

Autism: The Empathizing–Systemizing (E-S) Theory

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The mind-blindness theory of autism spectrum conditions has been successful in explaining the social and communication difficulties that characterize these conditions but cannot explain the nonsocial features (the narrow interests, need for sameness, and attention to detail). A new theory, the empathizing–systemizing (E-S) theory, is summarized, which argues two factors are needed to explain the social and nonsocial features of the condition. This is related to other cognitive theories such as the weak central coherence theory and the executive dysfunction theory. The E-S theory is also extended to the extreme male brain theory as a way of understanding the biased sex ratio in autism. Etiological predictions are discussed, as are the clinical applications arising from the E-S theory.

Key words: autism; Asperger syndrome; empathy; systemizing

Introduction

Classic autism and Asperger syndrome share three core diagnostic features: (1) difficulties in social development and (2) 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) as sharing features in two broad areas: social and communication difficulties and narrow interests/repetitive actions. The diagnosis of AS requires that the child began speaking on time and has average or above IQ. These features are manifested differently at different points in development. This article begins by summarizing the “mind-blindness” theory developed in the 1980s and 1990s, which has been a remarkably successful account of the social and communication difficulties in autism. A critique of this

theory is then considered, arguing it is better subsumed by a more recent, two-factor theory, the “empathizing–systemizing” (E-S) theory.

By way of background, it is worth reminding ourselves why we need a cognitive theory of autism at all. The features of autism spectrum conditions (ASC), of which classic autism and AS are the clearest subgroups, are behavioral and are diverse. Depending on how these are counted, one can identify dozens or even hundreds of behavioral features. A cognitive theory attempts to reduce these down to one or two underlying mental processes. This is not instead of a neurobiological theory, since both kinds of theory are needed if we are to understand how atypical neural functioning or neural structure can give rise to atypical behavior. Effectively, the cognitive level mediates the neurobiological and behavioral levels of description.

The Mind-blindness Theory

This theory proposed that children with autism spectrum conditions are delayed in developing a theory of mind (ToM): the ability to put oneself into someone else’s shoes, to

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imagine their thoughts and feelings (Baron-Cohen 1995; Baron-Cohen, Leslie, & Frith 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 also 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 mind-blindness theory proposes that children with autism or Asperger syndrome are delayed in the development of their ToM, leaving them with degrees of mind-blindness. 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 he or she not only looks at another person's face and eyes, but pays attention to what the other person is interested in (Scaife & Bruner 1975). Children with autism or Asperger syndrome show reduced frequency of joint attention, in toddlerhood (Swettenham et al. 1998). The 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 autism or Asperger syndrome show less pretend play, or their pretence is limited to more rule-based formats (Baron-Cohen 1987). The 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 & Bryant 1990). Children with autism or Asperger syndrome are delayed in this (Baron-Cohen & Goodhart 1994). See Figure 1.

The typical 4-year-old child passes the false belief test, recognizing when someone else has a mistaken belief about the world (Wimmer & Perner 1983). Most children with autism or Asperger syndrome are delayed in passing this test (Baron-Cohen et al. 1985).

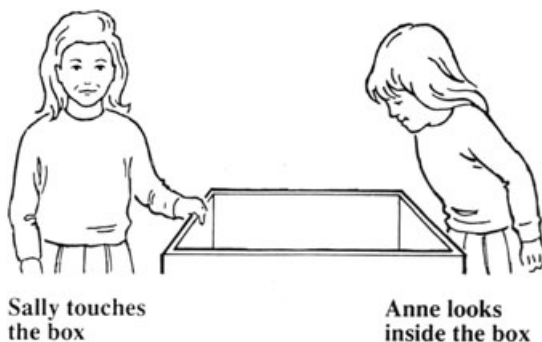


Figure 1. The seeing leads to knowing test. The child is told that Sally looks in the box, while Anne touches the box. Test Question: "Which one knows what's in the box?"

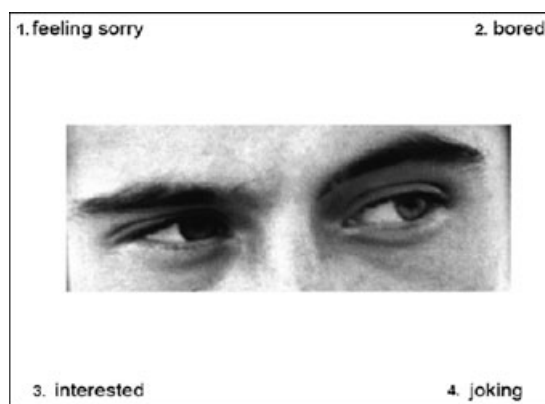


Figure 2. The child version of the reading the mind in the eyes test.

Deception is easily understood by the typical 4-year-old child (Sodian & Frith 1992). Children with autism or Asperger syndrome 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. Children with Asperger syndrome are delayed by around 3 years in this skill, despite their normal IQ (Baron-Cohen, O'Riordan, Jones, et al. 1999). The typical 9-year-old can interpret another person's expressions from their eyes, to figure out what they might be thinking or feeling (see Fig. 2). Children with Asperger syndrome tend to find such tests far more difficult (Baron-Cohen, Wheelwright, Schill, et al.

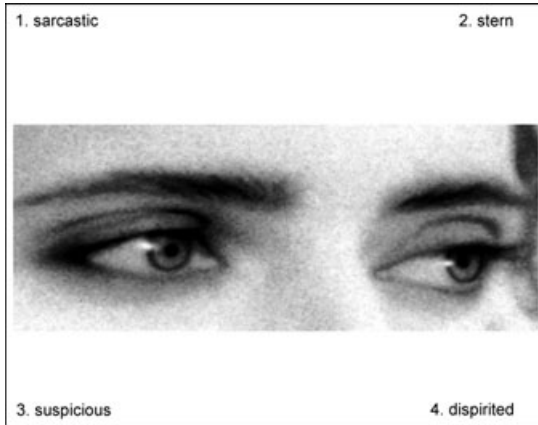


Figure 3. The adult version of the reading the mind in the eyes test.

2001), and the same is true when the adult test of reading the mind in the eyes is used (Fig. 3). Adults with autism or Asperger syndrome score below average on this test of advanced mind reading (Baron-Cohen, Wheelwright, Hill, et al. 2001).

Evaluation of the Mind-blindness Theory

There are several strengths of the mind-blindness theory. First, it can make sense of the social and communication difficulties in autism and Asperger syndrome, including the pragmatic difficulties in language (since, on a Gricean view, communication requires mind reading). Second, degrees of mind-blindness are universal in applying to all individuals on the autistic spectrum, in that when age- and mental-age-appropriate tests are used, deficits are found across the life span and independent of IQ. Third, functional neuroimaging studies have identified key areas of the “social brain” (medial prefrontal cortex, temporal parietal junction, anterior cingulate, insula, and amygdala) that are specifically activated during mind reading tasks in the typical brain and are underactive in the autistic brain (Baron-Cohen et al. 1999; Castelli, Frith, Happe, et al. 2002; Frith & Frith 2003;

Happe et al. 1996). Such neuroimaging studies provide a biological confirmation of the psychological differences that have been reported. Fourth, delays in the development of the precursors to mind reading (such as joint attention and pretend play) have proven to be strong predictors in infancy of a later diagnosis of autism (Baron-Cohen et al. 1996). Finally, the identification of mind-blindness in autism has led to the development of novel interventions to facilitate mind reading, with some success (Baron-Cohen 2007b; Baron-Cohen, Golan, Wheelwright, et al. 2004; Golan et al. in press; Golan, Baron-Cohen, Hill, et al. 2006; Hadwin, Baron-Cohen, Howlin, et al. 1997).

It is also important to identify shortcomings of the mind-blindness theory. First, it cannot account for the nonsocial features of the condition (such as the narrow interests and excellent attention to detail). Secondly, while mind reading is obviously 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). For example, they may be able to see that someone is crying, deduce that they are sad or upset, but not know why, or how to comfort them. Thirdly, a range of clinical conditions show forms of mind-blindness, such as schizophrenia (Corcoran & Frith 1997), narcissistic and borderline personality disorders (Fonagy 1989), and, in some studies, conduct disorder in children (Dodge 1993), so this may not be specific to autism and Asperger syndrome. Fourth, some studies have failed to find any evidence of a ToM deficit in ASC, though this may be because among high-functioning, older individuals the tasks need to be sufficiently subtle and age-appropriate to avoid “floor effects.” Finally, as a theory, the mind-blindness account focuses on what people with autism spectrum conditions find difficult, and ignores their areas of strength.

To address these five shortcomings, this theory has been revised in several ways: First, a

second factor has been proposed to account for the nonsocial areas of strength. Secondly, the concept of ToM has been broadened to include an emotional reactivity dimension. Third, the two-factor theory is proposed to distinguish ASC from other conditions. Finally, the two key traits have been dimensionalized in order to recognize how autism not only comes in degrees, but how it blends seamlessly into the general population.

This latter revision was introduced because 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 (AQ) (Baron-Cohen, Hoekstra, Knickmeyer, et al. 2006; Baron-Cohen, Wheelwright, Skinner, et al. 2001). This is a screening instrument in the form of a questionnaire, either completed by a parent about his or her child, or by self-report (if the adult is high functioning). There are 50 items in total, and when administered to a large population the results resemble a normal distribution. The AQ neatly separates autism from control groups, 93% of the general population falling in the average range of the AQ, and 99% of the autistic population falling in the extreme (high-end) of the scale (Baron-Cohen et al. 2006; Baron-Cohen, Wheelwright, Skinner, et al. 2001).

The Empathizing-Systemizing Theory

This new theory explains the social and communication difficulties in autism and Asperger syndrome 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).

Most people regard ToM as just the cognitive component of empathy in that it simply involves identifying someone else’s (or your own) mental states. Identification of mental states is

sometimes also referred to as requiring an attribution (since these are ultimately a postulate—mental states are not visible *per se*) or requiring recognition (if the mental state leaves cues in facial or vocal or postural expressions of emotion, for example). However, missing from ToM is the second component of empathy, 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 autism spectrum conditions score lower than comparison groups.

According to the empathizing–systemizing (E-S) theory, autism and Asperger syndrome 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 autism spectrum condition.

To understand this theory we need to consider 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 systems: collectible systems (e.g., distinguishing between types of stones), mechanical systems (e.g., a video-recorder), numerical systems (e.g., a train timetable), abstract systems (e.g., the syntax of a language), natural systems (e.g., tidal wave patterns), social systems (e.g., a management hierarchy), and motoric systems (e.g., 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 p and q are

associated in a systematic way (e.g., if p, then q). 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 for their age on a physics test (Baron-Cohen, Wheelwright, Scahill, et al. 2001). Children with Asperger syndrome as young as 8 to 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 than people in the general population (Baron-Cohen, Richler, Bisarya, 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, Leslie, & Frith 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, Frith, Leslie, et al. 1989). Both of these are signs of their intact or even strong systemizing.

Evaluation of the E-S Theory

The E-S theory has several strengths. First, it is a two-factor theory that can explain the cluster of both the social and nonsocial features in autism spectrum conditions. Below average empathy is a simple way to explain the social and 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. Secondly, this theory can help characterize the unique profile of autism spectrum conditions. Many groups show empathy difficulties, but arguably only people on the autistic spectrum show the dissociation between this and their intact or even superior systemizing drive.

Thirdly, this theory is giving rise to novel interventions, in particular using the strong systemizing to teach empathy, for example, presenting emotions in an autism-friendly format (Baron-Cohen 2007b; Golan et al. 2006). The DVD *Mind Reading* (www.jkp.com/mindreading) presents actors posing facial expressions such that people with autism can teach themselves emotion recognition via a computer. 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. in press). Such approaches, which have been evaluated and shown to lead to improvements in emotion recognition, tailor the information to the learning style of the learner so that they can begin to process it.

Fourth, the E-S theory can explain what is sometimes seen as an inability to "generalize" in autism spectrum conditions (Plaisted, O'Riordan, & Baron-Cohen 1998; Rimland 1964; Wing 1997). According to the E-S theory, this is exactly what you would expect if the person is trying to understand each system as a unique system. A good systemizer is a splitter, not a lumper, since lumping things together can lead to missing key differences that enable you to predict how these two things behave differently. The typical clinical example is a teacher who teaches a child with autism

to perform a task in one setting (e.g., taking a shower at home) but has to reteach it in a new setting (e.g., taking a shower at school). Consider though that if the child is treating the situation as system, the unique features of each (e.g., how the shower at home differs to the shower at school in the detail of their temperature control functions or the angle and height of the shower-head) may be more salient than their shared features (e.g., that both require getting in, turning the shower on, turning it off, and getting out).

Finally, the E-S theory destigmatizes autism and AS, relating these to individual differences we see in the population (between and within the sexes), rather than as categorically distinct or mysterious. For many decades, the diagnosis of autism was one that many parents dreaded, as it suggested their child was biologically set apart from the rest of humanity in lacking the basic machinery for social engagement and in suggesting autism is a disease of the brain. The E-S theory focuses not just on the areas of difficulty (empathy) but also on the areas of strength (systemizing) in ASC, and views ASC as a difference in cognitive style that is part of a continuum of such differences found in everyone, rather than as a disease.

One criticism of the E-S theory is that the evidence base for it is still quite limited. This reflects how new it is, but it does make predictions. For example, it predicts we should expect people with autism to show a preference for predictable over unpredictable motion, or show a preference for patterned over unpatterned information. We should expect deficits not just in ToM, but also in responding to others' emotions—an aspect of empathy that is difficult to test. fMRI may enable the latter prediction to be tested.

A second criticism is that perhaps the E-S theory only applies to the high-functioning individuals with autism or Asperger syndrome. While their obsessions (with computers or math for example) could be seen in terms of strong systemizing (Baron-Cohen, Wheelwright, Stone, et al. 1999), at first

glance it is not obvious that this applies to the low-functioning individuals. This criticism may however reflect how much more challenging it is to test empathy and systemizing in low-functioning people with autism. In fact, the original ToM studies of autism did test medium-functioning people with autism, since their IQs were low average, in the mild range of learning difficulties. But empathy should be testable even in someone with low IQ, for example by using gaze-tracking during an emotional face perception task, and systemizing should be testable in someone with low IQ by observing if they can detect repetitive patterns (structure) in input. Preferential looking paradigms that have been used with typical infants might be a suitable nonverbal paradigm for establishing if low IQ, nonverbal children with autism can discriminate (more quickly than IQ-matched controls) two types of information (with high versus low structure).

Leaving aside experimental methods, when we think of a child with autism, many of the classic behaviors they show as part of their natural history can be seen as a reflection of their strong systemizing. Some examples are listed in Table 1.

Relating the E-S Theory to Other Accounts

Like the weak central coherence (WCC) theory (Frith 1989), the E-S theory is about a different cognitive style (Happé 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 & Baron-Cohen 2001; Mottron, Burack, Iarocci, et al. 2003; O'Riordan, Plaisted, Driver, et al. 2001; Shah & Frith 1983, 1993). The difference between these two theories is that whereas the WCC theory sees people with autism spectrum

TABLE 1. Systemizing in Classic Autism (*and/or Asperger Syndrome, in Italics*)

• Sensory systemizing
○ Tapping surfaces, or letting sand run through one’s fingers
○ <i>Insisting on the same foods each day</i>
• Motoric systemizing
○ Spinning round and round, or rocking back and forth
○ <i>Learning knitting patterns or a tennis technique</i>
• Collectible systemizing
○ Collecting leaves or football stickers
○ <i>Making lists and catalogues</i>
• Numerical systemizing
○ Obsessions with calendars or train timetables
○ <i>Solving math problems</i>
• Motion systemizing
○ Watching washing machines spin round and round
○ <i>Analyzing exactly when a specific event occurs in a repeating cycle</i>
• Spatial systemizing
○ Obsessions with routes
○ <i>Developing drawing techniques</i>
• Environmental systemizing
○ Insisting on toy bricks being lined up in an invariant order
○ <i>Insisting that nothing is moved from its usual position in the room</i>
• Social systemizing
○ Saying the first half of a phrase or sentence and waiting for the other person to complete it
○ <i>Insisting on playing the same game whenever a child comes to play</i>
• Natural systemizing
○ Asking over and over again what the weather will be today
○ <i>Learning the Latin names of every plant and their optimal growing conditions</i>
• Mechanical systemizing
○ Learning to operate the VCR
○ <i>Fixing bicycles or taking apart gadgets and reassembling them</i>
• Vocal/auditory/verbal systemizing
○ Echoing sounds
○ <i>Collecting words and word meanings</i>
• Systemizing action sequences
○ Watching the same video over and over again
○ <i>Analyzing dance techniques</i>
• Musical systemizing
○ Playing a tune on an instrument over and over again
○ <i>Analyzing the musical structure of a song</i>

conditions 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).

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), whereas 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). Pitting the WCC and the E-S theories against each other is in fact very straightforward: any experiment that involves learning to understand a system should be predicted to give rise to deficits according to WCC, or to intact or even superior performance according to E-S.

It is worth noting that the executive dysfunction (ED) theory (Ozonoff, Pennington, & Rogers 1991; Rumsey & Hamberger 1988; Russell 1997) has even more difficulty explaining instances of good understanding of a whole system, such as calendrical calculation, or indeed why the so-called obsessions in autism and AS should center on systems at all. Thus, when the low-functioning person with classic autism shakes a piece of string thousands of times close to his eyes, while the ED theory sees this as perseveration arising from some neural dysfunction that would normally enable the individual to shift attention, the E-S theory sees the same behavior as a sign that the individual “understands” the physics of that string movement. He may for example make it move in exactly the same way every time. Or when he makes a long, rapid sequence of sounds, he may know exactly that acoustic pattern and get some pleasure from the confirmation that the sequence is the same every time. Much

as a mathematician might feel an ultimate sense of pleasure that the “golden ratio” $((a + b)/a = a/b)$ always comes out as 1.61803399... , so the child—even with low-functioning autism—who produces the same outcome every time with his repetitive behavior, appears to derive some emotional pleasure at the predictability of the world. This may be what is clinically described as “stimming” (Wing 1997). Autism was originally described as involving “resistance to change” and “need for sameness” (Kanner 1943), and here we see that important clinical observation may be the hallmark of strong systemizing.

To return to the ED theory, one question is whether there is executive dysfunction in ASC at all. That is, does the E-S theory make the ED theory redundant? Expressed differently, can the E-S theory explain the findings from ED theory of perseveration on the Wisconsin Card Sorting test or poor planning on the Tower of London test (Ozonoff et al. 1991; Rumsey & Hamberger 1988; Russell 1997)? One rejoinder to this is that deficits on tasks like the Wisconsin or the Tower of London may not reflect ED. For example, both the WCC and E-S theories could explain the Tower of London deficit in terms of an overfocus on local detail, and the E-S theory could explain the Wisconsin deficit in terms of a desire to persist with a systematic strategy. On this argument, performance on an ED task depends on the strategy being used, and a strategy driven by either WCC or strong systemizing may produce performance that is indistinguishable from ED.

It is however clear from clinical and parental accounts of ASC that there are everyday planning and organizational difficulties. In some people with AS, for example, their bedrooms are totally messy and they cannot organize their school-work to be finished in time. Surely these are simple, everyday examples of ED? However, the person with AS whose bedroom is a total mess but who is at the same time (systematically) working his or her way up through the levels of a computer game may be doing precisely what strong systemizing neces-

sarily entails: focusing on a specific system (the computer game), and attempting to understand that system in its entirety, all the while ignoring extraneous information (the messy bedroom). The clinical accounts usually report that if a parent comes in to tidy up their child’s messy bedroom this typically triggers a tantrum, because what appeared to be random mess to an outsider observer was in fact a complex and predictable pattern (or system) to the person with AS themselves. Amid the mess, every single item had its own (proper) place, and the person with AS can typically recall the location of every item within the apparent mess, such that the mess is itself a predictable system. A parent can be an unwelcome intrusion who disturbs this perfect system.

In addition, the clinical reports of children with AS who cannot complete an essay or homework assignment on time are describing real problems, but these need not reflect ED. These difficulties would also be predicted by WCC (not being able to see the whole essay because of a stronger focus on local detail) or E-S (not wanting to leave out any information in case it is relevant to understanding the whole system). Strong systemizing entails treating all information as potentially relevant, in the search for repeating patterns (if p, then q). A homework assignment or an exam essay that appears to contain far too much detail (a commonly reported problem in the work of people with AS) may be a sign of treating all detail as relevant (not being able to ignore information), and could also arise from a ToM deficit (not knowing how to judge what the reader needs to know, already knows, or does not need to know). The point is that deficits purported to reflect pure ED may reflect multiple possible sources.

Extending the E-S Theory: The Extreme Male Brain Theory

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 on many such tests) and in systemizing (males performing better on tests of this), such that autism and AS can be seen as an extreme of the typical male profile, a view first put forward by the pediatrician Hans Asperger (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* ($E \gg S$): individuals whose empathy is above average, but who are challenged when it comes to systemizing
- *Extreme Type S* ($S \gg E$): individuals whose systemizing is above average, but who are challenged when it comes to empathy

These “brain types” are defined at the cognitive or psychometric level, but they should correlate with structural and functional differences at the neural level, something that should be tested in the future. 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 autism spectrum conditions, 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. More males (54%) have a brain of Type S, more females (44%) have a brain of Type E, and more people with autism or Asperger syndrome (65%) have an extreme of the male brain (Goldenfeld, Baron-Cohen, & Wheelwright 2005). It is of interest that while one’s sex is

a strong predictor of brain type in the general population, within the ASC population it is not. Both males and females with ASC are statistically more likely to have a brain of Extreme Type S. Instruments that can measure both dimensions in individuals who are lower functioning may help us to determine the minimum size of the discrepancy between E and S that causes an individual to develop an ASC.

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, in which a child has to recognize when someone has said something that could be hurtful, typically girls develop faster than boys, and children with autism spectrum conditions develop even slower than typical boys (Baron-Cohen, O’Riordan, Jones, et al. 1999). On the reading the mind in the eyes test, on average women score higher than men, and people with autism spectrum conditions score even lower than typical males (Baron-Cohen, Jolliffe, Mortimore, et al. 1997). Regarding tests of attention to detail, on the embedded figures test, which requires one 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 & Baron-Cohen 1997).

Recently, the EMB theory has been extended to the level of neurology, with some interesting findings emerging (Baron-Cohen, Knickmeyer, et al. 2005). Regions of the brain that on average are smaller in males than in females (such as the anterior cingulate, superior temporal gyrus, prefrontal cortex, and thalamus) are even smaller in people with autism than in typical males. In contrast, in regions of the brain that on average are bigger in males than in females (including the amygdala, cerebellum, overall brain size/weight, and head circumference), these regions or measurements are even bigger in people with autism than in typical males. Also, the male brain is, on average, larger than the female, 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 hypermasculinization, 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 autism or Asperger syndrome than do females. As with any scientific program, this theory must be tested by a systematic search for evidence that does not fit the theory. The EMB theory extends the E-S theory, which has the power to explain not just the social and communication deficits in autism spectrum conditions, 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. Future research should also test if—while deficits in empathy are seen in many clinical groups—the particular pattern of low E in combination with intact or even high S is indeed unique to ASC. Candidate clinical control groups to test this hypothesis would be obsessive-compulsive disorder (OCD) and schizophrenia. In OCD one sees rigid behavior, but this may be more related to anxiety than to a love of systems per se. In schizophrenia one sees empathy difficulties, but it is unlikely that the logical thought required for strong systemizing is seen in this condition.

Implications of the E-S Theory: The Autistic Mind in Search of “Truth”

The function of systemizing is to predict lawful events, including lawful change, or patterns in data. The E-S theory can explain the preference of people with ASC 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 E-S theory, one could view people with ASC

as strongly driven to discover the truth. Here we are using 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. The 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.

Although 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 ASC (postulated to be hypersystemizers) 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 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 really is 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, that is, 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.

Seen in these terms, it may be that E and S are not truly independent dimensions, and it may be that one of the reasons why people with ASC have difficulties with empathy is that it cannot easily be systemized. It may be that there is a degree of trade-off between E and S, such that the better one is at one, the worse one is at the other. On this view, the single dimension that may underlie ASC may be the extent to which one is able to deal with degrees of unlawfulness in information. This warrants testing in the future.

Conclusions

The mind-blindness theory has proven useful as a cognitive account of autism spectrum conditions, but its value is limited to accounting for one of the major groups of features (social and communication difficulties) without addressing the other major group of features (repetitive behavior, narrow interests, and local attention to detail). The mind-blindness theory also neglects the difficulties in affective reactivity to another's mental state. For these reasons, the E-S theory—as a two-factor theory—appears better suited to explain the whole set of features characterizing ASC. This theory also seems more applicable than either the weak central coherence theory or the executive dysfunction account, which have shortcomings with respect to universality or explanatory scope. While the brain basis of empathy is being unraveled, future research is needed to understand the brain basis of systemizing.

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Conflicts of Interest

The author declares no conflicts of interest.

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