Are special abilities in autism spectrum disorder associated with a distinct clinical presentation?

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1. Review of literature

Autism spectrum disorders (ASD) has been characterized by impairments in social-communication abilities, repetitive and restrictive behaviors. However, the existence of unusual special skills, called “islets of ability”, “savant skills”, “splinter skills” or “talent” has been described in the ASD literature (Bennett & Heaton, 2012; Howlin, Good, Hutton, & Rutter, 2009). In the past, the term “savant skills” was used to describe individuals with intellectual impairment who demonstrated one or more outstanding skills in various areas that were above what was expected from their cognitive ability (Heaton & Wallace, 2004; Young & Nettelbeck, 1995). Special skills were reported in specific genetic syndromes. For example, memory and visual spatial skills were described in Prader-Willi syndrome (Milner et al., 2005) or exceptional music and memory abilities in Williams syndrome (Levitin et al., 2004). However, special skills have been most identified and described in connection to those with ASD. In his first reports on autism, Kanner (1943) described the presence of excellent memory and musical, mechanical and calculation skills. In later reports, numerous areas of special abilities were described in individuals with ASD.
Among the described talents were mathematical calculation (Heavey, Pring, & Hermelin, 1999), music (Heaton, Pring, & Hermelin, 1999), drawing (Pring, Hermelin, & Heavey, 1995), memory (Mottron, Belleville, Strip, & Morasse, 1998) and mechanical and spatial abilities (Joseph, Tager-Flusberg, & Lord, 2002). In a postal survey of 5,400 parents of children with autism, Rimland (1978) found that 53% (9.8%) were reported to have savant skills. Of this group, 53% reported special ability in music, 40% in memory, 25% in mathematical calculations, and 19% in art. Among 254 subjects with ASD, Bolte and Poustka (2004) reported that 13% had at least one special skill and 11% had special skills in several domains as assessed on the Autism Diagnostic Interview-Revised (ADI-R). In this study, the most frequently described special skill was exceptional memory. Previous reports assessed the association between special abilities and cognitive levels in ASD. Researchers reported that the mean IQ of “savants” with autism was considerably higher than that of those with ASD without special skills (Miller, 1999). Howlin et al. (2009) studied high cognitive ability in 137 individuals with ASD. Of these, 28.5% had either a savant skill (11.6%) or exceptional cognitive skills (16.9%), above population norms or above their own overall level of cognitive functioning. In this cohort, none of those with savant skills had a non-verbal IQ on the Wechsler test below 50 and, overall, the means of the savant group were consistently higher than those without special skills. Bolte and Poustka (2004) did not find differences in IQ between groups with ASD with and without special skills.

Researchers have reported sex differences in the frequency of special skills in ASD. Savant skills occur more frequently in males than in females (Bennett & Heaton, 2012; Hill, 1977; Howlin et al., 2009).

In several studies researchers have suggested in a link between the severity of the restrictive and repetitive behaviors (RRB) domain and having savant skills. O'Connor and Hermelin (1991) found that individuals with autism and savant skills showed a particular interest in one specific topic (i.e. names, birthdays) and in repetitive ordering of their belongings. Howlin et al. (2009) assessed the relationship between savant skills and stereotyped repetitive behaviors based on ADI-R scores on the RRB domain, including the entire severity range of 0–3 code for each item. Their study found that individuals with exceptional cognitive or parent-rated skills did not have higher rates of RRB than those who did not. They concluded that the severity of RRB domain was not related to savant skills. A recent study (Bennett & Heaton, 2012) supported this finding as the researchers, using their own newly-developed questionnaire that included items on social, communication, RRB and savant skills did not find increased repetitive behavior or increased obsessiosity in the savant group.

The findings from several studies suggested a local information bias in certain domains in individuals with savant skills. This has led researchers to suggest that special skills might be related to weak central coherence (Happe & Frith, 2006), one of the core theories to explain autism. In their hyper-systemizing theory, Baron-Cohen, Ashwin, Ashwin, Tavassoli, and Chakrabarti (2009) suggested that an autism-specific ability to identify repeated patterns in stimuli may help to explain the high prevalence of savant skills in ASD.

In a few studies, the neurological basis of “savant skills” has been investigated using neurobiological and neuroimaging techniques. It has been assumed that these savant skills are commonly associated with the right cerebral hemisphere function. The underlying cause could then be left hemispheric maldevelopment with right hemispheric compensation, possible right hemispheric disinhibition, or utilization of alternate memory circuits. Most imaging studies were based on case reports with special skills and suggested abnormal brain organization. For example, in a MRI study on a 54-year old with numerous savant skills, Treffert and Christensen (2006) found complete absence of corpus callosum and altered white matter tracts connecting the two hemispheres. Bor, Billington, and Baron-Cohen (2007) reported abnormal brain activation patterns in a fMRI study on a young man with Asperger syndrome and unusual numerical visual digit span memory skills. The researchers described abnormal activation patterns in the prefrontal cortex in the savant as compared with typical controls during the performance of a task of memorizing sequences of digits. In a study where a PET scan was used on a young person with autism and unusual ability in calendar calculation, researchers reported an activated fronto-temporal network that included the hippocampus (Boddaert et al., 2005). Recently, Corrigan, Richards, Treffert, and Dager (2012) reported in a DTI study performed on a 63-year old with savant skills that the amygdala and caudate nucleus were highly asymmetric with enlargement on the right side, suggesting differences in white matter integrity of the cerebral circuits involving these structures.

Although there have been several studies that investigated the phenomenon of special skills in ASD, many are single case or small group studies of individuals and only a few have been systematic and large-scale investigations (Corrigan et al., 2012). Heterogeneity in diagnosis procedures, criteria for diagnosis of ASD, and ages of the participants add to the inconsistency in the results regarding special abilities in ASD. For now, there is little valid information on rates of savant skills in ASD and whether the existence of such abilities indicates a more-or-less severe presentation of clinical symptoms. No published research has examined whether having special abilities is associated with functioning of individuals with ASD.

In addition, the phenomenon of special skills in ASD may have important theoretical implications. Evidence regarding a relation between having special skills and the repetitive and restricted behaviors domain and/or sensory abnormalities may support the hypothesis that systemizing or ‘enhanced perceptual functioning theory’ (Mottron, Dawson, & Soulieres, 2009) contribute to the occurrence of special skills in ASD.

The main aim of the current study was to compare behavioral functioning and head circumference as a biological marker in children with ASD and special skills to an age- and gender-matched ASD group without special abilities. The current study addresses two main assumptions regarding ‘special abilities’ in ASD. Firstly, ‘special abilities’ in ASD might represent either a separate subtype with a unique clinical presentation, or a distinct feature within ASD. Alternatively, having special abilities in ASD might be related to the restricted and repetitive behaviors (RRB) domain. Secondly, the study examined the frequency and characteristics of ‘special abilities’ in a large, well-characterized population with ASD in early childhood.
2. Methods

2.1. Procedure

The study was conducted at a tertiary autism center that provides diagnosis and treatment services and is involved in research in the field of ASD. Participants were referred to the Autism Center for a comprehensive assessment of a possible diagnosis of ASD. The evaluation included a neurological assessment, and behavioral and functional evaluations. Assessments were conducted by a skilled interdisciplinary team and included a pediatric neurologist, psychologist, and/or speech and language pathologist and/or special education teacher. Pediatric neurologists obtained medical, developmental and familial histories from the parents and conducted a comprehensive neurological examination of all participants.

The diagnosis of autism/ASD was obtained by using two standardized tests, the Autism Diagnosis Interview-Revised (ADI-R) (Le Couteur, Lord, & Rutter, 2003) and the Autism Diagnosis Observation Schedule (ADOS) (Lord, Rutter, DiLavore, & Risi, 1999) and by meeting criteria for autism/ASD based on DSM-IV criteria (APA, 1994). All the professionals involved in the diagnostic process established reliability on the ADI-R and ADOS tests as required. Adaptive skills were assessed using the Vineland Adaptive Behavior Scales (VABS) (Sparrow, Balla, & Cicchetti, 1984). Head circumference measurements were performed using standard methods (Deutsch & Farkas, 1994; Deutsch & Joseph, 2003) by a senior child neurologist and were plotted on normative head circumference growth charts and converted to percentile values (Nellhaus, 1968).

2.2. Participants

The study included 398 participants (339 boys, 59 girls) who were diagnosed with ASD during the years 2003–2008. To reduce variability among the participants, the sample was limited to the age range of 2–7 years and then individuals with special abilities were selected from this group. Of the entire ASD group, 112 children (28%) were identified as having at least one special ability, based on the ADI-R specific items. This group was defined as the ‘special abilities’ group. From the remaining 287 cases without special abilities, a matched ASD group of 79 children was selected based on age and gender in accordance with the ‘special abilities’ group. (Table 1).

The groups with and without ‘special abilities’ did not differ in M:F ($\chi^2(1) = 1.51, p > .05$) and age ($t(189) = 1.65, p > .05$).

2.3. Measures

2.3.1. Autism Diagnostic Interview-Revised (ADI-R)

A semi-structured interview administered to parents, designed to make a diagnosis of autism according to DSM-IV criteria (Le Couteur et al., 2003). For assessment of autism severity the ADI algorithm scores in communication, social and stereotyped behavior domains were used.

2.3.2. Autism Diagnosis Observation Schedule (ADOS)

A semi-structured, interactive schedule designed to assess social and communicative functioning (Lord et al., 1999). The definition of a participant with special ability was based on the parents’ report during the interview of the ADI-R. The ADI-R contains six items (nos. 106–111) that refer to special isolated skills in several domains: visuospatial ability (item 106), memory skill (item 107), musical ability (item 108), drawing skill (item 109), reading ability (item 110), and computational ability (item 111). Each item is coded on a four point scale as follows:

0 – no outstanding skill/knowledge in relation to overall level of ability, whether high or low,
1 – isolated skill/knowledge that is definitely out of keeping with subject’s general level of ability, but not above general population norms,
2 – isolated skill/knowledge that is definitely above the subject’s general level of ability and above the general population normal level, but is not used functionally or meaningfully to any marked extent,
7 – isolated skill/knowledge that is definitely above the subject’s general level and above normal population level of ability and is used meaningfully and recognized by peers as having exceptional skill.

In the current study, only children who received a code of 2 or 7 in at least one of the above items were included in the ‘special abilities’ group.

Four measures for autism symptom severity were based on full-scale coding of the ADOS:

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Male:female (M:F) ratio and age (mean and SD) in ASD groups with and without ‘special abilities’.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>112</td>
</tr>
<tr>
<td>Gender (M:F)</td>
<td>98:14 (7:1)</td>
</tr>
<tr>
<td>Mean age (SD), months</td>
<td>40.3 (14.6)</td>
</tr>
</tbody>
</table>
I. Communication measure was composed of the mean of all coded items in the ADOS language and communication section.

II. Socialization measure was composed of the mean of all coded items in the ADOS reciprocal social interaction section.

III. ADOS Sensory measure that rely on the item that evaluated ‘unusual sensory interest in play/material’ (D1).

IV. ADOS Repetitive restricted interested (RRI) measure was composed by the mean of the rest of the items in the ‘Stereotyped behaviors and restricted interests’ domain (D2–D4/D5)

Each item was coded in a full range of 3–4 levels, depending on the coding of the specific item in the schedule (several items are coded on a 3-level scale and several items are coded on a 4-level scale). Mean score for each of the above measures was chosen to eliminate differences between subjects on the basis of the ADOS module that was used, which differ in the numbers of items.

Since stereotyped, restricted and obsessive behaviors are sometimes not apparent during the ADOS evaluation, two more measures derived from the ADI-R scale were obtained:

1. ADI-R sensory measure – the mean of coding in three items (71–73) that evaluate sensory abnormalities was calculated. The items are defined as follows:

   - Item 71 – ‘unusual sensory interest’ refers to the ‘unusual sensory interests that are defined as unusually strong or repeated reactions to, or seeking of, stimulations from the basic sensation of sight, touch, sound, taste or smell dissociated from meaning. The focus is on the extent to which the abnormal interest disturbs or replaces “normal use” of the object”.

   - Item 72 – ‘undue general sensitivity of noise’ – explained as ‘the focus needs to be the predictable generally increased sensitivity to everyday sounds’.

   - Item 73 – ‘abnormal idiosyncratic negative response to specific sensory stimuli’; instructions include that “the subjects’ response must be predictable and specific to some identifiable and particular sensory stimulus, it must involve some form of negative, emotional reaction other than fear, and the response must be idiosyncratic”.

2. ADI-R Repetitive Restrictive Interests (RRI): mean scoring of seven items that evaluate those behaviors was calculated. The items includes: Unusual preoccupations (67), Circumscribed interests (68), Repetitive use of objects or interests in parts of objects (69), Compulsion/Rituals (70), Difficulties with minor changes in subjects own routines or personal environment (74).

3. Data analysis

To investigate the differences between the ‘special abilities’ and the ‘matched ASD’ groups in the severity of autism symptoms, adaptive functioning and head circumference percentiles, one-way MANOVAs and ANOVAs were used.

4. Results

To assess differences between the ‘special abilities’ and the ‘matched ASD’ groups in the severity of ASD social and communication symptoms, one way MANOVA was performed on the mean ADOS scores, in both domains. The analysis yielded a significant group effect \[ F(3,183) = 10.0, p < .001, \eta^2 = .14 \]. To examine the differences in the severity of social and communication symptoms between the studied groups, univariate ANOVAs for each domain was used separately (Table 2).

The ‘special abilities’ group demonstrated lower ADOS scores in both the communication and socialization domains, meaning that the ‘special abilities’ group had better social and communication skills than the ‘matched ASD’ group.

Then, the severity of the ADI– and ADOS ‘restricted and repetitive interests’ (RRI) and of the ‘sensory measure’ between the studied groups was examined. The differences between the groups were significant in both, the ADI-R \[ F(2,185) = 4.1, p < .05, \eta^2 = .04 \] and the ADOS measures \[ F(2,184) = 5.0, p < .01, \eta^2 = .05 \].

To compare the severity of the ASD sensory and repetitive behaviors between the studied groups, four univariate ANOVAs for the ADI-R and ADOS ‘sensory measure’ and RRI were applied (Table 2). The ‘special abilities’ group represented significantly lower scores than the ‘matched ASD’ group in both the ADI-R and ADOS RRI scores and in the ADOS ‘sensory measure’. Of note, although the analyses yielded significant differences between the groups in these measures, the effect sizes were smaller than those received for the social and communication scores (Table 3).

Table 2
Means and SDs of ADOS item scores in communication and socialization domains in the ‘special abilities’ and ‘matched ASD’ groups.

<table>
<thead>
<tr>
<th></th>
<th>Special abilities (N = 112)</th>
<th>Matched ASD (N = 75)</th>
<th>F(1,144)</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>M (.55)</td>
<td>M (.52)</td>
<td>23.6***</td>
<td>.11</td>
</tr>
<tr>
<td>Socialization</td>
<td>M (.56)</td>
<td>M (.56)</td>
<td>21.6***</td>
<td>.10</td>
</tr>
</tbody>
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*** \( p < .001 \).
To examine differences in adaptive skills between the ‘special ability’ group and the ‘matched ASD’ group, a one-way MANOVA was used for the VABS scores (communication, daily living skills and socialization). A significant group main effect was found ($F(3,142) = 8.90, p < .01, \eta^2 = .16$).

To examine the differences between the studied groups in the specific adaptive skills domains, univariate ANOVAs separately for each functional domain were applied (Table 4).

The analyses revealed that both groups demonstrated scores below the normal range in all the adaptive skills domains, communication, daily living skills and socialization. However, the ‘special ability’ group presented with significantly higher scores than the control group in all the examined domains.

Finally, head circumference (HC) percentile was compared between the ‘special abilities’ and the ‘matched ASD’ groups. The ‘special abilities’ group demonstrated a larger mean HC percentile ($M = 52.07, SD = 25.63$) than the ‘matched ASD’ group ($M = 43.41, SD = 31.43$). To address the large standard deviations found for the HC percentiles in the two studied groups, Leven test for variance comparison was conducted and yielded a significant difference ($F(1,153) = 5.81, p < .05$). Therefore, a nonparametric test (Mann–Whitney) was used to compare the HC percentiles between the studied groups that yielded a significant difference ($Z = 2.01, p < .05$). The ‘special abilities’ group demonstrated a significantly larger HC than the ‘matched ASD’ group.

The occurrence of the specific special abilities domains was further studied. Of the ‘special abilities’ group, 41% had special skill in one domain and 59% had special skills in two or more domains. Memory was the most frequent special ability domain (40.0%), then came the music (24.0%), visuospatial (21.4%) and reading (20.0%) domains. Computational (6.8%) and drawing skills (2.6%) occurred rarely in the examined group.

5. Discussion

Relatively little is known about differences in clinical presentation and functioning that differentiate ASD with and without special abilities. Thus, in addressing this lack of knowledge, the current study compared young children diagnosed with ASD, with and without parental-reported special abilities, in various areas of functioning. Children with ASD and parental-reported special abilities exhibited significantly less impaired ASD symptoms in the social, communication and stereotyped behaviors and significantly better adaptive skills than individuals with ASD without parental-reported special skills. Overall, having reported special abilities was associated with better functioning. To the best of our knowledge, previous researchers have not addressed the association between having special abilities in ASD and the level of autism severity. Vital, Roland, Wallace and Happe (2009) examined the relationship between special abilities and autistic-like traits in a large population-based sample of 8-year-olds. Based on parents’ reports, children with special abilities showed significantly more ASD-like traits than those without such abilities. However, this study did not focus specifically on a population formally diagnosed with ASD. Our study appears to indicate that children with ASD and parental-reported special abilities have less impaired social communication skills. In several research works, the investigators suggested that the restrictive and repetitive behaviors that are part of ASD core symptomatology form the basis for the development of savant skills. O’Connor and Hermelin (1991) argued that having interest in one specific topic may lead to a specialty in this domain.
Mottron et al. suggested the enhanced perceptual functioning found in ASD may be related to savants (Mottron & Burack, 2001; Mottron et al., 2009). Baron-Cohen et al. (2009) suggested that the ability to identify and structure repeated patterns in stimuli is related to the development of savant in individuals with ASD. If true, one might expect that more severe restricted repetitive behaviors and/or sensory abnormalities might be associated with having special skills. However, this association was not confirmed in two previous studies (Bennett & Heaton, 2012; Howlin et al., 2009). Our results seem to support this disassociation. In the current study, having parental-reported special abilities in ASD was associated with even less severe repetitive behaviors and sensory abnormalities than in ASD without special abilities.

In the current study, adaptive functioning was examined in children with ASD with and without parental-reported special abilities. It was found that having parental-reported special abilities was associated with better communication, daily living skills and socialization adaptive skills. Previously, the association between special skills in ASD and cognitive abilities was examined. Howlin et al. (2009) reported significantly higher full, performance and verbal IQ scores for the savant group than the non–savant group. Adaptive skills are known to have a strong association with cognitive abilities (Freeman, Del’Homme, Guthrie, & Zhang, 1999; Liss et al., 2001). Overall, these findings suggest that ASD with special abilities is associated with better cognitive and adaptive functioning than ASD without special abilities.

Lastly, having parental-reported special abilities in ASD was associated with a larger head circumference percentile than in ASD without special abilities. Courchesne, Carper, and Akshoomoff (2003) reported brain excessive overgrowth in the first years of life in ASD. Courchesne and Pierce (2005) hypothesized that the large brain in ASD enhances “local” connectivity which provides detailed information processing. Increased perceptual-cognitive processes might be expressed in special skills in certain domains depending on the brain areas involved. These theories might explain the larger head circumference found in ASD with special abilities in the current study. Future studies should follow head circumference growth trajectories in individuals with and without special abilities to support this notion.

In the current study, 28% of the young ASD population showed parental-reported special abilities in at least one domain. Memory skills were the most reported special ability, followed by musical, visuospatial and reading skills. Computational and drawing skills were rarely reported. Howlin et al. (2009) reported a similar percentage (28.5%) of special abilities/savant skills among 137 participants with ASD with an age range of 3–16 years. Calendrical calculators were the most frequent special ability reported in their study. The difference in the age range of our study (2–7 years) and the above study may explain the different special skills domains found in both studies. It is possible that ‘exceptional memory’ skills in the younger ages, as found in our study, might develop into a more specific special ability, such as calendrical calculation, in a defined area. Bolte and Poustka (2004) reported special skills only in 13% of 254 participants based on ADI-R relevant items. The definition of the group with special skills was similar to that used in the current study. The population included in our study was much older than in our study, with an age range of 7.5–49.4 years, which might explain the differences in the prevalence of special abilities. In a recent study on 125 individuals with ASD, a higher rate (42%) of special abilities in ASD was reported. In this study, information on special skills was obtained using a new questionnaire designed to assess special skills in ASD that was distributed through emails to families with known individuals with ASD (Bennett & Heaton, 2012). The reported high prevalence of special skills might be biased by the increased interest of families of individuals with special skills to participate. Little is known about the evolution of early onset special skills in ASD later in adolescence and adulthood. Follow-up research on the trajectory of early special abilities is needed. Further research is recommended to evaluate the stability of these special skills over the years and to determine whether they remain in the same domain or transform into other areas.

Taken together, these findings indicate that special abilities are highly prevalent in ASD. Individuals with ASD and parental-reported special abilities have a less severe presentation of ASD symptoms and better outcome in terms of adaptive skills, referring to milder clinical ASD presentation. Regarding our main questions in this study, it appears that the group with parental-reported special abilities might represent a distinct subgroup in ASD and that special abilities are probably not related to the severity of the restrictive and repetitive behaviors domain. In addition, having a parental-reported special ability with higher cognition might enable better learning and acquisition of social and adaptive skills in the natural environment and during intervention. These findings have diagnostic, educational and prognostic value. Clinicians should evaluate special abilities during the diagnostic procedure and notify parents regarding the possible more favorable outcome when those skills occur. Educators should use the special expertise demonstrated by the child in a specific developmental area in the educational curriculum, to improve socio-communication skills and daily life functioning. Having a special ability might be utilized to promote the child’s status among his peers by distinguishing his superb abilities in social contexts.

There is a paucity of research on special abilities in ASD. Complementary studies that assess the specific special abilities and other characteristics are needed to confirm the results of the current study. Developing an objective assessment/measure of the special abilities in addition to the parental report is highly important. This area needs further exploration for possible neurological etiologies and clinical outcome. Better understanding of the neurobiological basis for special abilities will support or deny theoretical explanations for these phenomena. Therefore, studies should include using advanced imaging techniques and fMRI. Genetic studies should investigate whether individuals with ASD who have special abilities represent a unique subtype in ASD. Behavioral studies that use more measures, such as verbal and non-verbal cognitive abilities, might shed light and a better understanding of individuals with ASD and special abilities. More research is needed on the developmental trajectories of special abilities and on the outcome and prognosis of young children with special abilities. In addition, future intervention research should focus on how these special skills, or practice with these skills, might support or deny theoretical explanations for these phenomena. Therefore, studies should include using advanced imaging techniques and fMRI. Genetic studies should investigate whether individuals with ASD who have special abilities represent a unique subtype in ASD. Behavioral studies that use more measures, such as verbal and non-verbal cognitive abilities, might shed light and a better understanding of individuals with ASD and special abilities. More research is needed on the developmental trajectories of special abilities and on the outcome and prognosis of young children with special abilities. In addition, future intervention research should focus on how these special skills, or practice with these skills, might improve social-communication, stereotypical and repetitive behaviors in individuals with ASD.
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