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Interests in high-functioning autism are more intense, interfering, and idiosyncratic, but not more circumscribed, than those in neurotypical development

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Abstract

Though circumscribed interests are pathognomonic with autism, how these interests differ from those expressed during neutotypical (NT) development remains unknown. Using a novel measure, the Interests Scale (IS), this study compares interests between 76 NT individuals and 109 individuals with high-functioning autism spectrum disorder (HF-ASD) matched group-wise on age, IQ and gender ratio. Participants and their parents/caregivers completed diagnostic measures (Autism Diagnostic Interview-Revised [ADI-R], Autism Diagnostic Observation Schedule [ADOS]; HF-ASD only), cognitive tests (Wechsler IQ Scales), and questionnaires (the Repetitive Behavior Scale-Revised [RBS-R], the Behavior Rating Inventory of Executive Function [BRIEF], and the Social Responsiveness Scale [SRS]), in addition to the IS. HF-ASD and NT individuals did not differ in number of interest areas, but the types of interests differed considerably. HF-ASD individuals had significantly more intense and interfering interests than NT individuals. Using only the intensity score, 77.5% of individuals were correctly classified (NT or HF-ASD) in a discriminant function analysis. Among individuals with HF-ASD, IS scores were significantly related to ADOS, BRIEF, RBS-R and SRS scores, but not to ADI-R scores, IQ, gender, age or psychotropic medication use. The type and intensity, but not the number, of interests distinguish high-functioning children with ASD from NT children.

Keywords

autism; circumscribed interest; restricted interest; executive function; repetitive behavior

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Conflicts of Interest

Lauren Kenworthy receives financial compensation for use of the BRIEF in this study. The other authors have no conflicts of interest.

Introduction

Interests and hobbies (e.g., sports participation or crafts) are an important feature in the development of typical children and adolescents (see McHale, Crouter, & Tucker, 2001 for a review), as they offer avenues for social connection (e.g., Werner, 1993). In contrast, the restricted and/or circumscribed interests (CIs) often seen in high-functioning autism spectrum disorders (HF-ASD), can have socially isolating effects due to their intensity or unusual nature. However, the quantitative and qualitative differences between interests/hobbies characteristic of typical development and those that are circumscribed, as in HF-ASD, have not been fully distinguished.

One of the defining symptoms of ASD is repetitive behaviors and restricted interests (APA, 2000). Because CIs are a defining symptom of ASD, the ability to distinguish the interests in HF-ASD from those in neurotypical (NT) individuals is critical. CIs, including topics of a non-social nature like fossils or vacuum cleaners (e.g., Baron-Cohen & Wheelwright, 1999; Klin et al., 2007), are pathognomonic with autism spectrum disorders (ASD), but understudied in high functioning individuals. The prevalence of CIs was recently estimated in 96 children with HF-ASD using an interview format and CIs were observed to be quite common (75% for preschool children and 88% for elementary school age children) and interfered with other activities in the child's life (Klin et al., 2007). This prevalence is higher than that found in an ASD sample including both lower- and higher-functioning individuals, which reported lifetime prevalence estimates for CIs based on three items from the Autism Diagnostic Interview-Revised (ADI-R) (Szatmari et al., 2006): 56% for CIs, 60% for unusual preoccupations, and 49% for attachment to objects. These findings suggest that CIs are quite common in ASD, but are more common in HF-ASD.

Prior studies of children and adults with ASD show that stereotyped/repetitive behaviors and CIs diverge in function (e.g., Turner, 1999), developmental trajectory (e.g., Moore & Goodson, 2003), and familiality (e.g., Lam, Bodfish, & Piven, 2008). Additionally, Carcani-Rathwell, Rabe-Hasketh and Santosh (2006) suggest that the higher-order cognitive rigidity behaviors (including CIs) are unique to ASD, while lower-order repetitive behaviors relate to intellectual disability (ID) with or without ASD. Furthermore, Klin, Danovitch, Merz and Volkmar (2007) argue that CIs are a larger problem in HF-ASD than lower-functioning ASD, and contribute to difficulties in daily functioning and socialization (though note that CIs can also be used as motivators/reinforcers to increase socialization; see Baker, 2000; Baker et al., 1998; Boyd et al., 2007).

Clinicians may struggle in determining whether an interest meets diagnostic criteria because there is insufficient empirical evidence documenting the boundary between a typical interest and a CI. Accordingly, there has not been any previous research directly comparing interests in HF-ASD and NT individuals. The prevalence estimates of intense interests in NT children show these behaviors are common, particularly in boys, with a developmental peak occurring during the preschool years (DeLoache, Simcock, & Macari, 2007). Nevertheless, even at its peak, the rates of intense interests in NT development are not as high as those found in studies of individuals with ASD (Alexander, Johnson, Leibham, & Kelley, 2008; DeLoache, Simcock, & Macari, 2007; Johnson et al., 2004; Knickmeyer et al., 2005).

CIs may also relate to executive functioning (EF), which is another area of difficulty in ASD. EF consists of several sub-domains that include the abilities to: initiate and sustain attention/behavior, inhibit impulses, set goals and make realistic plans, organize information and problem-solve, manage information "on-line" in working memory, shift strategies flexibly, and monitor and regulate one's own behavior (e.g., Gioia, Isquith, Guy, & Kenworthy, 2000; Kaplan, 1988; Welsh & Pennington, 1988). Just as CIs are costly to individuals with ASD (Klin et al., 2007), so has EF been consistently identified as an impairment in ASD (for review, see Hill, 2004; Kenworthy, Yerys, Anthony & Wallace, 2008; O'Hearn, Asato, Ordaz, & Luna, 2008; Pennington & Ozonoff, 1996; Sergeant, Geurts, & Oosterlaan, 2002). The relationship between EF and repetitive behavior more broadly has been explored, but without a focus on CIs specifically (e.g., Lopez, Lincoln, Ozonoff, & Lai, 2005; Kenworthy et al., 2009; Turner, 1997; Yerys et al., 2009; for review see Geurts, Corbett, & Solomon, 2009). In a notable exception, South, Ozonoff and McMahon (2007) explored, but did not find support for a relationship between CIs and EF in individuals with HF-ASD, though this study cannot be considered definitive, as there were limitations of sample size (ASD n=19) and EF measurement tools. Most prior studies, including South and colleagues, correlated performance on lab-based set-shifting measures, not ecologically-valid EF measures, with repetitive behavior (Kenworthy et al., 2008).

There is no widely accepted measure of CIs; most researchers use items from broader established scales. However, this approach presents challenges. Some have used the ADI (Lord, Rutter, & Le Couteur, 1994) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) for examination of CIs, but these instruments contain only a few questions that relate to CIs (Cuccaro, Shao & Grubber, 2003). In addition, using diagnostic data as the dependent variable introduces the risk of circular logic when examining ASD-NT group differences or attempting to correlate ASD symptoms with CIs. Diagnostic measures are further limiting because they are inappropriate for non-ASD children, do not provide continuous scores, and do not probe the content or intensity of the interests (Lam, Bodfish, & Piven, 2008). The Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) is a widely used continuous measure of ASD-related behavior that is also appropriate for use with NT individuals; however, the SRS combines CIs with other repetitive behaviors on the Autistic Mannerisms subscale, but this subscale does not load separately from social-communicative behaviors in factor analyses (Constantino et al., 2004). Turner's (1997) Repetitive Behavior Interview is fairly lengthy, and the time spent (2+ hours) on a single ASD symptom domain exceeds its clinical utility. The Yale Survey of Special Interests (Klin & Volkmar, 1996, as described in Klin et al., 2007) asks open-ended questions about the child's top three interests that are then coded into categories, followed by quantitative interference ratings. We chose to use the Interests Scale (IS; Bodfish, 2004), a 40-item checklist that asks the parent or caregiver to rate each area of interest as being present currently or in the past. The parent is then asked several additional questions about the three primary interests, including how intense the interests are, how much they interfere with social interactions and flexibility, and the need for accommodation around those interests. The IS has the advantage of offering a qualitative examination of the content or type of interest as well as providing a quantitative rating of the intensity of the interests.

Though there has been a recent increase in studies related to CIs in HF-ASD, much remains unknown regarding their intensity and content, relationship to other symptoms and gender, and how best to distinguish typical interests from CIs in ASD. Given that CIs are part of the diagnostic criteria for ASD, and particularly prevalent and important in HF-ASD, we chose to conduct this study with HF-ASD individuals. In addition, for the purposes of this paper, an interest becomes a CI when it is intense and interferes with daily functioning.

The present study directly compares the number, type, and intensity of interests in groups of HF-ASD and NT individuals matched on age, IQ and gender ratio. Furthermore, we examine how the interests relate to social-communication symptoms/behaviors and EF. We chose social and communication behaviors because they constitute the remaining two components of the triad of impairment in ASD (APA, 2000). We chose EF because it has been linked with restricted or repetitive behaviors and interests (Kenworthy et al., 2009; Lopez, Lincoln, Ozonoff, & Lai, 2005; South, Ozonoff, & McMahon, 2007; Turner, 1997; Yerys et al., 2009).

Hypotheses

We hypothesized that (1) individuals with HF-ASD would have fewer interests but have higher intensity or interference ratings, than NT individuals; consistent with the notion of a restricted number of interests that are also interfering in daily activities in the HF-ASD group, (2) individuals with HF-ASD would have fewer socially-oriented interests and more solitary or object/sensory-focused interests than NT individuals, (3) males and females from both groups would differ in their areas of interest, and (4) the IS would be negatively correlated with IQ and age but positively correlated with measures of autistic symptomatology and repetitive behavior in the HF-ASD group.

Method

Participants

For all participants, informed consent was obtained from parents/caregivers when participants were under the age of 18, and informed assent was obtained from the participants in accordance with the requirements of the IRBs from Children's National Medical Center and the National Institute of Mental Health. Informed consent was obtained from participants ages 18 and older.

Autism Spectrum Disorders (ASD)—One hundred and nine individuals with HF-ASD were recruited for this study through a hospital clinic specializing in ASD and through the community. Thirty-eight individuals (35%) were taking at least one psychotropic medication. Individuals in the ASD group received a clinical diagnosis of Autism, Asperger's Syndrome, or Pervasive Developmental Disorder-Not Otherwise Specified [PDD-NOS] based on DSM-IV-TR criteria (APA, 2000). All participants with ASD also met criteria for 'broad ASD' based on scores from the ADI or ADI-R (Le Couteur et al., 1989; Lord et al., 1994) and/or the ADOS (Lord et al., 2000), following criteria established by the NICHD/NIDCD Collaborative Programs for Excellence in Autism (Lainhart et al., 2006). A full-scale IQ score of at least 70 with either a Verbal/Verbal Comprehension or

Performance/Perceptual Reasoning IQ of at least 80 was required for study entry and was derived from testing on a Wechsler instrument: Wechsler Abbreviated Scale of Intelligence (n=85), Wechsler Intelligence Scales for Children-Third (n=3) or Fourth Editions (n=18) or Wechsler Adult Intelligence Scale-Third Edition (n=3) (Wechsler 1991; 1997; 1999; 2003). Subjects were also excluded if they had any history of comorbid medical or genetic disorders that would affect brain development and/or cognitive functioning.

Neurotypical (NT) Individuals—Seventy-six NT individuals were recruited from the community via advertisements. Individuals enrolled in the NT group did not receive diagnostic measures, but were screened through a brief parent-completed interview and questionnaire. Participants were screened and excluded if they or a 1st degree relative were found to have developmental, learning, neurological, or psychiatric disorders, or if the NT individual used any type of psychotropic medication. As with the ASD group, a full-scale IQ score of at least 70 with either a Verbal/Verbal Comprehension or Performance/Perceptual Reasoning IQ of at least 80 was required for study entry and was derived from testing on a Wechsler instrument: Wechsler Abbreviated Scale of Intelligence (n=74) or Wechsler Intelligence Scales for Children- Fourth Edition (n=2) (Wechsler 1999; 2003). The ASD and NT groups did not differ in terms of gender ratio, age, IQ or SES (*p*s>.05; see Table 1)

Measures

All participants were tested in a laboratory setting within the context of two separate, larger studies. Participation included a 3- to 4-hour testing session with a variety of neuropsychological, diagnostic and cognitive measures. Participants received monetary compensation for their time.

1. Interests Scale (IS; Bodfish, 2004)—The IS is an informant report of interests that consists of two sections. Part 1 is a checklist of 41 categories of interests (e.g., mechanical systems/actions, numbers/numerical information), and informants are asked to endorse all categories that constitute either a Current or a Past interest. In Part 2, informants are asked to identify the current primary, secondary and tertiary interests and are instructed to answer several questions designed to assess the intensity of each interest (e.g., frequency of specific activity related to interest, degree of interference with other activities, degree of resistance when interrupted). The IS yields a Total Number of Current Interests Endorsed score and a Total Intensity score. We use both scores in analyses, as well as examining item-level data. Higher scores indicate greater number or intensity of interests.

2. Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000)—The BRIEF is an informant report of EF in everyday situations. Its 86 items yield eight scales that are collapsed into a broad composite, the Global Executive Composite (GEC). Higher scores indicate greater impairment. We chose a parent report measure because it is more reliable at capturing EF problems seen in ASD (for review, see Geurts, Corbett, & Solomon, 2009; Kenworthy, Yerys, Anthony, & Wallace, 2008). For this study, we chose the GEC as the key dependent variable in order to limit the number of comparisons/ correlations, and because CIs may be related to a combination of EF impairments as discussed above. Higher scores are associated with greater impairment.

3. Social Responsiveness Scale (SRS; Constantino & Gruber, 2005)—The SRS is an informant report, 65-item questionnaire that assesses behaviors characteristic of ASD, covering interpersonal, communicative and repetitive/stereotypic behaviors. We use Total T scores in our analyses because factor analyses consistently suggest a single factor solution (Constantino et al., 2004). Higher scores are associated with greater impairment.

4. Repetitive Behavior Scale- Revised (RBS-R; Bodfish, Symons, & Lewis, 1999)—The RBS-R is an informant report, 39-item questionnaire assessing various categories of repetitive behavior, including Stereotyped Behavior, Self-Injurious Behavior, Compulsive Behavior, Ritualistic Behavior and Sameness Behavior. Raters are asked to consider the frequency of the behavior, the individual's resistance to interruption while engaging in the behavior and the extent to which the behavior interferes in daily functioning. We used the RBS-R Overall Score (sum of the Total subscale scores). Higher scores indicate more repetitive behaviors.

Data Analysis

Before hypothesis testing, basic psychometrics of the IS were evaluated for each group with descriptive statistics and internal consistency of the total scores (Current Interests Total and Intensity Score). Spearman or Pearson correlations were used to test our predictions that the IS total scores would be negatively correlated with IQ and age and positively correlated with ADOS, SRS, BRIEF and RBS-R scores. Multiple linear regressions were used to explore the relationships between IS total scores and age, gender and Full Scale IQ. These demographic variables were entered in the first step of the regression. Missing data reduced the combined sample size to 181; this reduced sample did not differ from the larger sample in any systematic way (e.g., age, IQ, gender ratio). To explore whether psychotropic medication usage was related to IS scores in this sample, a linear multiple regression was run for the HF-ASD group only.

We predicted that individuals with HF-ASD would have fewer interests and higher intensity or interference ratings than NT individuals. A discriminant function analysis was used to determine whether the IS scores differentiate HF-ASD from NT individuals. Both the IS Total Number of Interests and the IS Intensity Ratings were entered to predict diagnostic group membership, computing the prior probabilities from group sizes since the groups were unequal.

We also hypothesized that individuals with HF-ASD would have fewer socially-oriented interests and more solitary or object/sensory-focused interests than NT individuals and males with ASD would have different interest areas and more intense interests than females with ASD. To qualitatively assess interest areas, we tallied the top three most frequently reported primary interests by group (HFA vs. NT) and gender, and the most frequently reported primary interest by age (in three year increments, other than the youngest and oldest age groups: 7-0 to 8–11, 9-0 to 11-11, 12-0 to 14-11, 15-0 to 17-11, and 18-0 to 23) and gender. We also explored item-level differences on the IS between the HF-ASD and NT groups using independent samples t-tests.

Corrections for multiple comparisons were instituted throughout using the False Discovery Rate (FDR) set at $q<.05$ (Benjamini & Hochberg, 1995).

Results

Psychometrics of the IS

Cronbach's alpha for the 41 items on the IS was high (0.904). Cronbach's alpha for the eight interference items was also strong (0.808). Table 2 presents the correlations between the IS and ADOS, RBS-R, BRIEF and SRS in the HF-ASD sample only (to avoid artificially increasing the correlation coefficients by including the very low scores on most of those measures in the NT individuals) after FDR correction for multiple comparisons. As expected, the IS scales were strongly positively correlated with the RBS-R. The number of current interests was correlated with the ADOS Stereotyped Behavior Scale. The Intensity of Interests was also positively correlated with the SRS and BRIEF. The relationships with the ADOS, SRS and RBS-R lend support for the IS's construct validity.

Multiple regression analyses revealed that age, gender and Full Scale IQ do not significantly predict either Number of Interests (R^2=.441; F=1.79, p=.54; with none of the covariates approaching significance) or Intensity of Interests (R^2=.040; F=1.04, p=.67; with none of the covariates approaching significance) on the IS. Within the HF-ASD group, psychotropic medication use also did not predict IS scores (Number R^2=.005; F=0.49, p=.49; Intensity R^2=.009; F=0.06, p=.82).

We hypothesized that individuals with HF-ASD would have fewer interests, and that these interests would be more intense. To examine IS score differences between the groups, a discriminant function analysis was conducted. This analysis revealed that the Intensity Rating significantly discriminated between the two groups (Wilks' Lambda .684, df=1, $p<.001$), though Number of Interests did not (Wilks' Lambda .998). Using the IS Intensity Rating alone, 82% of the individuals with HF-ASD were correctly classified, and 71.2% of the NT individuals were correctly classified. This finding is striking, because the IS does not have any items assessing the other components of the 'triad of impairment' in autism (i.e., social reciprocity and social communication) per se.

To examine the second hypothesis that there will be differences in the foci of interests for NT individuals and those with ASD, t-tests were conducted on each IS item (0=Never had interest, 1=current interest, 2=current and past interest; past interests only were excluded). Item analyses with FDR correction for multiple comparisons suggest many similarities in areas of interests, with a few notable exceptions. Individuals with HF-ASD were more likely to show interest in: factual information, playing games alone, collecting/hoarding, cartoons, attachment to a particular object or item, and sensory seeking activities. NT individuals were more likely to be interested in people and sports. The two groups did not differ in many of the other non-social interests, such as computers, mechanical or building things, maps or astronomy, animals, calendars or math, though many people assume that these interests are more common in individuals with ASD. Please see Table 3 for details.

We further explored interest areas in a more qualitative way. At the end of the IS, the caregiver is asked to specify the individual's primary interests. We compared the top three specific interests for males and females with and without HF-ASD (please see Table 4). It was compelling to observe that males from both groups shared an interest in video games, but there was no overlap in the primary interests of females from each group; however, this potential gender difference should be interpreted with caution because there were relatively few females in the present study. Age differences were explored in a similar way. It is notable that the primary interest across all ages in the HF-ASD group was video games, while there was a shift in the NT group from television in 7 and 8 year olds, to sports in 8–17 year olds, to religion in the young adults.

Discussion

We find that: (1) interests in HF-ASD individuals are more intense, but surprisingly not more limited in number/scope (i.e., not 'restricted') than those found in NT individuals, (2) fact-, object-, and sensory-oriented interests are greater in HF-ASD, while people- and sports-oriented interests are greater in NT individuals, (3) the areas of interest for males and females differ in both groups, and (4) intensity of interests are associated with other ASD-related behaviors (e.g., symptoms) and difficulties (e.g., executive functioning).

The present study shows that individuals with HF-ASD do not have fewer interests than NT individuals, contrary to our predictions. Rather, the intensity of their interests is greater, and their interest areas are less likely to be socially-oriented (e.g., interaction with others) and more likely to be object or sensory oriented, consistent with our predictions. This suggests that the DSM-IV criterion "encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is *abnormal either in intensity or focus*" is the best way to distinguish the interests in HF-ASD from those in NT development, not merely the presence of an intense interest, nor a restriction in the number of interests (APA, 2000).

This study is also the first to directly compare the interest areas of NT and HF-ASD individuals. There were many intuitive, significant group differences, such as the HF-ASD group almost exclusively showing interests in a very particular item or object, sensory interests, collecting/hoarding things and interest in factual information, while interest in sports rarely occurred in HF-ASD. Qualitative analysis of the main interest areas broken down by gender and group (i.e., NT versus HF-ASD) revealed no overlap in interests in females, while males had an overlapping interest in video games (though they were especially common in HF-ASD). This could mean that females, as opposed to their male counterparts, with HF-ASD will have a more difficult time using their CIs to build friendships with NT females.

Furthermore, this study links everyday EF (BRIEF) with intensity of CIs (regardless of content area) and demonstrates an association between CIs and greater difficulties with social reciprocity and social communication (SRS). Whether intensity of CIs interferes with daily social interactions, or is just a proxy for more intensity of autism-related behavior regardless of domain is a question for future research. But these findings are consistent with Klin and colleagues' (2007) suggestion that CIs are related to the social and repetitive core

symptoms in HF-ASD. CIs may also cause significant family stress, as suggested by Bishop, Richler, Cain and Lord's (2007) finding of increased parental stress with higher reports of restricted and repetitive behaviors and interests on the ADI-R. Therefore, treatment of CIs to increase adaptability, reduce social deficits, and reduce parental distress is an important clinical need for individuals with ASD (and their families). Moreover, the strong relationship we have identified between everyday EF and CIs in HF-ASD might offer an avenue for therapy: cognitive behavioral intervention could improve flexibility, inhibition, generativity and organization, and thereby reduce the intensity and interference of these behaviors. It is also possible that improved social engagement and pragmatic language skills result in a reduction of the intensity of CIs, as can happen in repetitive behaviors (e.g., Koegel, Koegel, Hurley, & Frea, 1992), though this is not necessarily supported in HF-ASD (Piven, Harper, Palmer, & Arndt, 1996).

The measure of interests used here, the IS, appears to be an excellent complementary assessment tool to the ADI/ADOS because it offers a detailed, continuous measure that can be used in both ASD and NT children and adults. This issue is particularly important when looking for measures to assess non-social phenotypes in family and/or genetic association studies. For example, a recent compelling study by Smith et al. (2009) identified a strong familial pattern of intense preoccupations, but used the ADI-R for the children with ASD and the Modified Personality Assessment Scale–Revised (Tyrer, 1988) for their biological parents. The IS would allow using the same instrument to assess this domain in the proband and first-degree relatives, whether siblings or parents. Additionally, the IS had strong positive correlations with scores on the ADOS and RBS-R in the subjects with HF-ASD. These findings lend support for the IS's construct validity by revealing a strong relationship between intensity of CIs and other restricted and repetitive behaviors (RBS-R).

Contrary to previous research in ASD (Klin et al., 2007; Moore & Goodson, 2003), we did not find any significant relationships between number or intensity of CIs and age, gender, medication use or IQ in school age children and young adults. It would be especially important, however, to investigate this with the IS in a younger age range, since both the Moore and Goodson (2003) and Klin et al. (2007) studies showed greater prevalence of CIs in preschool children as compared to school-age children. The lack of association with IQ suggests that within the range of low average to above average IQ, CIs are not related to IQ as they are in samples that include individuals with ID. Inconsistent with our predictions, intensity and number of CIs did not correlate with IQ though our findings are consistent with a prior study of HF-ASD individuals (Bishop et al., 2006). CIs may be like "insistence on sameness" behaviors in that they are more prevalent in higher IQ individuals with ASD and unlike repetitive behaviors, which are more prevalent in lower IQ individuals with ASD (Richler et al., 2010).

The findings of this study, though maximizing ecological validity, are limited due to reliance upon parent-report measures of not only CIs, but also many of the correlates. Future research might include cross-informant and observational methods. Moreover, neuroimaging technologies could be used to assess neural underpinnings of intensity of CIs in HF-ASD and NT individuals, similar to prior investigations of interest areas in ASD (Grelotti et al., 2005). Longitudinal studies including preschool aged children could examine the changing

nature of interests over time, look for distinguishing patterns in ASD and could explore the potential relationship between CIs and subsequent higher academic pursuits and/or employment opportunities/careers. Finally, our sample was purposely restricted to HF-ASD because of the higher prevalence of CIs in this group and the ability to have age matched controls, but future studies should also include the full autism spectrum.

In conclusion, consistent with ASD diagnostic criteria, we find more intense interests among individuals with HF-ASD versus NT using the IS. Intriguingly, the overall number of interests did not differ between HF-ASD and NT individuals, though NT individuals were more likely to show socially-oriented interests while individuals with HF-ASD were more likely to show factually-, object- or sensory-oriented interests. These findings have strong clinical implications regarding the importance of documenting intense, unusual interests as opposed to limited numbers of interests in diagnosing HF-ASDs. Finally, CIs were related to repetitive behaviors (from the RBS-R and ADOS), and autistic traits in general (from the SRS), which implies that CIs should be important targets of intervention. The association between CIs and everyday executive control difficulties (from the BRIEF) indicates that CI intervention strategies could include teaching EF skills. The BRIEF-CI association also has theoretical implications for our understanding of the link between executive dysfunction and the third aspect of the triad in ASD. Overall, these findings indicate that measures of CIs, such as the IS, may prove useful in future phenotyping and behavior genetic studies in HF-ASD.

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Abbreviations

ADI-R	Autism Diagnostic Interview-Revised
ADOS	Autism Diagnostic Observation Schedule
ASD	autism spectrum disorder
BRIEF	Behavior Rating Inventory of Executive Functioning
CIs	circumscribed interests
EF	executive functioning
FDR	False Discovery Rate
HF-ASD	high-functioning ASD
ID	Intellectual Disability
IS	Interests Scale

NT	neurotypical
RBS-R	Repetitive Behavior Scale-Revised
SRS	Social Responsiveness Scale
WASI	Wechsler Abbreviated Scale of Intelligence

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Table 1

Participant Demographics

		NT (N=76)	HF-ASD (N=109)	Significance (two-tailed)
% Males		79%	85%	.259
Age	Mean (SD)	13.59 (3.85)	12.70 (3.79)	.122
	Range	7.22–24.25	7.13–22.92	
Full Scale IQ	Mean (SD)	115.03 (11.72)	111.56 (17.48)	.133
	Range	96–144	73–159	
SES	Mean (SD)	40.31(23.09)	36.99 (22.31)	.354
	Range	11–100	11–89	

Note. SES calculated with Hollingshead's (1975) coding; (Middle class range=28–43).

Table 2

Interests Scale Correlations for HF-ASD Participants Only

		ADOS Comm/Social^{S}	ADOS Stereotyped Behavior^{S}	SRS Total T Scores^{P}	RBS-S Total^{P}	BRIEF GEC^{P}	IS Sum of Current Interests^{P}
IS	Correlation	−.174	**.229***	.148	**.403***	.052	
Sum of Current	Sig (2-tailed)	.088	**.024**	.132	**<.001**	.606	-
Interests	N	97	100	105	107	100	
IS	Correlation	.070	.039	**.268***	**.285***	**.451***	.092
Total Intensity	Sig (2-tailed)	.498	.707	**.006**	**.003**	**<.001**	.343
Rating	N	96	98	103	105	98	107

*Significant (p<.05) correlations (after FDR correction in bold [q<.05]).

^{S}Spearman correlation.

^{P}Pearson correlation.

Table 3

Group Differences on IS Items

	Group	Mean	SD	*t* (df=183)	*p*
Machines/how things work	NT	0.58	0.72	0.78	.436
	HF-ASD	0.49	0.71		
Mechanical systems/mechanical actions	NT	0.34	0.62	1.29	.198
	HF- ASD	0.23	0.55		
Numbers/numerical information	NT	0.26	0.55	−1.32	.190
	HF-ASD	0.38	0.66		
Strongly attached to a particular item or object	NT	0.18	0.45	−3.31	.001**
	HF-ASD	0.50	0.75		
Seeks particular sensations or sensory experiences	NT	0.09	0.33	−4.01	<.001**
	HF-ASD	0.44	0.69		
Factual information	NT	0.25	0.59	−3.48	.001**
	HF-ASD	0.61	0.77		
Animals	NT	0.46	0.74	−0.15	.879
	HF-ASD	0.48	0.71		
Insects	NT	0.09	0.29	−0.98	.328
	HF- ASD	0.16	0.51		
Dinosaurs	NT	0.12	0.43	−1.68	.095
	HF-ASD	0.27	0.67		
People	NT	0.53	0.70	4.83	<.001**
	HF-ASD	0.15	0.35		
Collecting/hoarding things	NT	0.29	0.56	−2.78	.006**
	HF-ASD	0.59	0.81		
Arts/crafts	NT	0.47	0.68	0.95	.344
	HF-ASD	0.38	0.69		
Music	NT	1.04	0.66	2.32	.021
	HF-ASD	0.81	0.67		
Television/movies	NT	0.93	0.68	−1.49	.138
	HF- ASD	1.10	0.79		

	Group	Mean	SD	*t* (df=183)	*p*
Vehicles/transportation	NT	0.37	0.63	−0.62	.537
	HF-ASD	0.43	0.71		
Building things/construction	NT	0.66	1.30	0.40	.688
	HF-ASD	0.60	0.77		
Time	NT	0.17	0.38	−1.52	.130
	HF-ASD	0.27	0.51		
Measuring/measurement	NT	0.12	0.32	0.32	.746
	HF-ASD	0.10	0.38		
Geography/maps	NT	0.20	0.40	−2.03	.044
	HF-ASD	0.38	0.69		
Schedules	NT	0.06	0.25	−1.38	.169
	HF-ASD	0.13	0.34		
Calendars/dates	NT	0.08	0.27	−1.75	.081
	HF-ASD	0.19	0.52		
Math/counting/calculating	NT	0.21	0.44	−1.86	.064
	HF-ASD	0.37	0.63		
Computers/computing/computer science	NT	0.50	0.58	−1.80	.074
	HF-ASD	0.67	0.67		
Sports	NT	0.88	0.67	6.10	<.001**
	HF-ASD	0.31	0.59		
Astronomy/planets	NT	0.21	0.59	−0.78	.436
	HF-ASD	0.27	0.52		
Reading/writing	NT	0.70	0.67	0.17	.865
	HF-ASD	0.68	0.76		
Religion	NT	0.49	0.70	1.94	.054
	HF-ASD	0.30	0.58		
Rocks/minerals/geology	NT	0.18	0.51	−0.23	.816
	HF-ASD	0.20	0.50		
Politics/government	NT	0.32	0.47	0.39	.696
	HF-ASD	0.28	0.58		
Physics	NT	0.25	0.59	0.26	.795

	Group	Mean	SD	*t* (df=183)	*p*
	HF-ASD	0.23	0.48		
Psychology	NT	0.14	0.35	0.61	.540
	HF-ASD	0.11	0.39		
History/philosophy	NT	0.37	0.69	0.48	.631
	HF-ASD	0.32	0.63		
Language/linguistics	NT	0.18	0.39	−0.99	.324
	HF-ASD	0.26	0.55		
Object or item motions	NT	0.10	0.42	−2.17	.031
	HF-ASD	0.26	0.50		
Plants/gardening/farming	NT	0.13	0.34	0.24	.813
	HF-ASD	0.12	0.35		
Toys	NT	0.63	0.80	−0.52	.598
	HF-ASD	0.70	0.85		
Playing games with others	NT	0.58	0.68	0.18	.853
	HF-ASD	0.56	0.71		
Playing games alone	NT	0.76	0.65	−3.00	.003**
	HF-ASD	1.10	0.82		
Cartoons/animation	NT	0.39	0.59	−4.15	<.001**
	HF-ASD	0.85	0.83		
Building/architecture	NT	0.21	0.50	0.79	.430
	HF-ASD	0.16	0.43		
Other (not listed)	NT	0.14	0.35	−2.66	.009**
	HF-ASD	0.35	0.60		

** Group difference is significant after FDR correction (q<.05).

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Table 4

Primary Interest by Group and Gender

Group	Males	Percent	Females	Percent
NT	Sports	26.7%	Reading	18.8%
	Reading	8.3%	People	12.5%
	Video games	6.7%	Other (not listed)	6.3%
HF-ASD	Video games	21.5%	Numbers/math	18.8%
	Legos	7.5%	Music	12.5%
	Playing games alone	4.3%	Other (not listed)	6.3%

Table 5

Means and Primary Interest by Group and Age

Age	Group	N	Primary Interest (%)	IS Sum of Current Interests Mean (SD)	IS Total Intensity Mean (SD)
7–8	NT	8	Television (25)	11.88 (4.45)	25.25 (4.77)
	HF-ASD	25	Video games (17)	12.56 (5.90)	40.88 (11.92)
9–11	NT	22	Sports (22)	13.45 (9.70)	23.86 (5.57)
	HF-ASD	18	Video games (20)	14.85 (6.81)	37.61 (10.39)
12–14	NT	19	Sports (20)	12.05 (6.44)	28.31 (8.37)
	HF-ASD	23	Video games (29)	12.96 (5.27)	39.04 (11.67)
15–17	NT	17	Sports (39)	12.50 (6.40)	29.47 (6.01)
	HF-ASD	27	Video games (33)	12.78 (6.73)	38.37 (8.86)
18–23	NT	6	Religion (38)	9.25 (4.27)	25.33 (6.28)
	HF-ASD	11	Video games (18)	11.00 (7.22)	41.82 (13.53)