91 and .94) and their correlations with other measures of relevant constructs were significant (see Table 1). This provides preliminary support for their reliability and convergent validity. In relation to other potential measurement issues, the SIAS correlated .59 with the AQ, while the other measures of worry, obsessive–compulsive and depressive symptoms showed moderate associations (.27–.34) with autistic traits. Whether this reflects a true larger relationship between autistic traits and social anxiety or whether this may be an artifact of increased overlap in these two measures needs to be established. However, existing literature supports this strong association between these two constructs. One other limitation is that the role of the proposed mediators in explaining the relationship between autistic traits and specific phobias was not examined. Finally, participants were university students and all measurements relied on self-reports. The extent to which these findings can be extrapolated to other non-student adults or to individuals with diagnoses of ASD needs to be established.

Possible Theoretical and Clinical Implications and Recommendations for Future Research

Findings from the present study replicated those by Rosbrook and Whittingham (2010) in an Asian student sample providing some preliminary evidence for similar mechanisms explaining the relationship between autistic traits and anxiety and depressive symptoms in students in the US and in a predominantly Asian country (Anderson and Mayes 2010). Our findings also provide some support for some of the factors proposed by Wood and Gadow (2010) in their hypothetical model of anxiety in ASD (prevention/punishment of repetitive behaviors and aversive sensory

experiences) as being relevant in understanding the relationship between anxiety and autistic traits in non-clinical samples. Contrary to their proposed hypothetical model, however, social competence was not found to be a significant mediator in the relationship between autistic traits and the other anxiety subtypes examined, while aversive sensory experiences were not specific to explaining the relationship between autistic traits and depressive and other anxiety symptoms only, as they also contributed to explaining the relationship of autistic traits with social anxiety symptoms.

Given that social competence was a mediator in the social anxiety model only, social skills support and training for individuals with high levels of autistic traits could potentially lower their vulnerability of experiencing social anxiety in particular. Intervention studies have showed that children demonstrated significant improvements in anxiety coping (Cotugno 2009) following a social skills intervention program. Recent efforts in treating anxiety disorders in individuals with ASD which have incorporated social skills components into the evidence-based exposure-focused cognitive behavioral interventions for anxiety are also consistent with our findings and have shown promising evidence of effectiveness (see Danial and Wood 2013; Lang et al. 2011; White et al. 2009). Similarly, should our findings be replicated in individuals with diagnoses of ASDs, they support the recent emphasis in understanding and decreasing bullying and victimization in this population (see Schroeder et al. 2014 for a review). Our results also point towards the potential importance of placing more emphasis on social *problem-solving*, rather than on *acquiring* social skills per se. Learning to think about and manage various social challenges may be a more "crucial" ingredient in reducing anxiety and depressive symptoms in those with high autistic traits than acquiring social skills per se.

Should the present results be replicated in other non-student community and clinical samples of individuals with ASD, our findings also point towards the potential importance of assessing sensory sensitivity, aversive sensory experiences and experiences of being prevented from or punished for repetitive/circumscribed behaviors in individuals with high autistic traits who may experience increased worry and obsessive–compulsive related symptoms. It is possible that, alongside the more "traditional" CBT for anxiety and social skills training components, interventions tailored towards targeting sensory sensitivity and managing repetitive behaviors may be even more effective in decreasing generalized worry and obsessive–compulsive related symptoms.

Future research examining mediation relationships should employ longitudinal designs that allow for temporal sequencing of antecedent, mediating, and outcome variables. With the research hypotheses of the present cross-sectional study largely supported in a student sample, this study needs to be replicated with clinical samples of individuals with ASD as well as with those with anxiety disorders without ASD. Further disentangling the relationship and etiological underpinnings between autistic traits and anxiety and depressive symptoms in unselected as well as clinical samples could lead to better identification, conceptualization and intervention for comorbid mood and anxiety problems in those with high levels of autistic traits and may be useful in informing interventions for those with ASD.

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