

What aspects of autism predispose to talent?

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In this paper, we explore the question, why are striking special skills so much more common in autism spectrum conditions (ASC) than in other groups? Current cognitive accounts of ASC are briefly reviewed in relation to special skills. Difficulties in 'theory of mind' may contribute to originality in ASC, since individuals who do not automatically 'read other minds' may be better able to think outside prevailing fashions and popular theories. However, originality alone does not confer talent. Executive dysfunction has been suggested as the 'releasing' mechanism for special skills in ASC, but other groups with executive difficulties do not show raised incidence of talents. Detail-focused processing bias ('weak coherence', 'enhanced perceptual functioning') appears to be the most promising predisposing characteristic, or 'starting engine', for talent development. In support of this notion, we summarize data from a population-based twin study in which parents reported on their 8-year-olds' talents and their ASC-like traits. Across the whole sample, ASC-like traits, and specifically 'restricted and repetitive behaviours and interests' related to detail focus, were more pronounced in children reported to have talents outstripping older children. We suggest that detail-focused cognitive style predisposes to talent in savant domains in, and beyond, autism spectrum disorders.

Keywords: autism; savant skills; central coherence; theory of mind; genetic

1. INTRODUCTION

Special skills, such as lightning multiplication, identification of prime numbers, calendar calculation, perfect-perspective drawing, absolute pitch, instant reproduction of newly heard music and extraordinary memory for facts, are far more common in autism spectrum conditions (ASC: autism, Asperger's syndrome, atypical autism or PDD-NOS) than in any other group examined to date (see Treffert 2009). While robust epidemiological data are lacking, estimates from surveys of parents and carers (Rimland 1978) suggest that around one in 10 individuals with ASC have a talent out of line with their other abilities (but see Howlin *et al.* (2009), for an even higher estimate), compared with perhaps 0.6–0.1 per cent among those with other developmental or intellectual disabilities (Hill 1977; Saloviita *et al.* 2000). The reason for this association between special abilities and ASC remains unclear. In this paper, we briefly review three current cognitive accounts of ASC, and consider their explanatory power in relation to special skills. We then present some data from our own research with a large population-based twin sample examining relationships between ASC-like traits and talent. We begin, however, with a brief word about the unitary or fractionable nature of the core behavioural and cognitive features of ASD.

2. THE 'FRACTIONABLE TRIAD'?

Autism and Asperger's syndrome (together referred to here under the umbrella term 'ASC') are diagnosed on

the basis of qualitative impairments in social interaction and communication, with restricted and repetitive behaviours and interests (RRBIs). All three aspects of what has been termed the autistic 'triad' (after Wing & Gould's (1979) of social, communication and imagination impairments) must co-occur for the diagnosis to be made. However, elsewhere, we (and others; e.g. Wing & Wing 1971; Bishop 1989; Goodman 1989; Mandy & Skuse 2008) have argued that the three parts of the diagnostic triad are in fact fractionable (see Happé *et al.* 2006; Happé & Ronald 2008). Very briefly, in population samples, it appears that individual differences in social interaction, communication and RRBIs correlate only moderately (Ronald *et al.* 2006a), that isolated impairments in just one (or two) part(s) of the triad can be found (e.g. in relatives of those with ASC; Piven *et al.* 1997; Pickles *et al.* 2000) and that largely non-overlapping genetic effects appear to operate on different parts of the triad (e.g. Ronald *et al.* 2006a,b; for a counter-view, see Constantino *et al.* 2004). While we recognize that this 'fractionable triad' view is still a working hypothesis, we take it as a starting point for the present paper: we ask not why ASC is linked to talent, but what (potentially dissociable) aspect(s) of ASC predispose to talent.

3. CURRENT COGNITIVE ACCOUNTS OF ASC: 'STARTING ENGINES' FOR TALENT?

(a) *Mind-blindness*

There is now good agreement that at the heart of ASC lies a difficulty in recognizing and representing mental states (Frith 2003), reflected in abnormal brain functioning (e.g. Happé *et al.* 1996). While there are a number of alternative accounts of the nature of the

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primary social deficit (e.g. reduced salience of social stimuli; Klin *et al.* 2003), the fact that most people with ASC find it difficult to put themselves in another's shoes, or 'mind read', has been successful in explaining much of the pattern of impaired and intact social and communicative behaviour in ASC, as well as inspiring practical efforts in early diagnosis and intervention (for a review, see Baron-Cohen *et al.* 2000).

Can impaired recognition of mental states help explain the association between ASC and talent? Three possibilities seem worth considering. First, it might be argued that individuals with ASC free up both mental and time resources that so-called 'neurotypicals' use on tracking and remembering social content,¹ and that these may contribute to talent development. The idea of cortical 'rededication' underlying talent in ASC was suggested by Waterhouse (1988). For example, Grellotti *et al.* (2005) reported the case of a young boy with ASC who did not activate the fusiform gyrus in response to faces, but did so in response to Digimon cartoon characters—on which he was an expert. If reallocation of neural and cognitive resources from social to other (savant-skill relevant) processing explains the association between ASC and talent, we might predict an inverse correlation between social interest and savant talent within ASC, and perhaps within the general population. Despite the stereotype of the eccentric genius or artist with no understanding of those around her/him, there is little evidence to date in support of this idea, and none to suggest a causal direction (but see Baron-Cohen (2002), for a discussion of systemizing–empathizing). Of course, those with exceptional talent may find it harder to find similar peers with whom to make close friendships, or may have to spend time in practice that limits socializing hours.

Second, difficulty tracking the mental states of others may contribute to the *originality* expressed in a developing talent. It is notable that typically developing (TD) children lose aspects of originality in, for example, their art as a result of acquiring stereotyped forms from their peers (think, for example, of rays drawn on a sun or birds drawn as 'ticks'). Without doubt, the obligatory and automatic recognition of others' mental states, and the desire to be viewed by others as part of the in-group, place blinkers on most TD young people. People with ASC, on the other hand, may be oblivious to what others think, what is considered the fashionable or correct mode of thought or how others perceive them or their work. Thus, individuals with ASC are, perhaps, more able than TD individuals to think their own thoughts, regardless of what others think. This contributes to originality, in the sense of a unique world view. However, originality of this type does not guarantee talent—an idea may be merely outré without being an advance on traditional thinking. Thus, Kanner and Asperger both highlight the unusual ideas of the young people they describe in their first accounts of ASC—some of these being interesting and potentially insightful, some bizarre and maladaptive. Kanner describes, for example, Donald; 'When asked to subtract 4 from 10, he answered "I'll draw a hexagon"' (Kanner 1943, p. 222). Another of Kanner's original cases, Alfred, is described as follows: 'He once stopped and asked, very

much perplexed, why there was 'The Johns Hopkins Hospital' printed on the history sheets: 'Why do they have to say that?' This, to him, was a real problem of major importance, calling for a great deal of thought and discussion. Since the histories were taken at the hospital, why should it be necessary to have the name on every sheet, though the person writing on it knew where he was writing?' (Kanner 1943, p. 235).

Third, mind-blindness for one's *own* mind may be relevant to talent development. The possibility that difficulty in representing mental states in ASC also affects the ability to reflect on one's own inner states has been suggested elsewhere (Frith & Happé 1999; Happé 2003; Williams & Happé *in press*). If people with autism are less self-aware in some ways, this might be advantageous for those skills best developed through implicit learning. To take a light-hearted example, it is said that the best way to disadvantage your golfing opponents is to ask them exactly how they achieve their perfect swing! Some tasks, such as extracting the regularities in an artificial grammar, are better achieved through implicit learning and are disrupted by attempts at explicit rule identification (e.g. Reber 1976; Fletcher *et al.* 2005). Interestingly, level of implicit learning (unlike explicit learning) is unrelated to IQ, and unimpaired in intellectually disabled groups (for a review, see Underwood (1996)). Also relevant to difficulty 'reading own mind', perhaps, is the notion of 'flow' (Csikszentmihályi 1990)—which, though non-scientific, describes a familiar state of reduced self-awareness and altered sense of the passage of time during periods of intense engagement with a task or process. If at least some people with ASC have reduced awareness of own inner states, it may be easier for them to enter a state of flow—which is thought to be inherently reinforcing and rewarding (Csikszentmihályi & Lefevre 1989) and might be especially so for individuals with ASC (in whom anxiety and depression are common; Kim *et al.* 2000).

Mind-blindness, then, may contribute an original world view and might foster skill development, but is unlikely, we would suggest, to act as the starting engine for talent.

(b) *Executive dysfunction*

The umbrella term executive function covers some areas of top-down control that are strikingly impaired in ASC. People with ASC show difficulties planning ahead, shifting from old patterns and generating new responses to adapt to novel demands in standard tests (see Hill (2004a,b) for a review), and in everyday life these difficulties significantly limit adaptation and independence in even the highly intelligent. Again, the popular stereotype would suggest a link between special talent and lack of common sense—the brilliant professor who cannot manage his everyday household needs. Is executive dysfunction a predisposing factor for talent?

Snyder has suggested that reduced frontal function may release special skills—a fascinating and bold proposal examined elsewhere in this volume (Snyder 2009, see also Snyder *et al.* 2003, 2006). On this account, executive dysfunction in ASC paradoxically facilitates development of savant skills. However,

executive dysfunction occurs in many other clinical groups (e.g. attention deficit hyperactivity disorder; Pennington & Ozonoff 1996), not characterized by a raised incidence of special skills. Good data on the relationship between executive function performance and talent are lacking. Reduced cognitive flexibility is perhaps the executive dysfunction most consistently associated with ASC (Liss *et al.* 2001), and might be considered to be related to obsessive pursuit of narrow interests. However, some authors have suggested that some executive skills, such as working memory, may be *superior* in savant versus non-savant groups with ASC (Bölte & Poustka 2004; but see Heavey 1997). From the small group studies to date, it appears that, for example, generativity is much better in the domain of talent (e.g. drawing) than in other areas (e.g. verbal fluency) or in non-savant individuals with ASC (Ryder 2003). However, large group and developmental studies would be needed to establish a causal role for individual differences in executive functions in talent development.

(c) *Detail-focused cognitive style*

Unlike the executive dysfunction and theory of mind accounts of autism, the suggestion that ASC is characterized in part by a different cognitive style has aimed from the outset to explain islets of ability typical of this condition (Frith 1989, 2003). Central coherence refers to the tendency in TD individuals to process incoming information in context for meaning, preserving gist and gestalt form at the expense of detail and featural information. People with ASC, the theory suggests, have instead a processing bias towards detail and featural information, and tend to succumb less to contextual and gestalt effects. Among the earliest demonstrations of so-called weak coherence were superior ability in block design and embedded figures tests by ASC groups compared with CA/IQ-matched control groups (see Happé & Frith (2006) for a review). A link between detail focus and well-developed talents in areas such as maths, music and art has been suggested in relation to weak central coherence (e.g. Happé 1999), 'enhanced perceptual functioning' (Mottron *et al.* 2006) and systemizing accounts of ASC (Baron-Cohen 2002). Since the latter accounts are elegantly discussed elsewhere in this volume, the weak coherence account will be discussed in what follows (although for many of the predictions, these accounts, with their agreement on superior local processing, may not differ).

How might a tendency to process featural rather than configural information predispose to the development of specific talents? The suggestion is that attention to detail and tendency towards exemplar-based memory, rather than prototype extraction, is the starting engine for talent in the savant domains. Take the example of musical talent; musical savants appear universally to have absolute pitch, which is a great advantage in (at least some aspects of) musical memory and performance. Absolute pitch, it has been argued, is easy for young children to acquire in the first three or four years of life because, at this stage, music is processed with more attention to the exact notes and less attention to the relationships between the notes,

i.e. the melody (Takeuchi & Hulse 1993). People with ASC show much better performance, regardless of age, on tests of memory for pitch, and absolute pitch seems to be more common in ASC than in comparable groups (see Heaton (2009), for a review). The argument is that detail-focused processing bias, which in ASC lasts throughout life, makes it easy for individuals with ASC to establish pitch-label representations that are stable and enduring.

In the domain of art, the ability to attend to details, to break the gestalt into parts, is probably helpful in achieving realistic-looking drawings. A trick used in teaching accurate drawing to TD students is to copy pictures turned upside down: inversion disproportionately disrupts configural processing. Pring *et al.* (1995) reported that block design skill, which may result from ability to see the parts within the to-be-copied design, was notable in children with artistic abilities and in children with autism. In the area of calendar calculation, too, Heavey has suggested that the starting point may be the discovery of small day-date regularities (Heavey *et al.* 1999).

The relationship between bias towards/superior local processing and reduced global processing has been re-examined in recent accounts of 'weak coherence' (see Happé & Booth (2008) for a discussion). The assumption of trade-off has been questioned, and, instead, the suggestion made that weak coherence may reflect two somewhat independent and dissociable features seen in some but not all individuals with ASC; bias towards/superior local processing, and bias away from/reduced global processing (Booth 2006). If this suggestion is confirmed, a testable hypothesis is that the individuals with ASC most likely to develop talents are those that show superior local processing without any impairment of global processing.

It is intriguing to wonder whether the top-down influences that usually suppress savant skills, in Snyder's account, relate to global processing biases—which require inhibition (from TMS or brain lesion) in TD individuals if featural information is to be processed. If so, individual differences in strength of global processing bias might predict which individuals show improvement of skill under TMS, or 'release' of talent in dementia or brain injury. In ASC, on the other hand, there may be no default bias towards global processing—hence no 'talent-suppressing' top-down influences, in terms of Snyder's account.

4. EXPLORING THE RELATIONSHIP BETWEEN ASPECTS OF AUTISM AND TALENT

O'Connor and Hermelin, the founders of the modern interest in special skills in autism (and other developmentally disabled groups) asked the important question; what is alike among savants? Their answer, briefly, was that a strong tendency towards repetitive behaviour and preoccupation characterized those with savant skills regardless of their diagnosis (O'Connor & Hermelin 1991). The subsequent broadening of diagnostic criteria probably means that many individuals then considered 'non-autistic' would now fall within the autism

spectrum. However, it remains of interest that non-social ASC-like traits, rather than social-communicative difficulties, were highlighted in this early work. Young's work with a large number of savants with and without ASC also led her to conclude that a common characteristic of these individuals was an almost obsessional preoccupation with a restricted area of interest (Young 1995).

A rather different study compared personality and cognitive traits of musicians with and without absolute pitch. Brown *et al.* (2003) found that their 13 musicians with absolute pitch showed a significant peak in block design, were rated more often by interviewers as eccentric and showed (non-significantly) worse social-communicative skills and more rigid/aloof/hypersensitive personality (at a level found in the broader autism phenotype) when compared with 33 musicians without absolute pitch. Block design skill has been taken as a marker of weak coherence, and an intriguing question is whether talent in the general population is related to non-social aspects of ASC, and specifically to detail-focused cognitive style.

(a) What aspects of autistic-like traits are associated with talent in the general population?

In our recent work, we have had the chance to explore what aspects of autism might predispose to talent, by examining the relationship between parent-reported ASC-like traits and parent-reported special abilities in a large sample of twins, then aged 8 (see Vital *et al.* (in press), for full details). The Twins Early Development Study (TEDS) is a longitudinal population-based study of twins born in England and Wales between 1994 and 1996 (for details see Oliver & Plomin 2007). We had relevant data, from postal measures at age 8, for 12 852 children participating in TEDS. Owing to the problems of non-independence of data points when considering twins, one twin from each twin pair was randomly selected for our analyses, with a final n of 6426. For these children, we could examine the relationship between parent-rated ASC-like traits as measured by the Childhood Asperger Screening Test (CAST; Scott *et al.* 2002) and special abilities, tapped by three simple questions to parents: (i) does (your child) display a striking skill, compared with her/his general ability level, (ii) does she/he display a striking skill, when compared with other children of her or his age, and (iii) does she/he display a special gift, when compared with children even much older? For each question, parents could tick a box to indicate skill in one or more of the following areas: maths; music; art; or memory. Because parents tended to be generous in their ratings (16% of children were reported to have a talent in response to question (iii)), we concentrated our analysis on the highest level of talent—skills considered to outstrip even those of much older children.

The results showed that ASC-like traits (as reported by parents using the CAST) were significantly more pronounced in children who were said to have special skill than in children not so rated. The overall elevated CAST score was particularly due to higher ratings on the 'RRBIs' items ($d=0.6$), while for social and communication items the significant effects were of small magnitude ($d=0.2$). Relationships between

CAST and reported special skills were not confounded by IQ effects; IQ was positively related to reports of special skills but negatively related to CAST ratings.

Ratings of RRBI were significantly higher regardless of area of talent, with effect sizes for music, maths, art and memory skill groups ranging from 0.4 to 0.9. By contrast, social skills/difficulty appeared to relate to specific area of talent. Children said to have special skills in music or art did not show significantly more social difficulty than children without such talents. Children skilled in maths or memory, on the other hand, showed slight, but significant, disadvantage in parent-rated social skills ($d=0.2-0.3$).

We explored the relationship between parent ratings of special skills and ratings of ASC-like traits in the non-social domain further, by dividing the RRBI items into the subtypes given in the current diagnostic criteria (DSM-IV TR; APA 2000). Regression analyses suggested that the items that most differentiated children said to show 'special gifts' from those not so rated had to do with detail focus (noticing and remembering details others miss; $d=0.7$) and to a lesser extent items to do with insistence on sameness or repetitive special interests ($d=0.2$ in each case). This association between talent and eye/memory for detail remained even if children with special gifts in memory were excluded from the analyses.

These group results were unchanged whether we included or excluded the approximately 1 per cent of children meeting diagnostic criteria for autism, Asperger's syndrome or atypical autism (on the Development and Well-Being Assessment, DAWBA; Goodman *et al.* 2000). Not reported in Vital *et al.* (in press), but of interest in the present context, is the relationship between symptoms and special skills *within* this ASC subgroup. Interestingly, while social and communication impairments were somewhat ($d=0.1$) reduced in the ASC children said to have special skills, RRBIs were raised in the special skills ASC group ($d=0.4$) compared with ASC children without such skills (figure 1). While causal direction remains to be tested, these data might suggest that, even at the extreme, eye for detail predisposes to special skills, as well as that special skills may aid social adaptation in ASC.

Lastly, comparison of correlations between identical and fraternal twins across the full sample of more than 6000 twin pairs suggests that the association between ASC-like traits in the non-social domain (RRBIs) and reported special skills (a phenotypic correlation of 0.37 for males and 0.52 for females) is in large part due to shared genetic effects (Vital *et al.* in preparation). The bivariate heritability, or the proportion of the phenotypic correlation accounted for by genetic factors, was 61 per cent for males and 78 per cent for females. This suggests that genetic factors play the central role in the co-occurrence of special abilities and RRBIs: approximately half of the genetic influences on individual differences in special abilities also appear to influence variation in RRBIs. Put simplistically, some genetic factors that predispose to ASC-like traits (and specifically RRBIs) also predispose to talent. We have previously shown, in a small sample of families, that around a half of fathers and a third of mothers of boys

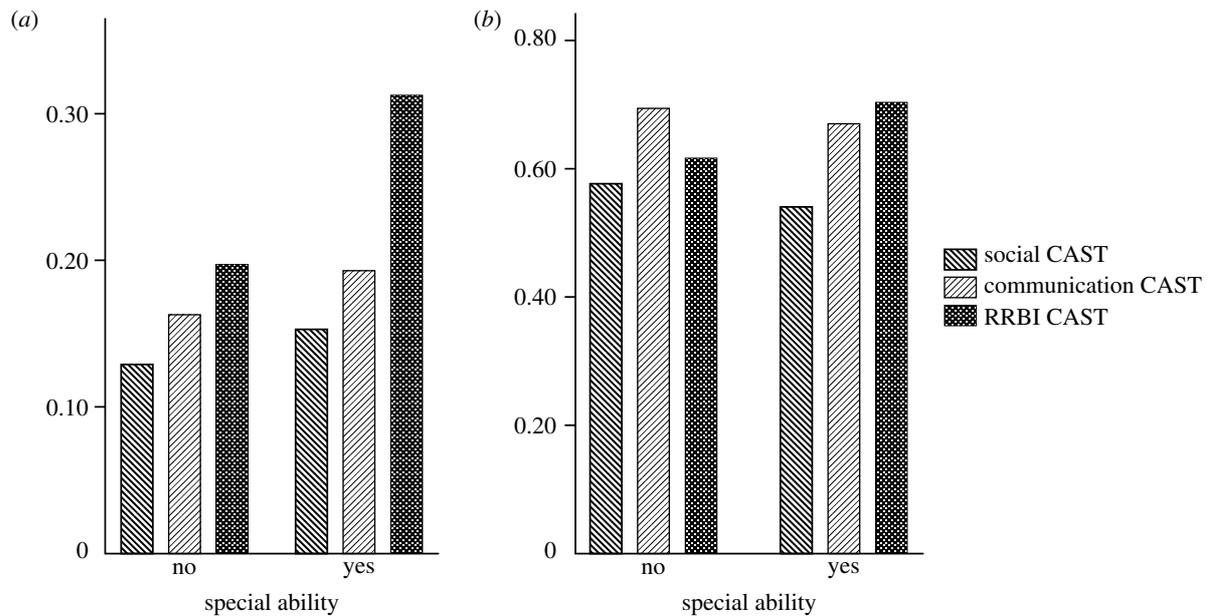


Figure 1. ASC-like trait scores (proportional, max=1) as a function of special ability in (a) non-ASC ($n > 6330$) and (b) ASC ($n = 81$) groups. *Note.* The range shown on the y -axes for (a,b) are not equivalent.

with ASC show detail-focused cognitive style across a battery of experimental tasks (Happé *et al.* 2001), and that this relates to self-reported 'eye for detail' (Briskman *et al.* 2001); we would predict that these traits will also be associated with increased rates of talent in the relatives of those with ASC.

5. CONCLUSIONS

In this paper, we have suggested that it is not autism *per se* that predisposes to talent, but rather the detail-focused cognitive style (weak coherence) that is characteristic of, but not confined to, ASC. Attention to detail, exemplar-based memory encoding, veridical (not context-distorted) representation is proposed to be the starting engine for talent. An interesting question for future research is whether individuals with ASC who develop talents are distinguished from those who do not do so by a more pronounced detail focus, by intact global processing (alongside local bias), or by aspects of personality or personal history for which we do not yet have good measures.

One implication of the fractionable triad proposal is that core components of ASC need not be unique to ASC—since it is the *combination* of cognitive deficits and assets that defines ASC uniquely. Because of this, it seems no problem, on our account, if special abilities and savant skills can be found in non-ASC groups. Our prediction would be that where savant-like talents are found, these will be linked to detail-focused cognitive style, regardless of diagnostic group. Because this cognitive style is extremely common in ASC, the incidence of savant skills and talents is raised.

We have summarized preliminary evidence of behavioural and genetic association between parent-reported special abilities and eye for detail in a large twin sample. We predict that family studies will show a raised incidence of talent among the relatives of those with ASC, and specifically among relatives sharing their detail-focused cognitive style. Unlike many other authors, we do not find implausible the notion of

a single starting engine for the varied array of talents seen in savants; data from our twin sample showed largely similar patterns across reported maths, music, art and memory skills.

We have also suggested that mind-blindness, while not the starting engine, may act to enhance talent. Reduced social influence and concern over others' views, as well as time devoted to talent rather than socializing, are obvious contributors to this. A more novel suggestion is that reduced self-awareness may contribute to implicit learning of certain regularities, and aid achievement of flow states in ASC. The combination of detail focus as starting engine and reduced mentalizing as 'fuel' may give a special flavour, independence and true originality to talent in ASC that is hard to find in other groups.

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ENDNOTE

¹Indeed, it is interesting to ask whether the neurotypical talent for, for example, remembering and recognizing hundreds of thousands of faces, might be considered a savant skill, were it not species-typical.

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