Systemizing and special interests: Characterizing the continuum from neurotypical to autism spectrum disorder

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Abstract

Special interests have been studied in children with autism spectrum disorder (ASD) but not in adults. Using an online survey, it was found that individuals with ASD reported more intense interests in systemizable domains, relative to neurotypical adults. Self-reported systemizing preference was correlated with intensity of interest in systemizable domains both for those with ASD and for neurotypical young adults. Few gender differences were found in the neurotypical group in the expected categories of machines, technology and vehicles, where gender differences have been found in children. Gender differences in these categories did appear for the ASD group. We propose a strength-based model of special interests, with the hobbies of neurotypical forming a continuum with the special interests of ASD.

Keywords:
Autism spectrum disorder
Asperger syndrome
Special interests
Adults
Systemizing

1. Introduction

Among individuals with Asperger syndrome, repetitive behaviors often occur in the form of intense interests which may be considered unusual or atypical in their content (e.g., World War II airplanes; see Asperger, 1991; Attwood, 2003; Winter-Messiers, 2007). These are sometimes called restricted or circumscribed interests (e.g., Klin, Danovitch, Merz, & Volkmar, 2007). Following Winter-Messiers (2007), we use the term “special interests” because it promotes a strength-based approach and it is also the term most frequently used by individuals on the Internet discussion forums from which we recruited survey participants in the current study. We describe and defend the view that special interests are not primarily repetitive behaviors, but reflect information processing styles and cognitive strengths (Baron-Cohen, 2002). The interests and hobbies of neurotypical individuals (i.e., those without ASD, Attwood, 1998; Winter-Messiers, 2007) frequently reflect individuals’ cognitive-personality styles, and we thus propose that the special interests of those with Asperger syndrome or on the autism spectrum lie on a continuum with neurotypical hobbies. This leads to two primary hypotheses: (1) that the content of special interests exists on a continuum between neurotypical individuals and individuals with autism spectrum disorder (ASD), and (2) that special interests reflect information processing styles, such that the interests of individuals with ASD are correlated with systemizing ability, and interests of neurotypicals with mentalizing ability, as measured by the Systemizing Quotient (Wheelwright et al., 2006) and the Reading the Mind in the Eyes Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

Past research has focused primarily on the special interests of children with autism spectrum disorder (ASD), who develop these interests as early as 1–4 years of age (Attwood, 2003; Bashe & Kirby, 2001; Moore & Goodson, 2003), although some interests cannot be reliably scored on certain assessments until age 4 (Moore & Goodson, 2003). Approximately 75–90% of individuals with mild to moderate autism or Asperger syndrome develop one or more special interests (Bashe & Kirby, 2001; Klin et al., 2007). Other individuals on the autism spectrum, including those with PDD-NOS (Sturm, Fernal, & Gilberg, 2004) and Rett syndrome (Mazzocco et al., 1998), also exhibit intense interests.

Special interests are often manifested in efforts to collect objects or information relevant to the interest area, which can require extensive amounts of time (Bashe & Kirby, 2001). Parents often find special interests the most difficult to accommodate of autistic behaviors due to their intensity (Mercier, Mottron, & Belleville, 2000). Unlike other behaviors, special interests do not lessen with age (Fecteau, Mottron, Berthiaume, & Burack, 2003) and the number of interests may increase as the individual approaches adulthood (Bashe & Kirby, 2001).

Among children with ASD, special interests often reflect exceptional abilities, such as systemizing and heightened attention to detail. Systemizing is the drive to explore, analyze, and construct systems (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003). Domains that are amenable to systemizing are rule-based and predictable, facilitating detection of input–operation–output relationships (Baron-Cohen, Ashwin, Ashwin, Tavassoli, & Chakrabarti, 2009). The special interests of children with ASD frequently occur in systemizable...
domains, such as in mechanical, collectible, natural, and numerical systems (Baron-Cohen & Wheelwright, 1999).

Neurotypical (NT) individuals also develop special interests. While up to 90% of individuals with ASD develop special interests (Bashe & Kirby, 2001; Klin et al., 2007), about 30% of NT children develop an “extremely intense interest” (DeLoache, Simcock, & Macari, 2007). Special interests in NT children may appear as early as 1–2 years of age. Like children with ASD, the special interests of NT children reflect their cognitive strengths. NT children are often preoccupied by interests in people, imaginative play, and the social environment more broadly (Attwood, 2003; DeLoache et al., 2007). These interests are consistent with strong mentalizing ability (i.e., the capacity to understand and attribute mental states to others, Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Frith, Morton, & Leslie, 1991). While children with ASD often have higher systemizing ability than NT individuals (Baron-Cohen et al., 2003), NT individuals generally have higher mentalizing abilities (Baron-Cohen, Wheelwright, Hill, et al., 2001; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Furthermore, NT females tend to have higher mentalizing ability than NT males (Baron-Cohen, Wheelwright, Hill, et al., 2001; Baron-Cohen, Wheelwright, Skinner, et al., 2001), while NT males generally have higher systemizing ability than NT females (Baron-Cohen et al., 2003).

Little is currently known about special interests in adulthood. Understanding adults’ special interests is important for illuminating the positive role that interests play in adult life, such as rewarding careers (Attwood, 2003; Grandin & Duffy, 2008; Jackson, 2002). No studies yet compare the interests of individuals with ASD to those of NT individuals. The current study examines the content of special interests held by adults with ASD and NT adults, with the expectation that individuals with ASD will hold more intense interests in domains previously identified as systemizable, such as machines and technology, sorting, categorizing, and organizing, factual and numerical information, collecting, and the sciences. We also expect that NT individuals will hold more intense interests in mentalizing domains, such as in people and sports and games (as discussion of sports fosters social affiliation, see Mueller, Agamanolis, & Picard, 2003). The current study will also assess participants’ systemizing and mentalizing abilities, with the goal of identifying whether interest categories previously identified as systemizable correlate with high systemizing ability, and likewise whether interest categories expected to rely on mentalizing correlate with high mentalizing ability. By identifying cognitive abilities that contribute to special interests, we hope to develop a strength-based continuum model of special interests, where the interests of individuals with ASD and NT individuals coexist and vary depending on systemizing and mentalizing ability (see Fig. 3 and Discussion section). A strength-based model of special interests can inform the development of educational and therapeutic programs that capitalize on individual abilities and use special interests as a medium for learning other important skills.

We also hope to better understand gender differences in special interests. Winter-Messiers (2007) reported that ASD girls were more likely than boys to have more neurotypical interests, such as a 10-year-old girl being interested in horses. Attwood (2003) also noted ASD girls’ intense interests in dolls, animals and fiction, but remarked on some aberrant qualities of these interests. Girls didn’t use their dolls to play with others, but would self-play with a large doll collection. An interest in animals could become consuming; girls would want to act like animals, or to sleep in a stable. Interests in fiction included collecting and wanting to contact the author. The focus of the writing interest was not related to school success or an anticipated career.

ASD is well known to be less frequent in girls, which has been hypothesized to reflect protective aspects of girls’ socialization (e.g., Constantin & Todd, 2003) or lower fetal testosterone (Auyeung et al., 2006). It would be useful to know if systemizing and/or a person’s autism traits predicted their type of interests independently of gender.

Gender differences in interests also exist in typically developing children. In the study of DeLoache et al. (2007), half of the intense interests that parents reported for boys were for vehicles, trains, and machines, and another 27% were for balls, dinosaurs, and tools. Girls’ intense interests were clothes/dressing up, babies, and tea sets. These gender differences in interests were observed in the youngest children studied (approximately 1 year old). Since knowledge of gender stereotypes, implicit or explicit, does not occur until 18 months or later, DeLoache et al. speculated that biological factors, such as fetal testosterone, play a role.

Gender differences in special interests have not previously been studied in adult persons with ASD. Our secondary hypothesis is that we will see continuity between childhood and adulthood. We thus expect that both ASD and neurotypical males will have interests in more systemizable domains than will ASD and neurotypical females. Understanding gender differences in special interests during adulthood is important, as it can provide a means to adapt skill development in the workplace and higher educational settings to individual cognitive styles.

2. Materials and methods

2.1. Participants

Participants with ASD were recruited from WrongPlanet.net, a large online discussion forum created for individuals with ASD, and their families, friends, and supporters (Plank & Yellow Sneaker Media, 2004). Among 70 individuals who self-reported themselves as having an ASD, 67 identified themselves as having Asperger syndrome, while only 2 reported autism spectrum disorder and 1 reported PDD-NOS. Slightly more than half (58.6%) of individuals with ASD reported being diagnosed by a clinician (see Table 1 for summary of other demographic and diagnostic variables). The most common disorders reported by both groups were anxiety disorders (including panic attacks, social phobia, generalized anxiety), followed by depression. Less commonly reported was ADHD, followed by OCD.

In the ASD group, 42.9% of participants were female, while 50.4% of the NT group was female. Although ASD is typically more prevalent in males, this gender ratio is similar to that reported in past studies of ASD special interests on Internet discussion forums (Jordan & Caldwell-Harris, 2012).

Neurotypical participants included participants who were forum users from the WrongPlanet.net website (n = 68) who identified themselves as neurotypical (i.e., not having an ASD) and students from Boston University who participated for course credits (n = 51). Recruitment from a university allowed us to approximately match the age and education level of the ASD and NT groups.

To determine whether participants reporting themselves as NT who were recruited from the WrongPlanet.net forum should be considered neurotypical, we compared their Systemizing Quotient, Autism Quotient, and Eyes Test scores (see Materials) to those earned by NT participants recruited from Boston University. WrongPlanet NT individuals did score slightly higher on the autism quotient than Boston University NT participants (WrongPlanet NT M = 22.9, SD = 11.1, BU M = 17.1, SD = 7; t(79) = −3.1, p < .005) and thus some of them may be considered part of the broader autism phenotype (Constantino & Todd, 2003). However, there were no differences between the two NT groups on the Systemizing Quotient or Eyes Test. Furthermore, WrongPlanet NT individuals had lower scores than ASD individuals on the Autism Quotient (WrongPlanet NT M = 22.9, SD = 11.1, ASD M = 36.4, SD = 7.3; t(78) = −7.2, p < .001) and the Systemizing Quotient (WrongPlanet NT M = 35.1, SD = 14.7, ASD M = 43.8, SD = 16.5; t(97) = −2.8, p < .05), and higher scores on the Eyes Test (WrongPlanet NT M = 24, SD = 5.4, ASD M = 18.4, SD = 9; t(88) = 3.9, p < .001). Although the WrongPlanet NT participants were substantially neurotypical, their scores were slightly elevated compared to the Boston University NT students and the NT norms of 16.4 reported by Baron-
The Systemizing Quotient-Revised (SQ, Wheelwright et al., 2006) provided a measure of mentalizing ability, and a modified version of the Eyes Test (Baron-Cohen, Wheelwright, Hill, et al., 2001) was used to assess systemizing ability. Our overall NT sample thus did have a slightly higher than average number of autistic traits.

### 2.2. Materials

An online survey was administered using SurveyMonkey online survey software. The Cambridge University Obsessions Questionnaire (Baron-Cohen & Wheelwright, 1999) was modified by adding the categories of nature, history and culture, and psychological disorders, with the existing category of plants being included under the broader nature category (see Table 2).

If a participant indicated an interest in a given category, they were asked to provide a brief description of their particular interest, and to rate the intensity of their interest in from 1 to 3, 1 indicating a casual interest, 2 a moderate interest, and 3 an intense interest. Participants who did not express an interest in a given category were assigned an interest intensity of 0.

To measure how strongly autistic traits were expressed, the survey included the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Hill, et al., 2001). The Reading the Mind in the Eyes Test Revised (Eyes Test, Baron-Cohen, Wheelwright, Skinner, et al., 2001) provided a measure of mentalizing ability, and a modified version of the Systemizing Quotient-Revised (SQ, Wheelwright et al., 2006) assessed systemizing ability.

### 3. Results

#### 3.1. Preliminary analyses Systemizing Quotient and Eyes Test

#### 3.1.1. Internal consistency of scales

The internal consistency of the Autism Spectrum Quotient (AQ) was high, with a Cronbach alpha of 0.94. Our modified version of the Systemizing Quotient-Revised (SQ-R) also showed high consistency, with a Cronbach alpha coefficient of 0.89.

#### 3.1.2. Effects of age and diagnosis type

The Systemizing Quotient, AQ, and Eyes Test were examined for effects of age and whether individuals reported a disorder other than ASD. Age did not correlate significantly with scores on any of the measures, nor were there differences in scores between individuals with a disorder other than ASD in either group. In the ASD group, no differences in scores on these three scales were obtained for individuals diagnosed by a clinician and those who were self-diagnosed, or between individuals who had received therapy and those who had not.

#### 3.1.3. Correlations between scales

Consistent with prior work, the Systemizing Quotient correlated positively with the AQ ($r = 0.49$, $p < .001$), and negatively with the Eyes Test ($r = -0.19$, $p < .05$). The AQ also correlated negatively with the Eyes Test ($r = -0.49$, $p < .001$).

### Table 1

Summary of participants.

<table>
<thead>
<tr>
<th>Special interest category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines &amp; technology</td>
<td>Interests in computers, radios, television, clocks, etc., or expresses interest in how things work. Does not include interests in watching or listening to movies, television, music, etc.</td>
</tr>
<tr>
<td>Belief systems</td>
<td>Interests in religions, mythologies, political systems, philosophies, alternative beliefs (such as conspiracy theories), etc.</td>
</tr>
<tr>
<td>Numerical information</td>
<td>Interests in timetables, calculators or calculations, calendars, prime numbers, reading or creating charts or tables of information, etc.</td>
</tr>
<tr>
<td>Sports &amp; games</td>
<td>Interests in football, tennis, walking, biking, tennis, playing cards, chess, board games, puzzles, video games, etc.</td>
</tr>
<tr>
<td>Item attachment</td>
<td>Interests focused on a particular item or type of object, as well as interests in certain words or phrases.</td>
</tr>
<tr>
<td>Sensory</td>
<td>Interests in touching or feeling certain things, or mentions fascinations with texture, specific sounds, lighting, colors, smells, etc.</td>
</tr>
<tr>
<td>Crafts</td>
<td>Interests in model making, knitting, sewing, carpentry, etc.</td>
</tr>
<tr>
<td>Factual information</td>
<td>Interests in reading or memorizing lists, reading encyclopedias, dictionaries, newspapers, etc.</td>
</tr>
<tr>
<td>Creative arts</td>
<td>Interests in movies, television shows, art work, painting, playing an instrument, music, writing and reading fiction, creating media (e.g., online films), performing arts, etc.</td>
</tr>
<tr>
<td>Psychological disorders</td>
<td>Expresses interest in any psychological disorder.</td>
</tr>
<tr>
<td>History &amp; culture</td>
<td>Interests in existing languages, particular countries or civilizations, time periods or eras in history, etc.</td>
</tr>
<tr>
<td>Information &amp; mechanical systems</td>
<td>Interests in plumbing, light switches or electrical wiring, maps, city planning, subway maps and/or schedules, businesses and organizations, etc., or an interest in creating systems (such as languages or maps).</td>
</tr>
<tr>
<td>Sorting, categorizing, &amp; organizing</td>
<td>Interests in making lists, lining objects up, arranging objects in certain orders or categories, planning, or obsession with neatness or organization.</td>
</tr>
<tr>
<td>Food &amp; drink</td>
<td>Interests in consuming or creating a particular food or drink, cooking, baking, etc.</td>
</tr>
<tr>
<td>Vehicles</td>
<td>Interests in trains, airplanes, buses, boats, cars, etc.</td>
</tr>
<tr>
<td>People</td>
<td>Interests in a particular person, in types or groups of people, or in interacting with people, including participation in online communities, etc., or an interest in creating systems (such as languages or maps).</td>
</tr>
<tr>
<td>Collecting</td>
<td>Interests in acquiring collections of particular items, e.g., bottles, keys, caps, stamps, rocks, etc.</td>
</tr>
<tr>
<td>Nature</td>
<td>Interests in plants, interacting with nature (e.g., hiking, gardening, exploring, etc.), and natural phenomena (e.g., volcanoes, tsunamis, lightning, etc.).</td>
</tr>
<tr>
<td>Animals</td>
<td>Interests in pets, wild or farm animals, insects, fish, birds, etc., also includes animal-related activities (e.g., bird watching), but does not include mythical creatures.</td>
</tr>
<tr>
<td>Sciences</td>
<td>Interests in astronomy, chemistry, biology, physics, engineering, mathematics, logic, economics, psychology, meteorology, specific diseases or conditions, etc.</td>
</tr>
<tr>
<td>Other</td>
<td>Interests that did not fit within a specific category.</td>
</tr>
</tbody>
</table>
3.1.4. Gender and group differences in the scales

For each of the three measures, a two-way between-groups analysis of variance was conducted to examine main effects of gender and group as well as potential interaction effects. Not surprisingly, ASD participants had significantly higher scores than NT participants on the Systemizing Quotient (ASD $M = 44.8$, SD $= 16.8$, NT $M = 32.4$, SD $= 11.9$, $F(1, 108) = 14.1$, $p < .001$, $\eta^2_g = .12$) and on the AQ (ASD $M = 36.4$, SD $= 7.3$, NT $M = 20.0$, SD $= 9.7$, $t(153) = -11.2$, $p < .001$, $\eta^2 = .45$). Also as hypothesized, NT participants had higher Eyes Test scores than ASD participants (ASD $M = 18.4$, SD $= 9$, NT $M = 24.9$, SD $= 5$, $t(71.8) = 4.8$, $p < .001$, $\eta^2 = .14$). The only gender differences occurred for the Systemizing Quotient, with no interaction of gender and diagnosis. Males had higher systemizing scores than females (male $M = 42.6$, SD $= 15.5$, female $M = 33.6$, SD $= 13.8$, $F(1, 108) = 4.8$, $p < .05$, $\eta^2_g = .04$).

3.2. Special interests analyses

Our primary hypotheses were that individuals with ASD would have interests of different contents than NT individuals, and that interests would vary with systemizing and mentalizing abilities for both groups. As shown in Table 3, individuals with ASD had more intense interests in item attachment, collecting, factual information, and sorting, categorizing, and organizing, as well as in sciences, sensory, and machines and technology. NT individuals had more intense interests in food and drinks. Individuals with ASD also identified interests in more categories overall than NT individuals (ASD $M = 10.9$, SD $= 4.9$, NT $M = 9$, SD $= 5.2$, $t(187) = 2.4$, $p < .05$, $\eta^2 = .03$), and had more intense interests overall than average (ASD $M = 1.3$, SD $= 0.7$, NT $M = 1$, SD $= 0.6$, $t(187) = -2.8$, $p < .01$, $\eta^2 = .04$).

Combining over both ASD and neurotypical individuals, scores on the Systemizing Quotient correlated positively with intensity of interest in machines and technology, sorting, categorizing, and organizing, item attachment, sensory, and factual information, as well as vehicles, collecting items, and sciences (see Table 4). Scores on the Eyes Test correlated positively with food and drink, but negatively with item attachment, factual information, and collecting. The Systemizing Quotient also correlated positively with the total number of interest categories ($M = 9.7$, SD $= 5.1$, r $.37$, p < .001) and with the average intensity of all interests ($M = 1.1$, SD $= 0.7$, r $.41$, p < .001). Many correlations remained significant even when correlating within the ASD or neurotypical group, although correlations were lower because the SQ range was smaller when only one group was analyzed. Finding robust correlations between systemizing scores and intensity of interests among neurotypicals is consistent with the concept of a continuum between neurotypicals’ hobbies and ASD individuals’ special interests.

### Table 3

<table>
<thead>
<tr>
<th>Special interest category</th>
<th>Autism spectrum disorder (M, SD)</th>
<th>Neurotypical (M, SD)</th>
<th>t(187)</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item attachment</td>
<td>$1.5 (1.3)$</td>
<td>$0.7 (1.2)$</td>
<td>$-4.1**$</td>
<td>$.08$</td>
</tr>
<tr>
<td>Collecting</td>
<td>$1.1 (1.2)$</td>
<td>$0.6 (0.9)$</td>
<td>$-3.2**$</td>
<td>$.06$</td>
</tr>
<tr>
<td>Factual information</td>
<td>$1.8 (1.3)$</td>
<td>$1.1 (1.2)$</td>
<td>$-3.5**$</td>
<td>$.06$</td>
</tr>
<tr>
<td>Sorting, categorizing, &amp; organizing</td>
<td>$1.7 (1.1)$</td>
<td>$1.2 (1.2)$</td>
<td>$-2.7**$</td>
<td>$.04$</td>
</tr>
<tr>
<td>Sciences</td>
<td>$1.6 (1.3)$</td>
<td>$1.3 (1.3)$</td>
<td>$-2.6**$</td>
<td>$.04$</td>
</tr>
<tr>
<td>Sensory fixation</td>
<td>$1.7 (1.1)$</td>
<td>$1.3 (1.1)$</td>
<td>$-2.4**$</td>
<td>$.04$</td>
</tr>
<tr>
<td>Machines &amp; technology</td>
<td>$1.6 (1.4)$</td>
<td>$1.2 (1.2)$</td>
<td>$-2.3**$</td>
<td>$.03$</td>
</tr>
<tr>
<td>Food &amp; drink</td>
<td>$0.3 (0.5)$</td>
<td>$0.5 (0.5)$</td>
<td>$1.6*$</td>
<td>$.06$</td>
</tr>
</tbody>
</table>

Note. Participants indicated the intensity of their interests on a scale from 0 to 3, corresponding to no interest, 1 a casual interest, 2 a moderate interest, and 3 an intense interest. **p < .01. *p < .05.

3.3. Special interests, group and gender

Our secondary hypothesis was that ASD and NT males would have interests in more systemizable domains than ASD and neurotypical females. We analyzed how gender interests interact with diagnosis and type of special interest by conducting 2 x 2 analyses of variance on each interest category. Four categories revealed significant 2 x 2 interactions. The resulting patterns are complex and can be best appreciated in graphic forms. Fig. 1 plots the significant gender X diagnostic group interactions for machines and technology, $r^2 = .04$, and vehicles, $r^2 = .05$, both $p < .05$. These are plotted together because they show the same pattern of no gender differences for neurotypicals, but males having stronger interests than females in the ASD group, confirmed with post-hoc Scheffe tests. Fig. 2 plots the significant interactions for sorting, categorizing, and organizing, $r^2 = .06$, and collecting interest category, $r^2 = .05$, both $p < .05$. We plotted these special interests together because the Scheffe post-hoc tests revealed a pattern of greater interests by females than males among neurotypicals for both interest categories, but either no gender differences in the ASD group (Sorting, Organizing) or males having somewhat greater interest than females (but smaller differences than seen in the ASD group in Fig. 1).

Since the lack of gender differences among neurotypicals was unexpected, we scrutinized individuals’ comments accompanying their intensity ratings to determine whether engagement with these objects occurred because objects facilitate systemizing.

3.3.1. Machines and technology

Some comments did indicate that the object afforded systemizing, as in examples (1)–(3):

1. “I like to take things apart when I get the opportunity to observe how it functions firsthand.” Female NT
2. “Building computers from scratch and this hobby/interest has been around since I was 8 years old and its still around.” Male ASD
3. “Computers, mostly. Have repaired and built several. Also a Linux user.” Female NT

However, comments such as those in (4)–(6) emphasized machines as merely conduits to information, not as being mechanistically interesting.

4. “Tv since I was 4, I can watch tv for hours at a time. I am now addicted to the Internet.” Female NT

### Table 4

<table>
<thead>
<tr>
<th>Special interest category</th>
<th>Systemizing Quotient</th>
<th>Eyes Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASD only</td>
<td>Neurotypical only</td>
</tr>
<tr>
<td>Machines &amp; technology</td>
<td>.30**</td>
<td>.42**</td>
</tr>
<tr>
<td>Vehicles</td>
<td>.47**</td>
<td>−21*</td>
</tr>
<tr>
<td>Sorting, categorizing, &amp; organizing</td>
<td>.13</td>
<td>.11</td>
</tr>
<tr>
<td>Item attachment</td>
<td>.02</td>
<td>.27*</td>
</tr>
<tr>
<td>Sensory</td>
<td>.08</td>
<td>.17</td>
</tr>
<tr>
<td>Factual information</td>
<td>.36**</td>
<td>.35**</td>
</tr>
<tr>
<td>Collecting</td>
<td>.29*</td>
<td>.17</td>
</tr>
<tr>
<td>Sciences</td>
<td>.27*</td>
<td>.05</td>
</tr>
<tr>
<td>Food &amp; drink</td>
<td>.08</td>
<td>.14</td>
</tr>
<tr>
<td>Average interest intensity</td>
<td>.38</td>
<td>.38</td>
</tr>
</tbody>
</table>

Note. For the Systemizing Quotient, higher scores are indicative of higher systemizing ability, while for the Eyes Test, higher scores are indicative of higher mentalizing ability. Participants indicated the intensity of their interests on a scale from 0 to 3, corresponding to no interest, 1 a casual interest, 2 a moderate interest, and 3 an intense interest. ***p < .001. **p < .005. *p < .05.
"I am in college so obviously my laptop, ipod, and other electronics are basics in my life!" Female NT

"I like using my Iphone and Mac for virtually everything." Male NT

The proportion of males and females who gave examples of each type were similar, although the comments that emphasized systemizing were fewer in number in both genders.

3.3.2. Vehicles
ASD males reported the highest intensity of interests in vehicles, but the average intensity was still only just above 1, indicating a casual interest, while ASD females were almost 0 (on average no interest). While NT males and females reported having similar intensity of interests, both averaged around 0.5, which is low compared to other interest categories. Lack of gender differences may thus have occurred because of floor effects. But a larger issue has become apparent, concerning these interests and developmental stage. Vehicles (like machines) afford systemizing because they have many parts that can be analyzed. These parts can be studied to determine how they work as independent components (doors and windows open and close, wheels turn), and what these parts contribute to the functioning of the whole object. Vehicles also afford systemizing because sets of vehicles can be compared and contrasted, thus yielding opportunities for developing mechanistic theories around attributes such as the function and speed of different categories of vehicles. But note that these are reasons why children who like systemizing will be attracted
to vehicles. Adults who like systemizing will turn to domains that are more challenging for their cognitive abilities (computer programming, the sciences).

3.3.3. Sorting, categorizing and organizing

The comments of female neurotypicals were similar to ASD males and females. These three groups also had roughly similar reported intensities (see Fig. 2). Examples appear in (7)–(9). By contrast, NT males expressed almost no interests in this category.

(7) “I like to write things down in my yearly organizer, if I have any plans. Only when cleaning my room, I sometimes like to arrange objects in a certain order.” ASD female

(8) “Since I was a child, I have loved organizing and planning. Sometimes I spend a whole day to clean my room. Especially, my closet has to be in some order. Ex. colors.” NT Female

(9) “I love list-making; lining objects up; symmetry; organizing music; filing; data entry.” ASD male

The comments overall suggest that sorting, categorizing and organizing inhabit the shallow level of systemizing. They are not used to analyze or predict a system, but to impose control and order into one’s life. There was a trend among the comments for all females to sort, categorize and organize as an end towards a goal of having an organized life, while ASD males reported enjoying sorting, categorizing and organizing because it enabled systemizing (i.e., understanding) systems that were not set up by oneself.

3.3.4. Collecting

Neurotypical respondents reported quite low intensities, with only ASD males reporting on average having a moderate interest in collecting. Types of collections were similar for neurotypical males and females and ASD females, with rocks being the most common item collected, then shot glasses, sea shells, and coins, as in examples (10)–(12).

(10) “Rocks and minerals, turtles (not real ones), stamps, coins, books...spool knitters, small looms, antique plates...” NT Female

(11) “Dolls, buttons, fairies, egyptian, chinese, flying tigers” ASD Female

(12) “Collect boxes and perfume oils.” ASD Female

Statements were more eccentric for ASD males, as in (13)–(14).

(13) “When I was 4, I used to collect the cushions that go on the gaps between eye pieces of swimming goggles. At various times in childhood I obsessed over certain items, but this no longer happens.” ASD Male

(14) “I delete nothing. Not files, not letters, not notes, not music, not books, not computers, not electronics, nothing. I keep it all...” ASD Male

This category thus resembles the vehicles interest in that floor effects in interest intensity means reduced opportunity to observe gender effects. The higher interest levels reported among ASD males are consistent with this group having the highest systemizing propensity but also may reflect hoarding, a characteristic of OCD, which can be co-morbid with ASD, as in example (14).

4. Discussion

4.1. Gender differences and special interests

We found no gender differences in interests among neurotypical adults, contrary to the robust differences observed in children (DeLoache et al., 2007). While this could reflect lack of power and sampling error due to small sample sizes, we suggest that this is at least partly an artifact of using The Cambridge University Obsessions Questionnaire (Baron-Cohen & Wheelwright, 1999; see Table 2). Before widespread computer and Internet use, being interested in machines and technology typically occurred because machines and technology afforded systemizing (taking apart machines; computer programming). But the neurotypical young adults we surveyed reported being interested in machines and technology primarily for information access, socializing, and entertainment. No gender differences were suggested by the few respondents who did report having systemizing interests in machines and technology. Similarly, lack of gender differences in interest in vehicles, and possibly also in sorting, organizing, categorizing and collecting may have occurred because these interests do not afford challenging systemizing opportunities for adults. Future work on gender differences in systemizing can start anew by asking what systemizing activities are common for the target age group in the Internet and personal computer era.

4.2. What causes special interests?

The prevailing explanations for special interests are (1) that they function to reduce anxiety (Atwood, 2003), or (2) reduce over arousal caused by sensory stimuli (Hutt, Hutt, Lee, & Ounsted, 1965). These explanations need to be reconsidered given Turner’s (1997) observation that individuals with ASD engaged in repetitive behaviors and special interests when alone and un-stimulated. Turner also found that repetitive behaviors were least likely to occur during social interactions when anxiety is maximal.

We propose that people’s unique cognitive abilities, and especially systemizing and mentalizing, prompt the development of special interests in particular domains (as illustrated in Fig. 3; see also Baron-Cohen & Wheelwright, 1999). In this view, ASD special interests exist on a continuum with NT interests. ASD special interests that draw on strong systemizing abilities may be shaped in early childhood by the low salience of social stimuli (Carruthers, 1996; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008). Sasson et al. (2008) found that children with ASD showed decreased gaze time at social objects such as faces, and increased gaze time at objects that are frequently the subject of ASD special interests (“high-autism-interest” stimuli), such as trains, vehicles, and electronics.

The concept of a continuum of special interests is consistent with social scientists’ conception that the domains of human knowledge range along dimensions of compact/diffuse and rule-governed vs. open-ended (Simonton, 2009; Toullin, 1972). We will summarize these dimensions with the term granularity. Fields of knowledge (interests) with small granularity are predictable and rule-based, such as the sciences. The opposing end of the continuum is comprised of large granularity interests, which, like diffuse domains and “soft” disciplines, involve few rules and are less definable. Fields of knowledge with large granularity require the ability to understand broadly defined domains, which involve few rules. The social environment is the earliest large granularity domain to which a child is exposed, and mentalizing abilities develop so that the individual can navigate the social world. High mentalizing ability may thus represent a cognitive style that is most attracted to large granularity interests.

The granularity concept provides a means of explaining why an individual develops interests in particular domains, as the appeal of phenomena at different granularities would appeal to different cognitive styles. We propose that each individual has a unique cognitive “comfort zone,” or preferred granularity, which describes the range of granularities most attractive to a person with specific cognitive abilities, such as systemizing and mentalizing. Existing evidence for a continuum includes Nettle’s finding (2007) that NT individuals’ scores on the Systemizing Quotient correlated positively with technological interests, which are lawful and of small granularity. Billington, Baron-Cohen, and Wheelwright (2007) found that strong systemizing ability and weak
empathizing ability predicted academic study in the physical sciences (e.g., mathematics, physics, engineering, etc).

In our study, the reported intensity of interests in large granularity domains, such as food and drink (which may heavily involve social interaction) correlated with mentalizing ability. High systemizing correlated not only with intense small granularity interests but also with having more intense interests overall, as well as a high total number of interests. Individuals with large granularity interests may have fewer interests overall than those with small grain interests, because large granularity interests are broadly defined and may encompass a wider range of topics in themselves. The extreme large granularity end of the continuum represents the cognitive comfort zone of individuals with high mentalizing ability. NT interests, particularly those of females, are predicted to occur more frequently on the large granularity end, as females tend to have higher mentalizing abilities and develop mentalizing earlier than NT males (Frith & Frith, 2003). The interests of NT individuals with varying propensities for systemizing and mentalizing may occur in the middle range of the continuum, but would not otherwise be labeled as restricted or obsessive.

4.3. Individual variation in cognitive styles

What causes individual differences in systemizing and mentalizing ability? Previous work has implicated several brain regions in the development and maintenance of mentalizing, including the mirror neuron system, the temporo-parietal junction, temporal poles, and medial prefrontal cortex (Frith & Frith, 2003). The functioning of these areas can vary depending on many genetic and environmental factors.

Fetal testosterone is thought to be one cause of high systemizing ability. Fetal testosterone was found to correlate with systemizing ability for both genders (Auyeung et al., 2006). High fetal testosterone is correlated with boys having a number of special interests, while low fetal testosterone is correlated with high quality social relationships in both boys and girls (Knickmeyer, Baron-Cohen, Raggatt, & Taylor, 2005).

Another cause of high systemizing ability may be a heightened attention to detail, as details in a system must be tracked should they contribute to input-operation–output relationships (Baron-Cohen et al., 2009). Attention to detail, in turn, could arise from hypersensitivity to various sensory stimuli, which might affect low-level information processing and result in the development of interests in unusual domains (Baron-Cohen et al., 2009). Mottron, Dawson, Soulières, Hubert, and Burack (2006) propose that hypersensitivity may result from underconnectivity or local-overconnectivity between neurons in the brain. The under-connectivity hypothesis suggests that the ASD brain lacks long-range neural connections responsible for high-level cognitive processes (Mottron et al., 2006). The failure to develop integrated connections might lead to hyperspecialization in some brain areas in the form of local overconnectivity, which could contribute to the abnormal sensory processing that causes hypersensitivity.

4.4. Implications for education

Understanding special interests is crucial for educators, since students find their interests inherently rewarding, and educators can bring them into individualized lesson plans. The continuum model suggests that individuals with ASD, and males, on average, are more likely to have small granularity interests, associated with high systemizing ability. This understanding could be used in the classroom or work environment, where large granularity topics can be gradually introduced and related to preexisting interests. For example, children or adults may be interested in machines and technology, but could be required to study history, a more “diffuse” domain, for a school or a workplace requirement. Initial learning could first be stimulated in the context of small granularity subtopics, such as a discussion of how technology propelled historical events. Large granularity abstract concepts could then be progressively added to the curriculum. The continuum model also suggests that females, on average, tend to have large granularity interests, associated with high mentalizing ability. This understanding could be used to adapt educational materials for teaching more compact small granularity topics, such as mathematics. Work by Gredlein and Bjoeyklund (2005) suggests that even minor educational tailoring can significantly improve individual performance: while boys were initially more likely to use tools to retrieve a toy, girls performed at the same level once they were given verbal hints by the experimenter, and generalized their learning to a second tool-use session. It is interesting to note that verbal hints may have capitalized on girls’ mentalizing ability.

The strength-based continuum model of interests can inform career placement, degree selection, or aptitude testing (Armstrong, 2011;
Gardner, S. (2006). "Grigorenko & Stemberg, 1997"). Understanding the nature and career potential of special interests may provide support and relief for parents who are frustrated with their child's consuming interests. More generally, the continuum approach lends further insight into individual cognitive differences, and may help us better understand why these abilities develop. Finally, the special interests continuum provides a more complete understanding of the deep interests that motivate people, bring richness to our lives, and often lead to new scientific and technological advances.

References


