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The content and function of interests in the broad autism phenotype

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ABSTRACT

Background: The Broad Autism Phenotype (BAP) refers to mild characteristics of autism spectrum disorder (ASD) that extend beyond the threshold of diagnosis into the general population. Individuals with BAP traits exhibit reduced social skill and social cognitive ability relative to individuals without these traits, but the degree to which non-social aspects of ASD extend to the BAP has received considerably less attention. The current study examined whether a prominent non-social characteristic of ASD, circumscribed interests (CIs), are qualitatively similar in the BAP.

Method: Typically-developing adults (N = 174) categorized as either BAP positive (n = 49) or BAP negative (n = 125) on the Broad Autism Phenotype Questionnaire rated their subjective emotional responses to images of common CIs and non-CIs (i.e., interests not commonly reported in ASD). Participants also completed the Interests Scale measuring the number of their current interests and the intensity with which they pursue their primary interest.

Results: BAP positive adults rated CIs more arousing (i.e., more energizing) and non-CIs lower on valence (i.e., less pleasurable) compared to BAP negative adults. Additionally, BAP positive males but not females showed higher valence responses for CIs relative to their BAP negative counterparts. BAP positive adults also endorsed more CIs than BAP negative adults on the Interests Scale, and reported greater intensity and inflexibility when engaging with their primary interest.

Conclusions: These findings suggest that many aspects of the content and function of CIs reported for autism extend to the BAP in the general population in a milder form.

1. Introduction

The Broad Autism Phenotype (BAP) consists of mild autism-related traits that do not rise to the level of diagnosis (Bolton et al., 1994; Constantino & Todd, 2003; Piven & Palmer, 1999). Although the BAP includes traits that are both social (e.g., social reticence and unctactful behavior) and non-social (e.g., rigid or perfectionistic behaviors) corresponding to core features of Autism Spectrum Disorder (ASD; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Hurley, Losh, Parlier, Reznik, & Piven, 2007; Losh et al., 2009), research examining cognitive and behavioral manifestations of the BAP has largely focused on its social features. These studies have demonstrated that social BAP traits in the general population are associated with reduced social skill and social cognitive ability (Ingersoll, 2010; Losh et al., 2009; Losh & Piven, 2007; Sasson, Nowlin, & Pinkham, 2013), and poorer social outcomes, including higher levels of loneliness and lower friendship satisfaction (Faso, Corretti, Ackerman, & Sasson, 2016; Jobe & White, 2007; Wainer, Ingersoll, & Hopwood, 2011; Wainer, Block, Donnellan, & Ingersoll, 2013).

By comparison, there has been little work examining how non-social characteristics of ASD extend to the BAP. Non-social

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characteristics of ASD generally fall under the category of repetitive and restricted behaviors, including motor stereotypies, ritualistic behavior, sensory sensitivities, and circumscribed interests (CIs; [Esbensen, Seltzer, Lam, & Bodfish, 2009](#)). CIs are defined as an abnormally intense preoccupation with a restricted range of activities or objects that interfere with daily functioning ([American Psychiatric Association, 2013](#)). They affect up to 88% of individuals with ASD ([Klin, Danovitch, Merz, & Volkmar, 2007](#)), making it one of the most prevalent characteristics of the disorder. Although strong interests are normative during early childhood ([DeLoache, Simcock, & Macari, 2007](#)), both the content and function of these interests differ between children with ASD and typically developing children ([Anthony et al., 2013](#); [Baron-Cohen & Wheelwright, 1999](#); [Turner-Brown, Lam, Holtzclaw, Dichter, & Bodfish, 2011](#)). For example, individuals with ASD typically show more interest in non-social systematizing domains (e.g., understanding machines, numbers), and less interest in social domains and activities (e.g., sports; [Anthony et al., 2013](#); [Baron Cohen & Wheelwright, 1999](#); [South, Ozonoff, & McMahon, 2005](#)). These patterns do not abate in adolescence or adulthood, and can negatively impact communication and daily functioning ([Bruckner & Yoder, 2007](#); [Chowdhury, Benson, & Hillier, 2010](#); [Piven, Harper, Palmer, & Arndt, 1996](#); [South et al., 2005](#); [Turner-Brown et al., 2011](#)). Indeed, parents of children with ASD report that the accommodation needed to manage circumscribed interests and behaviors is among the biggest challenges they encounter on a day-to-day basis ([Mercier, Mottron, & Belleville, 2000](#); [South et al., 2005](#)). Thus, although CIs offer positive benefits to many individuals with ASD, providing reward and pleasure ([Dichter et al., 2010](#); [Sasson, Dichter, & Bodfish, 2012](#)), areas of unique strength ([Mercier et al., 2000](#)), and can in some cases create avenues to specialized skills and vocational ability ([Koenig & Hough, 2017](#)), they are clinically-relevant in ASD because they can impair daily functioning and interfere with the development of social skills ([Turner-Brown et al., 2011](#)).

The BAP, however, is not a clinical diagnosis and therefore is not presumed to be clinically impairing. Thus, interests in the BAP may be similar in content (e.g., a greater preference for non-social and systemizing domains) and function (e.g., pursued with high intensity and inflexibility) to those in ASD, but not to an impairing degree. The current study assessed whether the content and function of interests differ for individuals with and without the BAP. Specifically, we tested whether individuals with the BAP would demonstrate a greater tendency than those without the BAP to pursue and derive pleasure from common CIs in ASD, and interact with them in a more circumscribed and restricted manner. This was assessed in several ways.

First, participants provided subjective ratings of valence and arousal for a series of images depicting CIs commonly reported in ASD and interests not commonly reported as CIs. Valence and arousal are separable components of emotion elicited in response to various stimuli ([Lang, 1995](#)). Whereas valence refers to the perceived “pleasantness” of a stimulus that evokes a positive or negative state of mind associated with approach and withdrawal behavior, arousal is the perceived feeling of energy generated by a stimulus, ranging from calm to excited. Given prior findings indicating that adults with ASD report elevated positive valence but not higher arousal ratings to images of common CIs and less positive valence ratings to social images than typically-developing controls ([Sasson et al., 2012](#)), we anticipate similar differences to emerge in the current study between adults high and low on BAP traits. Second, participants completed the Interests Scale ([Bodfish, 2003](#)), a validated inventory developed to measure the current number of CIs and the intensity of involvement of a primary interest, including whether (as is often seen in ASD) the interest interferes with other aspects of life, requires accommodation, and is pursued inflexibly. We hypothesized that individuals with the BAP would endorse fewer total interests than those without the BAP, signifying a more “circumscribed” range of interests, but more CIs than those without the BAP. We also expected for high BAP individuals to report greater intensity, involvement, and inflexibility with their primary interest. Finally, we also explored whether these patterns might be differently associated with social and non-social sub-domains of the BAP.

2. Methods

2.1. Participants

One hundred and seventy-nine undergraduates ranging in age from 18 to 39 participated in this study. Undergraduates were recruited through the university’s online study sign-up system that allowed them to receive course credit for participating in research. Five participants were excluded from data analyses for the following reasons: one reported an ASD diagnosis, two were younger than 18, and two did not complete the entire study battery. Using G*Power version 3.1, this sample size was determined to be sufficient to detect a small effect with at least 95% power ([Faul, Erdfelder, Buchner, & Lang, 2009](#)). The university’s Institutional Review Board approved this study and this study is consistent with the ethical standards of the Declaration of Helsinki. All participants provided informed consent.

2.2. Measures and procedures

Participants first completed the reading subtest of the Wide Range Achievement Test 3rd Edition (WRAT-3; [Wilkinson, 1993](#)) as an estimate of IQ, and then completed the following tasks in a counterbalanced order on a computer desktop through an online survey interface: the Broad Autism Phenotype Questionnaire (BAPQ), the Valence and Arousal of Interests task, the Interests Scale, and a demographic questionnaire.

2.2.1. Broad autism phenotype questionnaire

The self-report version of the Broad Autism Phenotype Questionnaire (BAPQ; [Hurley et al., 2007](#)) is a 36-item questionnaire assessing subclinical autistic traits. While many measures have been developed to parse autistic traits in the general population and ASD population (e.g., Autism Spectrum Quotient (AQ), Social Responsiveness Scale), the BAPQ was developed specifically to measure

BAP traits in the general population, and shows stronger psychometric properties than the AQ and SRS (Ingersoll, 2010). Participants rated how often each statement characterizes them on a six-point Likert scale (very rarely to very often). In addition to a total score, the BAPQ also yields three subscales characterizing domains associated with ASD: social aloofness (e.g., less enjoyment and interest in social interactions), pragmatic language (e.g., difficulties with communication), and rigidity (e.g., insistence on sameness, routines). Participants were categorized as BAP positive if their total BAPQ score exceeded the gender-specific self-report cutoff scores defined in previous work (3.55 for males, 3.17 for females; Sasson, Lam et al., 2013).

2.2.2. Valence and arousal of interests task

The valence and arousal of interests task was modeled on the image rating study detailed and validated in Sasson et al. (2012). Here, fifty color images depicting activities or hobbies related to common adult interests were drawn from public domain photographs. Pictures were divided into CI images (i.e., interests common in ASD) and non-CI images (i.e., interests uncommon in ASD) based on previous research (Baron-Cohen & Wheelwright, 1999; Caldwell-Harris & Jordan, 2014). Non-CI images were derived from work examining prevalent hobbies and interests in the general population, including social events and physical activities (e.g., concerts, sporting events, dancing, running; Stebbins, 2009). CI images included interests commonly reported for individuals with ASD, such as video games, electronics, science, calendars, and specific media interests (e.g., Japanese animation; Baron-Cohen & Wheelwright, 1999; Caldwell-Harris & Jordan, 2014; South et al., 2005). No images in the CI or non-CI conditions included pictures of people's faces. The images used in this task differ from those originally used in Sasson et al. (2012). In Sasson et al. (2012), participants viewed images depicting CIs commonly found for children with ASD (e.g., road signs, toy vehicles), whereas the current study included images depicting CIs found for adults with ASD to make the task appropriate for adults (Baron-Cohen & Wheelwright, 1999; Caldwell-Harris & Jordan, 2014). The new images have strong internal consistency for both valence ($\alpha = .73$) and arousal ($\alpha = .87$).

Images were presented in randomized order one at a time, and participants rated their emotional response (e.g., valence and arousal) to each image using the Self-Assessment Manikin (SAM), a visual scale used to anchor responses (Bradley & Lang, 1994). Participants first rated valence to the image (e.g., how good or bad the picture makes you feel) from negative four (most bad) to positive four (most good), then rated arousal to the image (e.g., how calm or excited the picture makes you feel) from zero (calm) to eight (excited).

2.2.3. Interests scale

Participants also rated interests using the Interests Scale (IS; Bodfish, 2003), a well-validated questionnaire developed to measure the number of interests and the degree of involvement in a primary interest of both typically developing and ASD children (Turner-Brown et al., 2011). Participants first completed a checklist of 38 interests (e.g., animals, television) rating current interests pursued within the last month, and as in previous work (Anthony et al., 2013), the total number of current interests was counted, yielding a possible range from zero to 38 interests. The IS showed strong psychometric properties in the sample ($\alpha = .77$). Participants then identified their primary current interest and answered seven questions assessing the primary interest's intensity, which in ASD relates to aspects of functional impairment. These questions include the overall degree of the interest, frequency of activity, degree of interference, degree of resistance when interrupted, degree of flexibility, amount of accommodation required, and whether the interest is done with others or alone. Each item was rated on a Likert scale, where higher scores indicate higher intensity of impairment. These items were summed to yield an intensity score, ranging from zero to 23 (Anthony et al., 2013). This scale yielded lower internal consistency ($\alpha = .54$).

The IS was modified for use in the current study. First, as this scale is a parent-report measure, questions were reworded for self-report. Second, to examine the content of interests, IS items and the primary interest were categorized as either CIs (e.g., mechanical systems, video games; items 1–9, 11, 13–23, 25–26, 28, 30, 32, 34, 36, and 38 of the IS) or non-CIs (e.g., people, psychology, politics; items 10, 12, 24, 27, 29, 31, 33, 35, and 37 of the IS) based on previous conceptualizations of CIs (Baron-Cohen & Wheelwright, 1999; Turner-Brown et al., 2011). Internal consistency was high for the CI category ($\alpha = .76$), but weaker for the non-CI category ($\alpha = .39$). Internal consistency was likely higher for the CI category because the included CIs tended to overlap on important qualities (e.g., being more systemizing and non-social in nature) that increased the likelihood of similar responses across items. In contrast, the non-CI items are broader, more wide-ranging, and less conceptually related (e.g., sports and politics), which likely resulted in reduced internal consistency. Additionally, because categorization of the IS resulted in more CIs relative to non-CIs, proportion values were used in all analyses comparing endorsement of items between the two subscales (i.e., % of CI items vs. non-CI items endorsed).

2.3. Statistical analyses

To examine differences in ratings for the valence and arousal of interests task, we used 2 (BAP status: BAP positive, BAP negative) \times 2 (gender: male, female) \times 2 (interest type: CI, non-CI) mixed ANOVAs. The Greenhouse-Geisser sphericity correction was applied to analyses, and significant interactions were followed up with independent samples *t*-tests. To examine differences in the number and content of current interests, we used a 2 (BAP status: BAP positive, BAP negative) \times 2 (gender: male, female) \times 2 (interest type: CIs, non-CIs) mixed ANOVA. Content of primary interest was analyzed using a Chi-Square test to see if there were differences between males and females and BAP positive and negative adults on the type of primary interest (CI or non-CI) endorsed on the IS. We also examined group differences on the total intensity score and seven intensity items using MANOVA to better understand the function of the primary interest for BAP positive and BAP negative individuals. Lastly, to look at how the BAP

Table 1
Participant Demographics.

	BAP Positive (n = 49)		BAP Negative (n = 125)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
WRAT-3	109.16	8.53	108.16	10.72
Age	22.31	4.18	21.54	3.43
	<i>n</i>	%	<i>n</i>	%
Males	15	30.6%	74	59.2%
Females	34	69.4%	51	40.8%
Caucasian	25	42.4%	62	49.6%

Note: WRAT-3 = Wide Range Achievement Test, 3rd Edition. BAPQ = Broad Autism Phenotype Questionnaire.

subscales relate to our overall findings we conducted exploratory correlation analysis examining how BAP total, aloofness, rigidity, and pragmatic language were related to valence and arousal for non-CIs and CIs, and number, intensity, and type of interests on the Interests Scale. To account for the number of significance tests, we used the Randomization Procedure (Sherman & Funder, 2009) which allows for testing if the number of significant correlations observed is greater than that expected by chance alone.

3. Results

3.1. BAP status of participants

One hundred twenty-five participants were classified as BAP negative and 49 were classified as BAP positive based upon the cutoff scores reported in Sasson, Lam et al. (2013). The groups did not differ in ethnicity ($\chi^2(5) = 3.85, p = .57$), age ($F(1, 172) = 1.56, p = .21, \text{partial } \eta^2 = .009$), or IQ ($F(1, 172) = .34, p = .56, \text{partial } \eta^2 = .002$; see Table 1). However, because groups significantly differed in gender distribution ($\chi^2(1) = 11.51, p < .001$) and because interests between males and females can differ in typical and ASD populations (Sasson et al., 2012), gender was included in analyses as a between groups factor.

3.2. Valence and arousal of interests task

Group means for valence and arousal are displayed in Fig. 1 and Table 2, respectively. For arousal ratings, the main effects of BAP, gender, and interest type were not significant ($ps > .11, \text{partial } \eta^2 < .02$). Across all interest types, ratings did not differ between the BAP positive and BAP negative groups, nor between males and females. However, interest type significantly interacted with both BAP status ($F(1, 170) = 1.86, p = .001, \text{partial } \eta^2 = .06$) and gender ($F(1, 170) = 18.90, p < .001, \text{partial } \eta^2 = .10$). The BAP positive group rated CIs significantly more arousing than the BAP negative group ($t(172) = -2.14, SE_D = .12, p = .03, d = .35$), but the groups did not differ on arousal ratings for non-CIs ($t(172) = -.30, SE_D = .13, p = .76, d = .05$). Images of non-CIs were rated as higher on arousal by females than males ($t(172) = -2.76, SE_D = .12, p = .006, d = -.42$), but there were no gender differences on CIs ($t(172) = .28, SE_D = .11, p = .78, d = .04$). The three-way interaction of BAP status, gender, and interest type was not significant ($p = .29$).

For valence ratings, the main effect of interest type was significant ($F(1,170) = 21.07, p < .001, \text{partial } \eta^2 = .11$), with non-CIs rated higher on valence ($M = 1.17, SD = .66$) than CIs ($M = .71, SD = .58$). The main effects of BAP status and gender were not significant ($ps > .15, \text{partial } \eta^2 < .01$), but interest type interacted significantly with both BAP status ($F(1, 170) = 22.15, p < .001, \text{partial } \eta^2 = .12$) and gender ($F(1, 170) = 51.88, p < .001, \text{partial } \eta^2 = .23$). The BAP positive group rated non-CIs lower in valence than BAP negative individuals ($t(172) = 2.43, SE_D = .11, p = .02, d = -.41$), but there was no difference between the groups for CIs ($t(172) = -.39, SE_D = .10, p = .70, d = .06$). Males rated CIs higher on valence than females ($t(172) = 3.51, SE_D = .09, p < .001, d = .53$), but females rated non-CIs as higher on valence than males ($t(172) = -3.51, SE_D = .10, p < .001, d = -.53$). However, these two-way interactions were subsumed by a significant three-way interaction between BAP status, gender, and interest type ($F(1, 170) = 7.18, p = .01, \text{partial } \eta^2 = .04$; see Fig. 1). For males, BAP status interacted with interest type ($F(1, 87) = 25.48, p < .001, \text{partial } \eta^2 = .227$): BAP positive males rated CIs higher on valence than BAP negative males ($t(87) = -2.39, p = .02, d = .68$), while BAP negative males rated non-CIs higher on valence than BAP positive males ($t(87) = 3.15, p = .002, d = -.91$). There were no differences in valence ratings of non-CIs and CIs between BAP positive and BAP negative females ($F(1, 83) = 2.37, p = .13, \text{partial } \eta^2 = .028$).

3.3. Interests scale

3.3.1. Current interests

Group means and effect sizes are displayed in Table 3. Participants endorsed a higher proportion of non-CIs than CIs ($F(1, 170) = 94.89, p < .001, \text{partial } \eta^2 = .36$), but there was no main effect of BAP status ($F(1, 170) = 2.80, p = .10, \text{partial } \eta^2 = .02$) or gender ($F(1, 170) = .81, p = .37, \text{partial } \eta^2 = .005$) on the proportion of interests endorsed. However, interest type significantly interacted with both BAP ($F(1, 170) = 11.03, p = .001, \text{partial } \eta^2 = .06$) and gender ($F(1, 170) = 5.81, p = .02, \text{partial } \eta^2 = .03$).

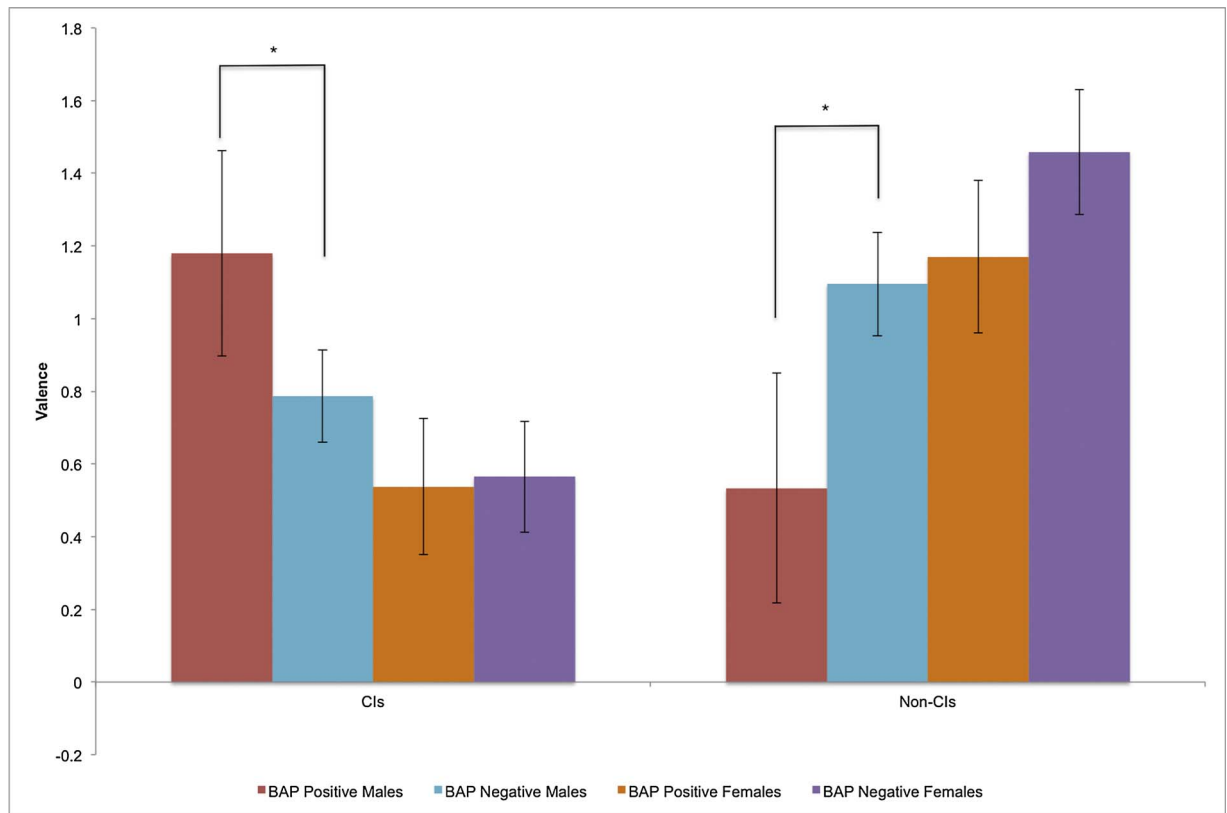


Fig. 1. Valence ratings for Cls and non-Clis, by BAP group and gender. Error bars indicate the 95% confidence interval.

Table 2
Group Means for Arousal to Cls and Non-Clis.

		Arousal	
		Clis M(SD)	Non-Clis M(SD)
BAP Positive	Males	4.86 (0.99)	4.46 (1.02)
	Females	4.88 (0.71)	5.09 (0.64)
BAP Negative	Males	4.67 (0.75)	4.76 (0.75)
	Females	4.53 (0.61)	5.00 (0.82)

Note: The task is scored from 0 to 8, higher ratings are indicative of higher arousal responses to interest categories.

BAP positive individuals endorsed a higher proportion of Cls than BAP negative individuals ($t(172) = -3.23, p = .001$), but groups did not differ on the proportion of non-Clis endorsed ($t(172) = .10, p = .92$). Males did not differ from females on the proportion of Cls endorsed ($t(172) = 1.45, p = .15, d = .22$) or non-Clis ($t(172) = .09, p = .93, d = .01$). The interaction of BAP status and gender was not significant ($F(1, 170) = .16, p = .69, \text{partial } \eta^2 = .001$), nor was the interaction of BAP, gender, and interest type ($F(1, 170) = 3.00, p = .09, \text{partial } \eta^2 = .02$).

3.3.2. Content of primary interest

BAP groups also significantly differed on the type of primary interest endorsed ($\chi^2(1) = 6.67, p = .01$). The BAP positive group endorsed more Cls (BAP positive 61.2%; BAP negative 39.5%) and fewer non-CI primary interests (BAP positive 38.8%; BAP negative 6.5%) compared to the BAP negative group.

3.3.3. Intensity of primary interest

The overall effect of BAP status on intensity items was significant ($\lambda = .90, F(7, 164) = 2.49, p = .02, \text{partial } \eta^2 = .096$); however, the groups only significantly differed on total intensity ($F(1, 170) = 5.60, p = .019, \text{partial } \eta^2 = .032$) and degree of flexibility

Table 3
Interests Scale Number, Content, and Intensity Group Means and Effect Sizes.

	BAP Positive		BAP Negative		
	M	SD	M	SD	d
Proportion of CIs endorsed	26%	0.12	20%	0.10	0.52*
Proportion of Non-CIs endorsed	11%	0.05	11%	0.04	0.02
Proportion of Total Interests endorsed	37%	0.15	31%	0.12	0.41
Intensity Total	12.20	2.73	11.09	2.89	0.39*
Overall Interest	2.86	0.35	2.77	0.44	0.23
Frequency of Activity	3.31	0.94	3.22	0.89	0.10
Interference	1.20	0.71	1.14	0.82	0.08
Degree of Resistance	1.22	0.85	1.02	0.82	0.24
Inflexibility	1.39	0.79	0.90	0.83	0.61*
Accommodation Required	0.47	0.58	0.56	0.72	−0.14
Non-Social Involvement	1.76	0.86	1.47	1.01	0.31

Note: Cohen’s d was calculated with the pooled standard deviation used as the standardizer.

* $p < .05$.

($F(1, 170) = 13.71, p < .001, \text{partial } \eta^2 = .075$), with the BAP positive group showing higher total intensity scores and more inflexibility compared to the BAP negative group. No other items differed between groups ($ps > .13, \text{partial } \eta^2 < .014$), and the effect of gender and the interaction of gender and BAP status were not significant ($ps > .59, \text{partial } \eta^2 < .033$). Group means and effect sizes are displayed in Table 3.

3.4. Relationship between BAP subscales and interests

Table 4 displays the relationship between BAP subscales and outcomes from the valence and arousal of interest task and the IS. BAP total scores were associated with lower valence ratings for non-CIs and more CIs. Additionally, BAP total scores were related to primary interests pursued with more intensity, greater resistance when interrupted, more inflexibility, and higher non-social involvement. These overall patterns related to both social (aloofness and pragmatic language) and non-social (rigidity) BAP traits. Correlations of all BAP subscales with interests are presented in Table 4. The number of significant correlations observed for the BAP total score ($p = .002$), Aloof ($p = .02$), Pragmatic language ($p < .001$), and Rigidity ($p = .01$) subscales were greater than the number expected by chance alone. Correlations were examined separately for each gender, and the pattern of results was generally unchanged (see Table 4). For females higher BAP scores and higher rigidity scores were related to more arousal for CI interests and endorsing more current total interests on the IS. Males with higher aloofness had less arousal for non-CIs and had fewer non-CI interests as rated on the IS.

Table 4
Correlations of Interests with BAP Total Score and Subscale Scores.

	BAP			Aloofness			Pragmatic Language			Rigidity		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Valence and Arousal Task												
Arousal												
CIs	.13	.01	.27*	−.002	−.12	.14	.25**	.21**	.30*	.11	−.001	.23*
Non-CIs	−.02	−.18	.14	−.12	−.31*	.08	.04	.06	.03	.08	−.10	.20
Valence												
CIs	.02	.11	−.06	−.02	.01	−.04	−.12	.20	.04	−.03	.11	−.11
Non-CIs	−.27**	−.36*	−.23*	−.33**	−.44*	−.24*	−.15*	−.20	−.10	−.11	−.15	−.15
Interests Scale												
Intensity Total	.25**	.20	.32*	.20**	.12	.28*	.15*	.10	.21	.24**	.25*	.24*
Overall Interest	.02	−.01	.06	.003	.001	.01	.02	−.06	.10	.03	.02	.05
Frequency of Activity	.02	.06	−.02	.005	−.006	.02	−.15*	−.12	−.17	.16*	.26*	.07
Interference	.12	.08	.17	.10	.06	.14	.15*	.06	.25*	.03	.06	.03
Degree of Resistance	.21**	.17	.24*	.12	.10	.14	.19*	.11	.26*	.19*	.20	.19
Inflexibility	.33**	.24*	.43*	.23*	.15	.32*	.25*	.20	.30*	.29*	.23*	.37*
Accommodation Required	−.03	−.08	.03	−.08	−.13	−.01	.08	−.01	.20	−.05	−.004	−.07
Non-Social Involvement	.19*	.22*	.16	.25**	.22*	.28*	.01	.15	−.11	.13	.13	.11
Current CIs	.18*	.06	.30*	.10	−.003	.19	.19*	.16	.22*	.15*	.03	.28*
Current non-CIs	−.06	−.15	.03	−.11	−.24*	.02	−.02	−.02	−.02	.01	−.04	.06
Total Current Interests	.13	.001	.25*	.04	−.09	.16	.15*	.13	.17	.10	.005	.25*

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

4. Discussion

Many previous studies have demonstrated that social characteristics of ASD extend in milder but qualitatively similar forms to the Broad Autism Phenotype, but few have examined the ways in which the non-social aspects of ASD also characterize the BAP. Here, we assessed whether aspects of a highly prevalent non-social feature of ASD, circumscribed interests (CIs), extends to the BAP in the general population. Using a validated self-report measure (the Interests Scale) and a novel computer-based assessment (the Valence and Arousal of Interests task), adults classified as having the BAP demonstrated similar interests and behaviors surrounding these interests as CIs in ASD. Compared to participants without the BAP, those with the BAP reported more CIs and engaged with their primary interest with greater intensity and inflexibility. Higher level of BAP traits was also associated with fewer social interests and increased resistance and distress when their interest is interrupted. Additionally, BAP positive participants found images of CIs more energizing and those of non-CIs less pleasurable than participants without the BAP. Collectively, these findings highlight similarities between the content and function of CIs in ASD and the interests of individuals with the BAP in the general population, and suggest that the BAP is defined by certain non-social features of ASD along with its more heavily-studied social characteristics.

On the Valence and Arousal of Interests task, adults with the BAP reported experiencing higher levels of arousal than adults without the BAP in response to images related to common CIs in ASD, but the groups did not differ in arousal ratings for images unrelated to CIs. This suggests that the content of CI images (e.g., electronics, video games, science), rather than a bias for reporting higher arousal in general, elicited elevated arousal for BAP positive individuals. Interestingly, this finding differs from those in a previous study in which adults with ASD did not differ from typically-developing controls in arousal to CI images (Sasson et al., 2012). Although this could suggest different arousal responses in the BAP compared to ASD when viewing CI images, the discrepancy is more likely explained by the different images used in the two tasks. The Sasson et al. (2012) task used images of CIs based upon findings with children, and as a result many of the CI images used—blocks, road signs, toy vehicles—were likely not age-appropriate for the adults tested. This is a primary reason why we forgo using this previous task and instead updated the images for the current study based upon categories of common CIs for adults with ASD (Baron-Cohen & Wheelwright, 1999; Caldwell-Harris & Jordan, 2014).

BAP positive participants also differed from BAP negative participants in their valence ratings of interest images. Participants with the BAP reported feeling less pleasure when viewing non-CI images relative to participants without the BAP. The non-CI images were selected to represent common hobbies (Stebbins, 2009) not included in the CI-image condition, and as a result, many of the non-CI images depicted interests and activities with a social component (e.g., sports participation and attending concerts). Thus, the lower valence ratings reported by BAP positive participants for these images may indicate reduced interest and pleasure derived from socially-oriented activities and hobbies. This interpretation is consistent with prior findings of reduced valence responses to social images in ASD (Sasson et al., 2012) and theories of diminished social motivation in ASD and the BAP (Chevallier, Kohls, Troiani, Brodtkin, & Schults, 2012; Hurley et al., 2007). This conclusion is further supported by our finding that the BAPQ subscale measuring social interest and motivation (alofness) correlated most strongly with lower valence ratings for non-CI images.

Further, males but not females with the BAP reported significantly higher valence responses to CI images relative to their BAP negative counterparts. This result extends prior findings indicating heightened reward and motivational value of CI images in ASD (Benning et al., 2016; Dichter et al., 2010; Sasson et al., 2012; Watson et al., 2015) to the BAP for male participants. Importantly, males without the BAP did not exhibit these patterns, suggesting that higher valence ratings for CI images was not driven by these interests being more pleasing to males generally. Additionally, females with the BAP did not show this response. This gender difference in pleasure responses to CIs in the BAP contrasts with findings in Sasson et al. (2012) that reported elevated valence ratings to CI images for both adult women and men with ASD. However, several other studies have found discrepancies in the content of CIs between males and females with ASD (Harrop, Green, Hudry, & PACT Consortium, 2017; Mandy et al., 2012; Wilson et al., 2016), with females exhibiting less interest in systematizing domains and greater interest in gender-typical and more socially-oriented domains.

On the Interests Scale, participants with the BAP endorsed a greater proportion of CIs, and more often chose a CI topic as their primary interest, compared to participants without the BAP. This finding suggests similarity in the content of interests between the BAP and ASD. Contrary to prediction, however, BAP positive participants did not endorse fewer interests than BAP negative participants, suggesting that interests in the BAP may not be more “circumscribed” in range, or narrow in focus, as in ASD. This may have occurred because the interests included on the Interest Scale may not reflect the breadth of interests included in the Valence and Arousal task, specifically for non-CIs. This interpretation is supported by the fact that BAP positive participants only endorsed a higher proportion of CIs than BAP negative participants, with the groups not differing in the proportion of non-CIs endorsed.

Participants with the BAP also reported pursuing their interests in more restricted ways than those without the BAP. Compared to BAP negative participants, those with the BAP pursued their primary interest with greater intensity and less flexibility. Additionally, higher levels of BAP traits were associated with more solitary pursuit of their primary interest, and greater distress and resistance in response to having their interest interrupted or prevented. These findings are qualitatively similar to ways CIs are pursued by individuals with ASD, but the lack of group differences in other areas of functional engagement on the Interests Scale—frequency of pursuing their interest, how much their interest interferes with daily activities, and the amount of accommodation their interest requires—suggests that interests in the BAP do not reach the same comprehensive level of functional impairment as seen in ASD. Such findings align with traditional conceptualizations of the BAP as sharing characteristics with ASD, but at subclinical levels that may not warrant diagnosis. Consistent with the social motivation hypothesis of ASD (Chevallier et al., 2012) aloofness was related to lower valence for non-CI images that included many hobbies and interests with social components. Further, pragmatic language ability was positively associated with greater arousal for CI images and lower valence for non-CI images. The Pragmatic Language

scale captures self-perceived social competence (Faso et al., 2016), and thus this finding may indicate that being low on this trait aligns with greater excitement derived from depictions of more non-social CI images, and less pleasure derived from depictions of the more socially-laden non-CI activities.

The findings from the current study should be interpreted in the context of several limitations. First, because the content and function of interests were only compared between BAP positive and BAP negative adults in the general population, this study cannot explicitly address how interests in the BAP differ from CIs in ASD. Presumably, the greater intensity and inflexibility of interests reported for BAP positive individuals would fall short of the clinically-relevant levels of these characteristics in ASD, but this assumption necessitates confirmation via direct empirical comparison between the BAP and ASD. Future studies may choose to examine whether the greater intensity and inflexibility of interests reported here for individuals with the BAP affect social and functional outcomes, as has been found in ASD (Turner-Brown et al., 2011). If so, comparing the function of interests in the BAP and ASD could provide valuable data for empirically determining where interests transition from hobbies to clinically-relevant CIs. Second, the differences in valence ratings elicited by CIs between males and females with the BAP should be interpreted with caution, as the BAP positive sample was relatively small, and gender differences did not extend to findings on the Interests Scale. Further, a greater proportion of females than males were classified as BAP positive. This may have occurred because of a lower cutoff threshold for BAP classification for females than males (Sasson, Lam et al., 2013) that was based on an older population. Future work may investigate whether these thresholds need to be adjusted for younger participants. Nevertheless, given that many features of ASD can manifest differently in males and females (Dworzynski, Ronald, Bolton, & Happé, 2012), future work is encouraged to explore whether these gender patterns extend to the BAP. Moreover, the CI images selected for this study were based upon prior research that noted the most commonly occurring CI for individuals with autism (e.g., South et al., 2005). However, these studies relied primarily on male-based samples, and recent research indicates that CIs for females with autism may be more related to sex-typical female interests than the more male-typical interests often found for males with autism (Harrop et al., 2017; Hiller et al., 2014, 2016; Sutherland et al., 2017). If these patterns extend to the BAP, it could be the case that the higher valence ratings provided for CI images by males but not females with the BAP were driven by the nature of the CI stimuli. Future studies are encouraged to examine this possibility. Additionally, measuring interests using self-report and computer-based measures may not fully capture how interests are pursued in daily life. Finally, some of the effects reported here, though significant, are small in size and should be interpreted in this context. Thus, although overlap can be found in the content and function of interests between the BAP and ASD, the relatively small effects found here are consistent with a conceptualization of the BAP as sharing qualitatively similar features as ASD but in a milder form.

Despite these limitations, the current study demonstrates a number of similarities between the content and function of interests in ASD and the BAP. Consistent with previous studies of CIs in ASD, participants with the BAP endorsed more CIs overall, pursued them with greater intensity and inflexibility, and rated images of CIs as more exciting and images of non-CIs less pleasing than participants without the BAP. Collectively, these findings provide further evidence that characteristics of ASD, including non-social features like CIs, do not cease at the threshold for diagnosis but extend to the BAP in the general population. Future studies are encouraged to examine whether other aspects of repetitive and restricted behaviors in ASD can also be found in milder forms in the BAP, and whether these characteristics relate to broader patterns of autism-related behavior.

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Conflict of interest

The authors declare that they have no conflict of interest.

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