

ORIGINAL RESEARCH REPORT

What are Replicable Aspects of the Broader Autism Phenotype among College Students?

The Answer is *Not* Reduced Prosocial Behaviors

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Are people with heightened autistic traits less likely to help other people? Recent research suggests that heightened autistic traits are associated with reduced self-reported prosocial behavior among college students. However, the growing literature examining sub-clinical traits associated with autism, or the Broader Autism Phenotype (BAP), among college students has invested insufficient attention in replication of findings, potential interrelationships between constructs, or the degree to which social desirability bias may contribute to findings. To identify replicable aspects of the BAP, we administered a battery of measures to 391 undergraduate students. Replicating prior work, findings suggested that self-reported difficulties understanding the self and others (but *not* less feeling for others) and sensory atypicalities are core aspects of the BAP. Reduced social desirability bias was also associated with the BAP. Prior associations between reduced prosocial tendencies and the BAP were *not* replicated. Findings highlight the importance of assessing multiple potential aspects of the BAP, particularly reduced susceptibility to the social desirability bias, when using self-report measures.

Keywords: Broader Autism Phenotype; prosocial; Theory of Mind; alexithymia; social desirability bias; sensory processing

Autism is increasingly conceptualized in terms of individual differences, or as the extreme end of a distribution of autistic traits that extends into the general population, rather than as a category that can be unequivocally distinguished from “typical development” (e.g., Sucksmith et al., 2011). The Broader Autism Phenotype (BAP), or subclinical autistic traits, was initially studied among family members of autistic people (e.g., Baron-Cohen & Hammer, 1997). Researchers later realized that the BAP extended into the general population (e.g., Baron-Cohen, 2008) and began to examine it dimensionally among participants with no known familial relationships to autism,

frequently by recruiting undergraduate students. The BAP is believed to reflect an intermediate expression of genetic susceptibility for ASD, similar to proposed endophenotypes for other highly heritable conditions, like schizophrenia and bipolar disorder (Meyer-Lindenberg & Weinberger, 2006). A clearer conceptualization of sub-clinical characteristics associated with autism and other clinical conditions grows increasingly relevant to our understanding of human diversity as psychological conditions are re-framed as intersecting dimensions of difference that affect all of us to varying degrees rather than as categorical differences that affect only those with a specific diagnosis (e.g., Insel, 2013; Owen, 2014).

Studies examining the BAP among college students suggest that it is associated with enhanced creativity, difficulties understanding one’s own and others’ emotions and perspectives, sensory atypicalities, loneliness, challenges with executive functioning, and (more questionably) reduced prosocial behaviors (Austin, 2005; Best, Arora, Porter, & Doherty, 2015; Davis et al., 2017; Gökçen, Petrides, Hudry, Frederickson, & Smillie, 2014; Gökçen, Frederickson, & Petrides, 2016; Jameel, Vyas, Bellesi, Cassell, & Channon, 2015; Jameel, Vyas, Bellesi, Roberts, & Channon, 2014; Jobe & White, 2007; Sasson et al., 2013a; Wainer, Ingersoll, & Hopwood, 2011). However, research examining the BAP among college students has rarely ascertained if findings replicate. To identify replicable aspects of the BAP, we

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invited undergraduates to complete measures assessing individual differences that have been associated with both autism and the BAP in multiple independent studies, such as reduced Theory of Mind (ToM) or difficulty inferring others' intentions and emotions, also known as cognitive empathy; reduced self-understanding (i.e., alexithymia or difficulty identifying and describing one's own emotions); and sensory symptoms (e.g., over- and/or under-reactivity to sensory stimuli).

Although assessments of the BAP among college students typically rely on self-report, prior studies have not assessed if susceptibility to the social desirability bias, or the tendency to alter one's responses to please others, may influence responses. Numerous studies have *discussed* susceptibility to the social desirability bias as a factor that should be considered when examining the BAP (Jameel et al., 2014; Mörcke, Buitelaar, & Rommelse, 2016; Rubenstein et al., 2017; Wade, Cox, Reeve, & Hull, 2014). However, to the best of our knowledge, no prior peer-reviewed study has examined social desirability directly in relation to the BAP. Yang and Baillargeon (2013) found that heightened autistic traits were associated with less endorsement of lying to protect others' feelings. Indeed, autistic people tend to act more honestly than non-autistic people even when doing so impedes social success (e.g., Cage, Pellicano, Shah, & Bird, 2013; Chevallier, Molesworth, & Happé, 2012; Izuma et al., 2011; Scheeren et al., 2010; Strunz et al., 2015; Yafai, Verrier, & Reidy, 2014). Given that the BAP is defined as *sub-clinical* characteristics of autism, characteristics associated with the BAP should also be apparent among people with a diagnosis of autism. If the BAP, like autism, is associated with heightened honesty, failing to account for social desirability bias may lead to spurious associations between the BAP and self-reports of socially undesirable characteristics. We were motivated to develop the current study by research linking heightened autistic traits to reduced *self-reported* prosocial behaviors (or less interest in helping others; Jameel et al., 2014; 2015).

Are Reduced Prosocial Behaviors an Aspect of the BAP?

Two papers documenting a potentially stigmatizing association between the BAP and reduced prosocial tendencies were published by a single research group in a prominent autism journal. Jameel and colleagues (2014) screened college students with the Autism Quotient (AQ; Baron-Cohen et al., 2001) to identify participants with high (top 10% of their gender's scores) or low (bottom 10%) autistic traits. Participants with extreme AQ scores completed a self-report measure of prosocial behaviors developed by the authors. Participants with heightened autistic traits *reported* that they would be less likely to help others and would feel less pleased doing so relative to students with low traits. Jameel and colleagues (2015) then developed the *Social Expectations* task to investigate if people with more autistic traits would report less prosocial behaviors in ambiguous contexts in which a clear rule indicating what the response should be is lacking (e.g., help a young lady with a parcel) but not in clear-cut contexts where well-known social rules

indicate the appropriate response (e.g., help an old lady with a walking stick). College students ($N = 645$) were screened to identify those in the upper and lower 10% of the AQ distribution; 41 participants completed the *Social Expectations* task in-person, or ten vignettes with two alternate endings for each scenario, one clear-cut and one ambiguous, reflecting a within-subjects design. Participants with heightened autistic traits *reported* less prosocial responses toward their potential beneficiary than those with fewer traits.

More recently, another research group published a paper in the same prominent autism journal reporting that heightened autistic traits were associated with reduced self-reported prosocial behaviors among college students in China (Zhao, Li, Song & Shi, 2018). Although they used different measures than Jameel and colleagues, their study exhibited similar methodological weaknesses. College students completed the AQ and read a vignette depicting "Xiaobei, a passionate and beautiful eighteen-year old freshman...full of longing for the future...(who was) recently diagnosed with a rare disease...(and is) now dying. Her situation immediately aroused the attention of all...many people did their best to help her (p. 5)." Although prosocial behavior was never explicitly defined, it appeared to be the amount of hypothetical money participants self-reported that they would give to Xiaobei. Participants with heightened autistic traits *reported* that they would give Xiaobei less hypothetical money. However, social desirability bias was again not assessed.

All three prior studies describing the BAP as characterized by reduced prosocial behavior among college students utilized *self-report* measures of prosocial behavior that lacked evidence of reliability or validity and failed to assess social desirability bias. The latter omission is striking given that studies using *behavioral* measures of prosocial behaviors have *not* revealed reductions in *observed* prosocial behaviors associated with autism itself. A study using a well-validated, behavioral measure of prosocial behavior revealed that autistic children exhibited similar levels of prosocial behavior to non-autistic children (Deschamps, Been, & Matthys, 2014). A study using another behavioral measure of prosocial behavior also revealed *no* differences in prosocial behavior between autistic and non-autistic children (McDonald, Murphy, & Messinger, 2017).

Given that autism itself is *not* associated with reduced *observed* prosocial behaviors and research linking the BAP to reduced *self-reported* prosocial tendencies has clear methodological weaknesses, we designed our study to examine if putative associations between reduced self-reported prosocial behaviors and the BAP may be attributable to unexamined associations between social desirability bias and both prosocial behaviors and the BAP. The methodological issues plaguing prior research linking heightened autistic traits with reduced prosocial behaviors are compounded by evidence that the mechanisms put forth to explain this association are not well grounded in prior research. Jameel and colleagues (2015) interpreted their findings as evidence that people with heightened autistic traits exhibit reduced prosocial behaviors due to reduced cognitive and affective empathy

(i.e., emotional responsiveness to another's feelings) and alexithymia. Yet, none of these constructs were assessed in their work. Zhao and colleagues believed they found evidence for a pathway linking heightened autistic traits to reduced self-reported prosocial behaviors through reduced affective empathy. However, affective empathy is typically *not* reduced among autistic people and others with heightened autistic traits (Bird et al., 2010; Deschamps, Been, & Matthys, 2014; Dziobek et al., 2008; Gökçen et al., 2016; Jones et al., 2010; Lockwood, Bird, Bridge, & Viding, 2013; Poustka et al., 2010; Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007; Rueda, Fernández-Berrocal, & Baron-Cohen, 2015; Schwenck et al., 2012; but see Trimmer, McDonald, & Rushby, 2017 for evidence of reduced affective empathy in autism). Indeed, many autistic people report that they feel *more* for other people than non-autistic people do, leading researchers to speculate that affective empathy may be enhanced in autism at the expense of cognitive empathy (Smith, 2009).

Are Reduced Self and Other Understanding Aspects of the BAP?

Reduced cognitive empathy is commonly associated with autism (e.g., Baron-Cohen, Leslie, & Frith, 1985; Lukito et al., 2017; Deschamps et al., 2014; Sasson et al., 2013b). Autistic children often show delays in acquiring ToM and have marked difficulty with abstract perspective-taking tasks (Hamilton, 2009). Although ToM develops slowly in autism, autistic people with heightened language abilities often pass ToM assessments but may continue to struggle to respond efficiently to subtle cues to others' perspectives (Ahmed & Miller, 2011; Happé, 1995; Brewer, Young, & Barnett, 2017; Hooper et al., 2018; Williams, 2004).

A growing body of research links reduced cognitive empathy with the BAP. Categorical associations between reduced verbal ToM (using a language-based task) and the BAP were documented among parents of autistic children who were classified as aloof (Losh & Piven, 2007). Dimensional associations between verbal ToM and autistic traits were observed among college students (Gökçen, Frederickson, & Petrides, 2016), adolescents and young adults receiving educational supports (Best, Moffat, Power, Owens, & Johnstone, 2008), adults from the general population (Yang & Baillargeon, 2013), and school-aged siblings of autistic individuals (Tsang, Gillespie-Lynch, & Hutman, 2016). In contrast, Sasson and colleagues (2013b) found no evidence that autistic traits (assessed with the Broader Autism Phenotype Questionnaire; Hurley et al., 2007) were associated with a nonverbal ToM measure (assessed with the Cartoon Theory of Mind task; Brunet, Sarfati, & Hardy-Baylé, 2003) in a stratified sample of 74 undergraduates. This lack of association may be attributable to the nonverbal nature of the task, as autistic people often do not struggle with nonverbal ToM assessments (Wilkinson & Ball, 2012). Based on prior literature, we hypothesized that cognitive (but *not* affective) empathy would be a core aspect of the BAP in the current study.

Research suggests that difficulty understanding and identifying one's *own* emotions is a precursor to

difficulties understanding other minds (Lombardo & Baron-Cohen, 2011). Autistic people describe daily frustrations processing internal emotions and conveying them to others (Hill, Berthoz, & Frith, 2004). Indeed, alexithymia is often heightened among autistic people and their relatives (Berthoz, Lalanne, Crane, & Hill, 2013; Milosavljevic et al., 2016). Therefore, we hypothesized that heightened alexithymia would emerge as a core aspect of the BAP. We also expected sensory symptoms to contribute to difficulties understanding the self and others.

Do Sensory Differences Impact Self and Other Understanding?

Sensory symptoms are now recognized as a core aspect of ASD that fundamentally impact how individuals relate to and perceive themselves, others, and the world around them (APA, 2013; Bogdashina, 2016). Sensory atypicalities in autistic individuals have been replicated across numerous studies (e.g., Glod, Riby, Honey, & Rodgers, 2017; Leekam, Nieto, Libby, Wing, & Gould, 2007; Liss, Saulnier, Fein, & Kinsbourne, 2006). A rapidly growing body of research indicates that sensory atypicalities are also an aspect of the BAP. For example, Robertson and Simmons (2013) reported associations between sensory hypo- and/or hyper-responsiveness and autistic traits (assessed with the AQ). Mayer (2017) extended this finding by demonstrating that the strength of associations between sensory atypicalities and autistic traits (again assessed with the AQ) is similar among autistic and non-autistic adults. Donaldson and colleagues (2017) found that sensory processing atypicalities are more common among parents of multiple rather than one or no autistic children. They interpreted this finding as evidence that genetic susceptibility to ASD may be associated with sensory atypicalities. In support of this interpretation, parents of autistic children reported more similar sensory experiences to their children than parents of non-autistic children (Glod et al., 2017). Not only are sensory processing atypicalities common among parents of autistic children (Uljarević et al., 2014), they contribute to intolerance of uncertainty and anxiety (Uljarević et al., 2016). Therefore, it is crucial to understand the impact of sensory symptoms on other areas of functioning.

Sensory atypicalities relate to autistic traits, alexithymia, and emotional distress in both autistic (Milosavljevic et al., 2016) and non-autistic (Liss, Mailloux, & Erchull, 2008) individuals, which suggests they play a role in interpersonal understanding. Sensory and motor symptoms are among the earliest manifestations of autism (Gallagher & Varga, 2015; Gliga, Jones, Bedford, Charman, & Johnson, 2014; Rogers, 2009) and contribute to later social cognitive challenges (e.g., Sacrey, Bennett, & Zwaigenbaum, 2015). A growing literature suggests that social cognitive problems do not stem from specific domains but from broader processes including sensory processing (Gallagher & Varga, 2015; Kapp, 2013; Talay-Ongan & Wood, 2000; Wilkinson & Ball, 2012). Therefore, we hypothesized that sensory symptoms would emerge as a core aspect of the BAP that is associated with social cognitive difficulties.

Current Study

To allow us to see if their findings would replicate, Jameel and colleagues generously provided us with the measures they had developed to assess prosocial behavior. We noticed that specific questions in their scales could cause people with heightened autistic traits to respond in a less prosocial manner because the cost of helping another might be higher for them than it would be for someone with fewer traits. For example, one of the scenarios requires the respondent to alter their food choice to cater to another character's preferences while another scenario asks a respondent to move to a hot and windowless area. For individuals with strong sensory preferences for particular foods or temperatures, such concessions might be too great to overcome in the interest of pro-sociality. Therefore, we hypothesized that atypical sensory experiences might contribute to reduced self-reported prosocial behaviors among individuals with heightened autistic traits responding to the *Social Expectations* task.

By assessing a range of constructs that have been associated with the BAP in prior work, we aimed to identify core characteristics of the BAP by examining which constructs are most closely related to the BAP when a range of traits are measured within the same sample. We hypothesized that the BAP would be associated with a lack of susceptibility to the social desirability bias, sensory symptoms, reduced cognitive but *not* affective empathy, and heightened alexithymia. We did *not* expect that reduced prosocial behaviors would emerge as a core aspect of the BAP. Instead, we hypothesized that differences in *self-reported* prosocial behaviors in prior research might be attributable to reduced social desirability bias among people with heightened autistic traits.

Methods

Participants

Undergraduate students ($N = 391$; $M_{\text{age}} = 20.38$ years ± 4.90 ; age range 18–63 years) from a public university completed an online survey assessing autistic traits and constructs associated with the BAP in prior literature. Participants were recruited online through the Psychology Department subject pool (which consists primarily of students enrolled in Introductory Psychology courses). After completing an IRB approved online assent form, participants completed all measures using the Qualtrics survey platform. Participants who did not complete all measures were excluded from analyses ($n = 41$). Potential participants who not complete the entire survey did not differ from their counterparts who did complete the survey in terms of gender, age, or ethnicity ($ps > .18$). Most potential participants who did not complete the survey dropped out very early in the survey ($n = 32$), before completing the BAP measures, precluding analysis of how they may have differed from participants who completed the study in terms of key outcome variables. The sample was 61% female, 48.7% Caucasian, 21.3% Hispanic, 19.0% Asian, and 10.8% Black/African-American. Participants received course credit for participation.

Measurements

Participants completed a battery of online surveys. Across measures, higher scores indicate heightened levels of the construct assessed.

The Autism Spectrum Quotient-Short (AQ-Short)

The AQ is commonly used to assess global autistic traits (Baron-Cohen et al., 2001) but concerns about its validity are increasingly raised (e.g., Ingersoll, Hopwood, Wainer & Donnelan, 2011; Kloosterman et al., 2011; Lundqvist & Lindner, 2017). Although the longer 50-item AQ measure is often used in studies of the BAP (e.g., Jameel et al., 2015, 2014), we used an abridged version, the AQ-Short, consisting of 28 statements rated on a four-point Likert scale, to allow inclusion of a potentially more robust second BAP measure. The AQ-Short was validated in both English and Dutch samples using four independent samples (Hoekstra et al., 2011). However, its reliability was low in our study ($\alpha = .57$). A binary coding scheme produced a total score ranging from 0–28.

Social Responsiveness Scale-brief

A 16-item version of the Social Responsiveness Scale-2 (SRS-brief) was selected as a second self-report measure of autistic traits due to its strong psychometric properties (Constantino & Gruber, 2002; Moul, Cauchi, Hawes, Brennan, & Dadds, 2015). The SRS-brief measures autistic traits within four broad categories: social cognition, social communication, social motivation, and autistic mannerisms. Items are rated from 0 (never true) to 3 (almost always true) to yield a gender-normed raw score ranging from 0 to 48 ($\alpha = .86$).

Basic Empathy Scale in Adults (BES-A)

The BES-A, assessing cognitive and affective empathy (Carré et al., 2013; Jolliffe & Farrington, 2006), is a 20-item self-report questionnaire. Participants use a five-point Likert scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree), to rate statements about both cognitive empathy (e.g., "When someone is feeling 'down' I can usually understand how they feel") and affective empathy (e.g., "After being with a friend who is sad about something, I usually feel sad"). Nine items assess cognitive empathy ($\alpha = .77$) while eleven items assess affective empathy ($\alpha = .73$).

Toronto Alexithymia Scale (TAS-20)

The TAS-20 (Bagby, Parker, & Taylor, 1994) is a self-report questionnaire measuring understanding of one's own emotions using a five-point Likert scale with three domains: difficulty identifying feelings, difficulty describing feelings, and externally-oriented thinking. Scores range from 20 to 100 ($\alpha = .86$).

Ritvo Autism and Asperger Diagnostic Scale (RAADS-R) –

Sensory Motor Subscale

The sensory subscale of the RAADS-R (Ritvo et al., 2011) includes 20 self-report statements (e.g., "The same sound, color or texture can suddenly change from very sensitive

to very dull.”) on a scale from 0 (Never true) to 3 (True now and when I was young). Scores range from 0 to 60 ($\alpha = .85$).

Marlowe-Crowne Social Desirability Scale (SDS)

The SDS is a well-validated measure of susceptibility to the social desirability bias. We used a 13-item version of this scale, Short Form-C (Reynolds, 1982). Total scores were calculated by summing 13 binary (True or False) items (e.g., “No matter who I’m talking to, I’m always a good listener.”; $\alpha = .69$).

The “Social Expectations” task

Self-reported prosocial behaviors were examined using the *Social Expectations* task, which presents 10 scenarios depicting situations where someone needs help. Jameel and colleagues developed two alternative endings to each scenario, where the societal expectation to help someone is clear-cut (e.g., deciding whether to let a man go before you when he is in a hurry to get to an interview) or ambiguous (e.g., deciding whether to let the man go before you when he is in a hurry to take a cigarette break). In their study, participants were presented with each of the 10 scenarios twice using a within-subjects design, once with the ambiguous ending and once with the clear-cut ending. To avoid carry-over effects, we randomly assigned participants to two groups using a between-subjects research design. Five scenarios were presented to one group as clear-cut and the other five were presented as ambiguous, and vice-versa for a second group of participants. Participants rated their likelihood of helping the character in each scenario on a scale ranging from 0 (Not at all likely) to 10 (Extremely likely). Sub-scores reflect each randomly assigned group’s response to ambiguous (α s = .47; .60) or clear-cut scenarios (α s = .50; .63). Composite scores reflect summed responses to both ambiguous and clear-cut scenarios (α s = .57; .73). Participants were also asked to explain in their own words why they would act in a particular way.

Analytic Approach

First, we assessed kurtosis and skew. Most variables met the assumptions of parametric analyses. Only age and self-reported prosocial behaviors in response to the clear-cut scenarios of the *Social Expectations* task were excessively skewed. Responses to the ambiguous scenarios and composite prosocial behavior scores were normally distributed. Therefore, we utilized parametric analyses except when analyzing age or responses to clear-cut scenarios.

We implemented a categorical and a dimensional data analysis plan using SPSS version 26. Step 1 of the data analysis plan, modeled after Jameel and colleagues’ (2015) work, involved a series of independent sample t-tests to test whether those with AQ scores in the top and bottom 10% of our sample differed from one another in traits that had been associated with the BAP in prior literature. A low-AQ ($n = 40$) and high-AQ ($n = 40$) group were created using the combined upper and lower tenth of participants of each reported gender. Due to the overrepresentation of females in the sample, the composite groups included 16 males and 24 females each. Although recent work has shown that using a median split to distinguish between low- and high-scoring AQ groups may yield greater internal consistency and reliability when compared to groups consisting of those at the extremes (Stevenson & Hart, 2017), we used the strategy developed by Jameel and colleagues to make our results more directly comparable to theirs. Next, we conducted baseline correlations between all key variables. After verifying that the assumptions of linear regression were met (e.g., absence of multicollinearity, homoscedasticity, and approximately normal residuals), we used linear regressions to examine predictors of each of our measures of the BAP, the SRS-brief and the AQ-Short.

Results

Categorical Aspects of the BAP

Prosocial behaviors did not differ between the high and low AQ groups in this sample (See **Table 1**). Social

Table 1: Stratified BAP comparisons using t-tests.

Measure	Mean (SD)		Cohen’s <i>d</i>	<i>p</i>
	Low AQ ($n = 40$)	High AQ ($n = 40$)		
Social desirability ^a	7.50 (3.16)	6.68 (2.41)	.29	.19
Cognitive empathy ^b	38.30 (5.13)	33.08 (4.82)	1.05	<.001*
Affective empathy ^b	41.00 (5.93)	38.23 (6.48)	.45	.06
Sensory symptoms ^c	11.48 (9.66)	22.55 (12.26)	1.00	<.001*
Alexithymia ^d	42.25 (13.22)	57.68 (10.17)	1.29	<.001*
Prosocial behavior ^e (Composite)	66.35 (13.82)	63.65 (15.53)	.18	.41
Clear-cut ¹	40.13 (6.78)	38.70 (9.25)	NA	.89
Ambiguous	26.23 (11.15)	25.95 (9.77)	.03	.59

Note: * = $p \leq .05$; The measures from which each construct was derived are as follows: SDS^a, BES-A^b, RAADS-R^c, TAS-20^d, *Social Expectations* task^e.

¹ Unlike the other analyses in this table (which are t-tests), we used a Mann-Whitney test for this variable as it was skewed.

desirability biases were also not different between groups. The high- and low-AQ-scoring groups did exhibit the expected differences in constructs believed to be central to the BAP, or heightened sensory symptoms and alexithymia and reduced cognitive empathy. As expected, significant differences in affective empathy were not observed, although a trend toward reduced affective empathy in the high AQ group was observed ($p = .06$).

Dimensional Aspects of the BAP

We conducted baseline correlations examining associations between all key variables (see **Table 2**). Baseline correlations revealed that the measures of the BAP were correlated with one another and each was associated with reduced affective and cognitive empathy, heightened sensory symptoms and alexithymia, and reduced social desirability bias. As hypothesized, sensory symptoms were associated with social cognitive difficulties (i.e., reduced cognitive empathy) and heightened social desirability bias was associated with heightened self-reported prosocial behaviors. Inconsistent with our hypothesis, sensory symptoms were not associated with self-reported prosocial behaviors.

We conducted a multiple linear regression analysis to determine which constructs remained associated with the BAP (as assessed by the SRS-brief) after other constructs were accounted for (see **Table 3**). The predictors accounted for a large amount of the variance in SRS-brief scores, adjusted $R^2 = .52$. Reduced social desirability bias and cognitive empathy and heightened sensory symptoms and alexithymia were associated with the BAP in this analysis ($F(7, 383) = 61.38, p < .001$). Self-reported prosocial behaviors were *not* associated with the BAP.

We then conducted an identical regression with the AQ-Short as the measure of the BAP (see **Table 4**). The predictors accounted for less of the variance in the AQ-short, adjusted $R^2 = .20$. Only reduced cognitive empathy and heightened alexithymia were associated with the BAP in this model, ($F(7, 383) = 14.90, p < .001$).

Table 3: Regression Examining Predictors of the SRS-brief.

Predictors	B	SEB	β	t	p
Social desirability bias	-.75	.16	-.18	-4.62	<.001*
Cognitive empathy	-.35	.09	-.16	-3.83	<.001*
Affective empathy	-.002	.07	-.001	-.03	.98
Sensory symptoms	.34	.05	.34	7.43	<.001*
Alexithymia	.27	.04	.30	6.30	<.001*
Prosocial behaviors	-.02	.03	-.02	-.59	.56
Gender	-.79	.91	-.03	-.87	.39

Table 4: Regression Examining Predictors of the AQ-Short.

Predictors	B	SEB	β	t	p
Social desirability bias	-.02	.06	-.01	.30	.77
Cognitive empathy	-.13	.04	-.19	-3.61	<.001*
Affective empathy	.004	.03	.01	.13	.89
Sensory symptoms	.03	.02	.09	1.54	.12
Alexithymia	.08	.02	.28	4.61	<.001*
Prosocial behaviors	-.01	.01	-.02	-.41	.68
Gender	-.06	.35	-.01	-.18	.86

Table 2: Correlations between study variables.

	Age	Gender	SRS	AQ	Pro-social Ambiguous	Pro-social Clear cut	Social desirability	Affective Empathy	Cognitive Empathy	Sensory Symptoms
Gender	-.08									
SRS	-.09*	-.12*								
AQ	-.04	-.07	.50***							
Pro-social Ambiguous	.03	-.05	-.07	-.05						
Pro-social Clear cut	.02	.10*	-.06	-.04	.18***					
Social desirability	.05	-.03	-.37**	-.15**	.18***	.08*				
Affective Empathy	-.03	.28***	-.12*	-.10*	.13*	.14***	-.04			
Cognitive Empathy	-.003	.15**	-.41***	-.33***	.02	.14***	.09	.36***		
Sensory Symptoms	-.06	-.14**	.62***	.33***	.01	-.03	-.24***	-.08	-.33***	
Alexithymia	-.08	-.07	.63***	.42***	-.06	-.06	-.33***	-.09	-.39***	.61***

Note: * indicates $p < .05$, ** indicates $p < .01$, *** indicates $p < .001$.

Pearson correlations were used for all variables except for the two that exhibited excessive skew. Kendall's tau correlations were used for the variables age and pro-social clear cut.

Discussion

We observed *no evidence* that reduced self-reported prosocial behavior is an aspect of the BAP. As expected, reduced *self-reported* prosocial behavior was associated with reduced social desirability bias. Expected links between the BAP and reduced social desirability bias and sensory symptoms remained apparent after other variables were accounted for when we used a BAP measure with higher (SRS-brief) but not lower (AQ-Short) internal consistency.

As hypothesized, difficulty understanding the self and others (but *not* less feeling for others) were associated with the BAP. Consistent with the growing body of literature indicating that sensory atypicalities may contribute to challenges associated with autism and the BAP (e.g., Gallagher & Varga, 2015; Kapp, 2013; Talay-Ongan & Wood, 2000; Wilkinson & Ball, 2012), sensory atypicalities were associated with reduced cognitive empathy, heightened alexithymia, and heightened autistic traits. Consistent with evidence that difficulty understanding oneself contributes to difficulty understanding others (e.g., Lombardo & Baron-Cohen, 2011), heightened alexithymia was associated with reduced cognitive but not affective empathy.

No Evidence for Reduced Prosocial Behaviors

Neither categorical nor dimensional approaches revealed any evidence that reduced prosocial behaviors are an aspect of the BAP. This differs from reports by Jameel and colleagues (2015, 2014), who utilized the same data analysis strategy, but with a within- rather than a between-subjects experimental design. This difference in significance is not due to reduced power as our categorical sample size was larger than the sample sizes utilized by Jameel and colleagues. Selection biases are likely to be present across studies, as participants in Jameel and colleagues' research were initially screened online and then invited to participate in person. Differences in the pattern of findings may be attributable to the low reliability of the *Social Expectations* task, to cultural differences (as their research was conducted in the UK while our research was conducted in the US), or to design differences such as our decision to administer all measures online utilizing a between-subjects rather than a within-subjects design and to use the AQ-Short. Although research suggests that people may respond more honestly when their responses are collected anonymously online (e.g., Keeter et al., 2015), reduced susceptibility to the social desirability bias *was* associated with reduced self-reported prosocial behaviors in both models in the current study, indicating that responses conducted anonymously online were also unlikely to be completely honest.

As noted earlier, Cronbach's alpha was not provided in the initial presentation of the *Social Expectations* task (Jameel et al., 2015). As shown in the descriptions of measures, the Cronbach's alpha for the task in the current study was below optimal levels. Especially pertinent to a between-subjects experimental design is the discrepancy in alpha between the randomly assigned Group 1 ($\alpha = .73$) and Group 2 ($\alpha = .57$). These suboptimal and inconsistent alpha statistics indicate an issue with the

internal reliability of this measure. Perusal of participants' qualitative responses to the *Social Expectations* task suggest that the low reliability of the measure may have arisen from inconsistencies in the scenarios presented. For example, one ambiguous scenario termed the "Lift Scenario" yielded a particularly low average prosocial score with participants' average likelihood of helping the character 2.3 out of 10. The scenario reads: "You arrive at an elevator, which is empty and waiting to go up or down. You need to go up to a higher floor for a meeting. A man arrives and asks if you would mind going down to the ground floor first as he is in a hurry. He says he is rushing to get outside for a cigarette break." Qualitatively, when asked to justify their action, many participants responded by saying something to the effect of "I would definitely say no, I would be contributing to his addiction."

Although the scenarios in the *Social Expectations* task are highly variable in the degree to which prosocial behaviors impose additional costs on participants with heightened sensory symptoms, expected associations between sensory symptoms and self-reported prosocial behaviors were not observed. Nevertheless, issues with reliability, validity and demand characteristics suggest that further work is needed to refine the *Social Expectations* task and that previously documented associations between reduced prosocial behavior and the BAP should be interpreted with caution.

Core Aspects of the BAP

We found that heightened sensory symptoms, alexithymia, and reduced cognitive (but not affective) empathy were aspects of the BAP when defined categorically, with large effect sizes. Heightened alexithymia and reduced cognitive empathy were also aspects of the BAP when examined dimensionally through both models. Heightened sensory symptoms were an aspect of the BAP when investigated dimensionally with the model that utilized the SRS-brief to assess the BAP but not in the model using the AQ-Short. The full-length SRS-2 includes questions specifically asking respondents about sensory sensitivities. While these questions are not included in the SRS-brief, its relationship to sensory symptoms as measured by the RAADS in the current study show that social challenges and atypical interests and behaviors identified by the SRS-brief may be rooted in sensory differences. Sensory symptoms also emerged as associated with alexithymia and cognitive empathy. This pattern of findings is consistent with a growing body of research suggesting that sensory symptoms contribute to social-cognitive atypicalities associated with autism and the BAP (e.g., Gliga et al., 2014; Rogers, 2009; Sacrey et al., 2015).

Associations between the SRS-brief and social desirability bias may reveal an aspect of the BAP that has not been directly assessed in prior research. Cronbach's alpha was much stronger for the SRS-brief ($\alpha = .86$) than the AQ-Short ($\alpha = .57$) and only the SRS-brief was associated with sensory symptoms (a known aspect of the BAP) and reduced social desirability bias (a potential aspect of the BAP). Although associations between survey measures and susceptibility to the social desirability bias are often considered a design flaw, a growing body of

literature indicates that autism, and autistic traits more generally, may be associated with heightened honesty and reduced susceptibility to the social desirability bias (e.g., Cage et al., 2013; Chevallier et al., 2012; Izuma et al., 2011; Scheeren et al., 2010; Strunz et al., 2015; Yafai et al., 2014; Yang & Baillargeon, 2013). Therefore, findings suggest that the SRS-brief is a more reliable and valid BAP measure than the AQ-Short.

Categorical and dimensional results suggest that heightened alexithymia and sensory symptoms and reduced cognitive, but not affective empathy, are core aspects of the BAP. Findings highlight the importance of assessing multiple potential aspects of the BAP, particularly reduced susceptibility to the social desirability bias, when using self-report measures.

Limitations and Future Directions

Our use of a convenience sample of college students recruited online at a public university allowed for a large sample and streamlined data collection, but limits generalizability. The sample was primarily female (61%). A more proportional gender distribution is preferable, especially given the discrepancy in ASD diagnostic rates between men and women (Baio, 2012) and prior reports that autistic traits may be heightened among males (Baron-Cohen et al., 2001; Ruzich et al., 2015). However, gender was not associated with autistic traits in the dimensional models used in the current study. Additional research is required using more representative samples to better understand the BAP.

The use of strictly self-report measures in this study is a limitation. Future research should use a combination of self-report and behavioral measures. A mixed-measures approach was effectively implemented by Spek and colleagues (2010) who combined neuropsychological observations with self-reports to address potential difficulties associated with autism and the BAP, although they found self-report most predictive of well-documented difficulties with cognitive empathy.

While our study indicating that reduced prosocial behavior is *not* central to the BAP fails to replicate findings by Jameel and colleagues (2015, 2014), we implemented a between-subjects approach to the task rather than the original within-subjects design. While we believe this adjustment strengthens evaluation of the currently un-validated measure, it cannot be directly compared to the original studies.

Our categorical approach to investigating the BAP, selected to be consistent with prior research, relied upon the BAP measure with low reliability (the AQ) and utilized a splitting strategy that is considered to be less reliable than a median split (Stevenson & Hart, 2017). We used the AQ-Short and SRS-brief as measures of autistic traits to allow for direct comparisons. The BAPQ, a measure recently found to be stronger than AQ-Short for measuring BAP traits in terms of sensitivity and specificity (Nishiyama et al., 2014; Sasson et al., 2013a), was omitted due to the large number of scales already included in the study design and the burden placed on participants

to complete all scales accurately. Future research should include the BAPQ or the SATQ (Kanne, Wang, & Christ, 2012) as a measure of autistic traits rather than the AQ-Short given previously reported concerns about the AQ and the issues with its reliability documented in this study. The current findings suggest that it may be important to revise existing BAP measures to include a focus on sensory symptoms.

Implications and Future Directions

The central recommendation derived from this work is that research utilizing self-report to investigate the BAP should include a measure of social desirability bias and should assess multiple measures simultaneously to identify core aspects of the BAP that remain associated with autistic traits when other factors are accounted for. We believe that it is particularly important to carefully investigate the reliability and validity of new measures when reporting findings that may potentially be stigmatizing for autistic people and those with heightened autistic traits. Independent replication of findings, including the findings in the current study, is necessary to advance the field.

The current findings replicate prior work by suggesting that difficulty understanding the self and others and heightened sensory atypicalities are core aspects of the BAP, supporting the need for more research examining associations between sensory atypicalities and social-cognitive development. Given that sensory atypicalities have been associated with a range of disorders (as discussed in Donaldson et al., 2017) and psychological conditions more generally may be better understood when viewed as intersecting dimensions rather than as isolated categories (Insel, 2013), research examining associations between sensory and social-cognitive atypicalities and characteristics of a range of disorders may be particularly informative. Greater understanding of the complex and interconnected nature of BAP traits is needed to design effective supports to help students with high autistic traits succeed in college.

Data Accessibility Statement

All data were processed using IBM SPSS Statistics Version 26. Participant data is available at https://www.researchgate.net/publication/338047169_Data_File_Replicable_Aspects_of_BAP.

Competing Interests

The authors have no competing interests to declare.

Author Contributions

AR helped design this study, processed and analyzed the data, conducted the literature review, and wrote many drafts of this manuscript. SKK helped design this study while a PhD student at University of California, Los Angeles, Los Angeles, CA, USA. He contributed to the literature review and writing as a postdoctoral Research Fellow at the University of Exeter, supported by the Wellcome Trust, grant number 108676/Z/15/Z. ND helped design the

study and contributed to the writing of the manuscript. JS contributed to the writing of the manuscript. KGL, who is AR's doctoral advisor, developed the idea for this study, played a leading role in designing the study, developed the analytic approach and contributed substantially to the literature review and writing of the manuscript.

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