I. Savic (Ed.)
Progress in Brain Research, Vol. 186
ISSN: 0079-6123

CHAPTER 11

Empathizing, systemizing, and the extreme male brain theory of autism

Simon Baron-Cohen*

Department of Psychiatry, Autism Research Centre, Cambridge University, Douglas House, Cambridge, UK

Abstract: Females in the general population on average have a stronger drive to empathize, and males in the general population on average have a stronger drive to systemize. Evidence related to these claims is reviewed. People with autism spectrum conditions have below average empathy alongside intact or even above average interest in systems. As such, they can be conceptualized as an extreme of the typical male brain.

Keywords: Autism; Autism spectrum disorders; Brain; Empathy; Sex differences

Introduction

The psychology and neurobiology of sex differences have in recent years helped to throw light on our understanding of one of the major neurodevelopmental conditions, autism. Today autism is seen as lying on a spectrum ("the autistic spectrum") on which at least two subgroups are currently recognized: Classic autism and Asperger Syndrome (AS). These both share *three* core diagnostic features: (1) difficulties in social development, (2) and in the development of communication, alongside (3) unusually strong, narrow interests and repetitive behavior (A.P.A., 1994). Since communication is always social, it might be more fruitful to think of autism and Asperger Syndrome as sharing features in *two* broad areas: social-communication, and narrow interests/repetitive actions. As for distinguishing features, a diagnosis of Asperger Syndrome requires that the child spoke on time and has average IQ or above.

Today the notion of an autistic spectrum is no longer defined by any sharp separation from "normality" (Wing, 1997). The clearest way of seeing this "normal" distribution of autistic traits is by looking at the results from the Autism Spectrum Quotient (or AQ) (Baron-Cohen et al., 2001, 2006). This is a screening instrument in the form of a questionnaire, completed either by a parent about his or her child or by self-report (if the adult is "high-functioning"). There are 50 items like this in total, and when administered to a large population

* Corresponding author.
E-mail: sb205@cam.ac.uk

DOI: 10.1016/B978-0-444-53630-3.00011-7

the results resemble a "normal distribution." Most people without a diagnosis fall in the range 0–25; most with a diagnosis of an autism spectrum condition (ASC) fall between 26 and 50. Eighty percent score above 32, and 99% score above 26. So the AQ neatly separates the groups, showing that 93% of the general population fall in the average range of the AQ, and 99% of the autistic population fall in the extreme (high-end) of the scale.

In the general population, males score slightly (but statistically significantly) higher than females. This provides the first big clue that the study of sex differences may have relevance to understanding ASCs. A second clue is that ASCs are far more common in males than in females (classic autism occurs in four males for every one female, and AS occurs in nine males for every one female) (Rutter, 1978). This may suggest that the number of autistic traits a person has is linked to a sex-linked biological factor—genetic or hormonal, or both (Baron-Cohen et al., 2004, 2005). Before we look more closely at the link between autism and typical sex differences, we first take a step back to address what underlies the social and communication difficulties in ASCs.

The mindblindness theory

Early work explored the theory that children with ASC are delayed in developing a *theory of mind* (ToM): the ability to put oneself into someone else's shoes, to imagine their thoughts and feelings (Baron-Cohen, 1995; Baron-Cohen et al., 1985). When we mind-read or mentalize, we not only make sense of another person's behavior (why did their head swivel on their neck? Why did their eyes move left?), but we imagine a whole set of mental states (they have seen something of interest, they know something or want something) and we can predict what they might do next.

The mindblindness theory proposes that children with ASC are delayed in the development of their ToM, leaving them with degrees of *mindblindness*. As a consequence, they find other people's behavior confusing and unpredictable, even frightening. Evidence for this comes from difficulties they show at each point in the development of the capacity to mind-read:

- A typical 14-month-old shows *joint attention* (such as pointing or following another person's gaze), during which they not only look at another person's face and eyes, but pay attention to what the other person is interested in (Scaife and Bruner, 1975). Children with ASC show reduced frequency of joint attention, in toddlerhood (Swettenham et al., 1998).
- A typical 24-month-old engages in *pretend play*, using their mind reading skills to be able to understand that in the other person's mind, they are just pretending (Leslie, 1987). Children with ASC show less pretend play, or their pretence is limited to more rule-based formats (Baron-Cohen, 1987).
- A typical 3-year-old child can pass the *seeing leads to knowing* test: understanding that merely touching a box is not enough to know what is inside (Pratt and Bryant, 1990). Children with ASC are delayed in this (Baron-Cohen and Goodhart, 1994).
- A typical 4-year-old child passes the "false belief" test, recognizing when someone else has a mistaken belief about the world (Wimmer and Perner, 1983). Most children with ASC are delayed in passing this test (Baron-Cohen et al., 1985).
- Deception is easily understood by the typical 4-year-old child (Sodian and Frith, 1992). Children with ASC tend to assume everyone is telling the truth, and may be shocked by the idea that other people may not say what they mean (Baron-Cohen, 1992, 2007a). The typical 9-year-old can figure out what might hurt another's feelings and what might therefore be better left unspoken—*faux pas*. Children with Asperger Syndrome are delayed by around 3 years in this skill, despite their normal IQ (Baron-Cohen et al., 1999a).
- A typical 9-year-old can interpret another person's expressions from their eyes, to figure out what they

Fig. 1. The adult version of the *Reading the Mind in the Eyes* Test (correct answer = dispirited).

might be thinking or feeling. Children with Asperger Syndrome tend to find such tests far more difficult (Baron-Cohen et al., 2001), and the same is true when the adult test of *Reading the Mind in the Eyes* is used (Fig. 1). Adults with ASC score below average on this test of *advanced* mind reading (Baron-Cohen et al., 2001).

A strength of the mindblindness theory is that it can make sense of the social and communication difficulties in ASC, and that it is universal in applying to all individuals on the autistic spectrum. Its shortcoming is that it cannot account for the non-social features. A second shortcoming of this theory is that while *mind reading* is one component of empathy, true empathy also requires an emotional response to another person's state of mind (Davis, 1994). Many people on the autistic spectrum also report that they are puzzled by how to *respond* to another person's emotions (Grandin, 1996). A final limitation of the mindblindness theory is that a range of clinical conditions show forms of mindblindness (such as patients with schizophrenia Corcoran and Frith, 1997), or narcissistic and borderline personality disorders (Fonagy, 1989), and in some studies children with conduct disorder (Dodge, 1993), so this may not be specific to ASC.

Two key ways to revise this theory have been to explain the non-social areas of strength by reference to a second factor, and to broaden the concept of ToM to include an emotional reactivity dimension. Both of these revisions were behind the development of the next theory.

The empathizing–systemizing (E–S) theory

This newer theory explains the social and communication difficulties in ASC by reference to delays and deficits in *empathy*, while explaining the areas of strength by reference to intact or even superior skill in *systemizing* (Baron-Cohen, 2002). As we will see, this also brings us back to the theme of this volume, typical sex differences in the mind and brain.

ToM is just the cognitive component of empathy. The second component of empathy is the response element: having an appropriate emotional reaction to another person's thoughts and feelings. This is referred to *affective empathy* (Davis, 1994). On the Empathy Quotient (EQ), a questionnaire filled out either by an adult about themselves or by a parent about their child, both cognitive and affective empathy are assessed. On this scale, people with ASC score lower than comparison groups.

According to the Empathizing–Systemizing (E–S) theory, ASCs are best explained not just with reference to empathy (below average) but also with reference to a second psychological factor (systemizing), which is either average or even

above average. So it is the discrepancy between E and S that determines if you are likely to develop an ASC.

To understand this theory we need to turn to this second factor, the concept of *systemizing*. Systemizing is the drive to analyze or construct systems. These might be any kind of system. What defines a system is that it follows *rules*, and when we systemize we are trying to identify the rules that govern the system, in order to predict how that system will behave (Baron-Cohen, 2006). These are some of the major kinds of system:

- *collectible* systems (e.g., distinguishing between types of stones or wood),
- *mechanical* systems (e.g., a video recorder or a window lock),
- *numerical* systems (e.g., a train timetable or a calendar),
- *abstract* systems (e.g., the syntax of a language or musical notation),
- *natural* systems (e.g., the weather patterns or tidal wave patterns),
- *social* systems (e.g., a management hierarchy or a dance routine with a dance partner)
- *motoric* systems (e.g., throwing a Frisbee or bouncing on a trampoline).

In all these cases, you systemize by noting regularities (or structure) and rules. The rules tend to be derived by noting if A and B are associated in a systematic way. The evidence for intact or even unusually strong systemizing in autism and Asperger Syndrome is that, in one study, such children performed above the level that one would expect on a physics test (Baron-Cohen et al., 2001). Children with Asperger Syndrome as young as 8–11 years old scored higher than a comparison group who were older (typical teenagers).

A second piece of evidence comes from studies using the Systemizing Quotient (SQ). The higher your score, the stronger your drive to systemize. People with high-functioning autism or Asperger Syndrome score higher on the SQ compared to people in the general population (Baron-Cohen et al., 2003). The above tests of systemizing are designed for children or adults with Asperger Syndrome, not classic autism. However, children with classic autism perform better than controls on the picture sequencing test where the stories can be sequenced using physical-causal concepts (Baron-Cohen et al., 1986). They also score above average on a test of how to figure out how a Polaroid camera works, even though they have difficulties figuring out people's thoughts and feelings (Baron-Cohen et al., 1985; Perner et al., 1989). Both of these are signs of their intact or even strong systemizing.

The strength of the E–S theory is that it is a *two-factor theory* that can explain the cluster of both the social and non-social features in ASCs. Below average empathy is a simple way to explain the social–communication difficulties, while average or even above average systemizing is a way of explaining the narrow interests, repetitive behavior, and resistance to change/need for sameness. This is because when you systemize, it is easiest to keep everything constant, and only vary one thing at a time. That way, you can see what might be causing what, rendering the world predictable.

Like the Weak Central Coherence (WCC) theory (Frith, 1989), the E–S theory is about a different cognitive style (Happe, 1996). Like that theory, it also posits excellent attention to detail (in perception and memory), since when you systemize you have to pay attention to the tiny details. This is because each tiny detail in a system might have a functional role. Excellent attention to detail in autism has been repeatedly demonstrated (Jolliffe and Baron-Cohen, 2001; Mottron et al., 2003; O'Riordan et al., 2001; Shah and Frith, 1983, 1993). The difference between these two theories is that while the WCC theory sees people with ASCs as drawn to detailed information (sometimes called local processing) for *negative* reasons (an alleged inability to integrate), the E–S theory sees this same quality (excellent attention to detail) as being highly purposeful: it exists in order to understand a system. Attention to detail is occurring for *positive* reasons: in the service of achieving an ultimate understanding of a system (however small and specific that system might be).

Whereas the WCC theory predicts that people with autism or Asperger Syndrome will be forever lost in the detail and never achieve an understanding of the system as a whole (since this would require a global overview), the E–S theory predicts that over time, the person may achieve an excellent understanding of a whole system, given the opportunity to observe and control all the variables in that system. The existence of talented mathematicians with AS like Richard Borcherds is proof that such individuals can integrate the details into a true understanding of the system (Baron-Cohen, 2003). It is worth noting that the Executive Dysfunction (ED) theory (Ozonoff et al., 1991; Rumsey and Hamberger, 1988; Russell, 1997) has even more difficulty in explaining instances of good understanding of a whole system, such as calendrical calculation, or indeed why the "obsessions" in autism and AS should center on systems at all.

The extreme male brain theory: linking autism to typical sex differences in the mind and brain

The E–S theory has been extended into the Extreme Male Brain (EMB) theory of autism (Baron-Cohen, 2002). This is because there are clear sex differences in empathizing (females performing better) and in systemizing (males performing better), such that autism and Asperger Syndrome can be seen as an extreme of the typical male profile, a view first put forward by the pediatrician Hans Asperger (1944). To see how this theory is effectively just an extension of the E–S theory, one needs to understand that that theory posits two independent dimensions (E for empathy and S for systemizing) in which individual differences are observed in the population. When you plot these, five different "brain types" are seen:

- *Type E* (E > S): individuals whose empathy is stronger than their systemizing
- *Type S* (S > E): individuals whose systemizing is stronger than their empathy
- *Type B* (S = E): individuals whose empathy is as good (or as bad) as their systemizing. (B stands for "balanced.")
- *Extreme Type E* (E >> S): individuals whose empathy is above average, but who are challenged when it comes to systemizing
- *Extreme Type S* (S >> E): individuals whose systemizing is above average, but who are challenged when it comes to empathy

The E–S model predicts that more females have a brain of Type E, and more males have a brain of Type S. People with ASC, if they are an extreme of the male brain, are predicted to be more likely to have a brain of Extreme Type S. If one gives people in the general population measures of empathy and systemizing (the EQ and SQ), the results fit this model reasonably well. The majority of males (54%) *do* have a brain of Type S, whereas the majority of females (44%) have a brain of Type E. There are also subjects scoring close to zero (the Type B, thus in-between S and E). The majority of people with ASC (65%) have an extreme of the male brain (Goldenfeld et al., 2005).

Apart from the evidence from the SQ and EQ, there is other evidence that supports the EMB theory. Regarding tests of empathy, on the *faux pas test*, where a child has to recognize when someone has said something that could be hurtful, typically girls develop faster than boys, and children with ASC develop even slower than typical boys (Baron-Cohen et al., 1999b). On the *Reading the Mind in the Eyes Test*, on average women score higher than men, and people with ASCs score even lower than typical males (Baron-Cohen et al., 1997). Regarding tests of attention to detail, on the *Embedded Figures Test*, where one has to find a target shape as quickly as possible, on average males are faster than females, and people with autism are even faster than typical males (Jolliffe and Baron-Cohen, 1997).

Recently, the extreme male brain theory has been extended to the level of neurology, with some interesting findings emerging (Baron-Cohen et al., 2005). Thus, in regions of the brain that on average are smaller in males than in females (e.g., the anterior cingulate, superior temporal gyrus, prefrontal cortex, and thalamus), people

with autism have even smaller brain regions than typical males. In contrast, in regions of the brain that on average are bigger in males than in females (e.g., the amygdala, cerebellum, overall brain size/weight, and head circumference), people with autism have even bigger brain regions than is typical. Also, the male brain on average is larger than the female brain, and people with autism have been found to have even larger brains than typical males. Not all studies support this pattern but some do, and it will be important to study such patterns further. It will also be important to address the neurobiological mechanisms that may be causing this hyper-masculinization, one candidate being fetal testosterone (Auyeung et al, 2009).

In summary, the EMB theory is relatively new and may be important for understanding why more males develop ASC than do females. It remains in need of further examination. It extends the E–S theory which has the power to explain not just the social–communication deficits in ASCs, but also the uneven cognitive profile, repetitive behavior, islets of ability, savant skills, and unusual narrow interests that are part of the atypical neurology of this subgroup in the population.

The autistic mind: in search of "truth"

The function of systemizing is to predict lawful events, including lawful change or patterns in data. The hyper-systemizing theory of autism spectrum disorders (ASDs) can explain their preference for systems that change in highly lawful or predictable ways; why they become disabled when faced with systems characterized by less lawful change; and their "need for sameness" or "resistance to change." If "truth" is defined as lawful patterns in data, then, according to the hyper-systemizing theory, one could view people with ASD as strongly driven to discover the "truth." I am defining the term "truth" as precise, reliable, consistent, or lawful patterns or structure in data. If a wheel is spinning round and round, there are consistent, lawful patterns to be detected. Sometimes the pattern will occur with 100% predictability (this particular person's birthday always falls on April 4th), sometimes with relatively high predictability (daffodils typically bloom in the second week of March in England). Systemizing is the means by which we identify lawful patterns in data.

When we systemize, we make the *implicit* assumption that the pattern of data coming into our senses reveals the truth. My contention is that the autistic brain, being highly tuned to systemize, is the ultimate pattern detector and truth detector (Baron-Cohen, 2006). In a high-functioning individual on the autistic spectrum, such pattern-seeking can reveal scientific truths about the nature of reality, since their systemizing can help the individual understand how things work. What was previously dismissed as an "obsession" can be viewed more positively as a "strong, narrow interest" in a topic that, when harnessed, can lead the person with autism or AS to excel in a highly specific field.

While systemizing can deliver truths in the form of laws, it can only do so in domains that are ultimately lawful. One reason why people with ASD (postulated to be hyper-systemizers) may struggle with empathy and be less interested in topics such as pure fiction, pretence, or deception is that these are not and never will be truth oriented. Regarding the domain of emotions, human behavior is not 100% lawful. Different people can express the same emotion differently, or an emotion may even have no external expression. Regarding the domain of mental states, as Alan Leslie pointed out, the domain of mental states plays havoc with "truth relations." This is because of the opacity of mental states like "belief" or "pretence" (Leslie, 1987). The sentence "Mary believes that 'John is having an affair with his colleague' " is true if Mary believes it, irrespective of whether John is really having an affair. When we mind-read, we have to keep track of what we believe to be true (John is not having an affair) while representing someone else's different (possibly false) belief—what they believe to be true (Mary believes he is). Empathy is therefore arguably impossible without such an ability to play with and even suspend the truth.

Hyper-systemizing: implications for intervention

The E–S theory has implications for intervention, as is being tried by "systemizing empathy," presenting emotions in an autism-friendly format (Baron-Cohen, 2007b; Golan et al., 2006, 2009). In one example of a mind reading exercise, actors pose with facial expressions such that people with autism can teach themselves emotion recognition via DVD or computer (www.jkp.com/mindreading). This involves taking the quite artificial approach of presenting mental states (such as emotional expressions) as if they are lawful and systemizable, even if they are not (Golan et al., 2006). The children's animation *The Transporters* (www.thetransporters.com) grafts human actors' facial expressions of emotion onto mechanical systems such as trains and trams that move in a highly predictable fashion, along tracks, so that even young children with autism are attracted to look at faces while they are drawn to watch the kinds of material that is intrinsically rewarding for them (Golan et al., 2009). Such approaches tailor the information to the learning style of the learner and these approaches have been evaluated and shown to lead to improvements in emotion recognition.

Conclusions

In this chapter we have considered a psychological theory of ASC (the E–S theory) and its link to typical sex differences in the general population. The latter link was discussed in terms of its possible relevance to understanding the marked sex ratio in ASC and for its etiological implications. It was argued that the E–S theory may be useful not only as a way of explaining the very broad range of features of ASD, but also in designing autism-friendly psychological interventions. The guiding principle here is that if people with ASC have a different learning style to "neurotypical" individuals, and if people with ASC have a profile of strengths as well as disabilities, teaching methods should be designed to target their areas of disability by harnessing their areas of strength. Teaching about emotions in a highly systematic format is one example of this principle applied to education.

Acknowledgments

Portions of this paper appeared in Baron-Cohen, S. (2009). Autism, hyper-systemizing, and truth. *Quarterly Journal of Experimental Psychology, 61*, 64–75 and Baron-Cohen, S. (2008). Theories of the autistic mind. *The Psychologist, 21*, 112–116. The author was supported by the MRC UK and the Nancy Lurie Marks Family Foundation during the period of this work.

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