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AUTISM AND THE EMPATHIZING–SYSTEMIZING (E-S) THEORY

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Classic autism and Asperger syndrome both share three core diagnostic features: (a) difficulties in social development, (b) the development of communication, and (c) unusually strong, narrow interests and repetitive behavior (APA, 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 an 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, Hoekstra, Knickmeyer, & Wheelwright, 2006; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 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." Most people without a diagnosis fall in the range 0–25; most with a diagnosis of an autism spectrum condition fall between 26 and 50. It has been shown

that 50% score above 32, and 99% score above 26. Given 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, the AQ neatly separates these groups.

In the general population, males score slightly (but statistically significantly) higher than females. Since autism spectrum conditions 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, Knickmeyer, & Belmonte, 2005; Baron-Cohen, Lutchmaya, & Knickmeyer, 2004). These two aspects—the autistic spectrum and the possibility of sex-linked explanations—have been at the core of my research and theorizing over recent years.

THE MINDBLINDNESS THEORY

In my early work I explored the theory 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 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 mindblindness theory proposes that children with autism and Asperger syndrome 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 mindread:

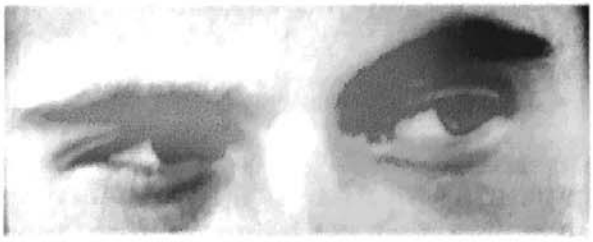
- A typical 14-month-old shows joint attention (such as pointing or following another person's gaze), during which they not only look at another person's face and eyes, but pay attention to what the other person is interested in (Scaife & Bruner, 1975). Children with autism and Asperger syndrome show reduced frequency of joint attention, in toddlerhood (Swettenham et al., 1998).
- The typical 24-month-old engages in pretend play, using their mindreading skills to be able to understand that in the other

person's mind, they are just pretending (Leslie, 1987). Children with autism and 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 and Asperger syndrome are delayed in this (Baron-Cohen & Goodhart, 1994).
- 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 and Asperger syndrome are delayed in passing this test (Baron-Cohen et al., 1985).
- Deception is easily understood by the typical 4-year-old child (Sodian & Frith, 1992). Children with autism and 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; Baron-Cohen, 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, Stone, & Plaisted, 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 Figure 7.1). Children with Asperger syndrome tend to find such tests far more difficult (Baron-Cohen, Wheelwright, Scahill, Lawson, & Spong, 2001), and the same is true when the adult test of Reading the Mind in the Eyes is used (Figure 7.2). Adults with autism and Asperger syndrome score

1. Feeling Sorry

2. Bored



3. Interested

4. Joking

Figure 7.1 The child version of the Reading the Mind in the Eyes Test.

Figure 7.2 The adult version of the Reading the Mind in the Eyes Test.

below average on this test of advanced mindreading (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

A strength of the mindblindness theory is that it can make sense of the social and communication difficulties in autism and Asperger syndrome, and that it is universal in applying to all individuals on the autistic spectrum. Its shortcoming is that it cannot account for the nonsocial features. A second shortcoming of this theory is that whilst 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 & 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 autism and Asperger syndrome.

Two key ways to revise this theory have been to explain the nonsocial areas 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 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).

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 as affective empathy (Davis, 1994). On the empathy quotient (EQ), a questionnaire either filled out 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 turn to this second factor, the concept of systemizing. (See Table 7.1) 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, Wheelwright 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

Table 7.1 Systemizing in Classic Autism and/or Asperger Syndrome (in italics)

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

(Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 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, & Leekam, 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 nonsocial features in autism spectrum conditions. 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.

When this theory first came out, one criticism of it was that it might only apply to 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, & Rutherford, 1999), surely this didn't apply to low-functioning individuals? However, when we think of a child with autism, many of the classic behaviors can be seen as a reflection of their strong systemizing. Some examples are listed here:

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 & Baron-Cohen, 2001; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001; Shah & Frith, 1983, 1993). The difference between these two theories is that while the WCC theory sees people with autism spectrum 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).

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, Pennington, & Rogers, 1991; Rumsey & 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 so-called obsessions in autism and AS should center on systems at all.

So, the low-functioning person with classic autism shaking a piece of string thousands of times close to his eyes is seen by the ED theory as showing a 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, or is attempting to understand, the physics of that string movement. He may be able to make it move in exactly the same way every time. 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 their 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.

One final advantage of the E-S theory is that it 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 were trying to understand each system as a unique system. A good systemizer is a splitter, not a lumper, since

lumping things t gether can lead to missing key differences that enable you to predict how these two things behave differently.

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 Asperger syndrome 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>>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 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. The largest subgoup of males (54%) do have a brain of Type S, the largest subgroup of females (44%) have a brain of Type E, and the majority of people with autism and Asperger syndrome (65%) have an extreme of the male brain (Goldenfeld, Baron-Cohen, & Wheelwright, 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 autism spectrum conditions develop even slower than typical boys (Baron-Cohen, O'Riordan 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, & Robertson, 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 & 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 typical males. Also, the male brain on average is larger than in females, 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.

In summary, the EMB theory is relatively new and may be important for understanding why more males develop autism and Asperger syndrome 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 autism spectrum conditions, but also the uneven cognitive profile, repetitive behaviour, islets of ability, savant skills, and unusual narrow interests that are part of the atypical neurology of this subgroup in the population. 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, Baron-Cohen, Wheelwright, & Hill, 2006). Finally, the E-S theory destigmatizes autism and Asperger syndrome, relating these to individual differences we see in the population (between the sexes, and within the sexes), rather than as categorically distinct or mysterious.

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REFERENCES

APA (1994). *DSM-IV Diagnostic and Statistical Manual of Mental Disorders (4th ed.)*. Washington, DC: American Psychiatric Association.

Asperger, H. (1944). Die "Autistischen Psychopathen" im Kindesalter. *Archiv fur Psychiatrie und Nervenkrankheiten, 117*, 76–136.

Baron-Cohen, Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high-functioning adults with autism or Asperger Syndrome. *Journal of Child Psychology and Psychiatry, 38*, 813–822.

Baron-Cohen, S. (1987). Autism and symbolic play. *British Journal of Developmental Psychology, 5*, 139–148.

Baron-Cohen, S. (1992). Out of sight or out of mind: Another look at deception in autism. *Journal of Child Psychology and Psychiatry, 33*, 1141–1155.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. MIT Press/Bradford Books: Boston.

Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in Cognitive Science, 6*, 248–254.

Baron-Cohen, S. (2003). *The Essential Difference: Men, Women and the Extreme Male Brain*. Penguin: London.

Baron-Cohen, S. (2006). The hyper-systemizing, assortative mating theory of autism. *Progress in Neuropsychopharmacology and Biological Psychiatry, 30*, 865–872.

Baron-Cohen, S. (2007a). I cannot tell a lie. *In Character, 3*, 52–59.

Baron-Cohen, S. (2007b). Transported into a world of emotion. *The Psychologist, 20*, 76–77.

Baron-Cohen, S., & Goodhart, F. (1994). The "seeing leads to knowing" deficit in autism: The Pratt and Bryant probe. *British Journal of Developmental Psychology, 12*, 397–402.

Baron-Cohen, S., Hoekstra, R. A., Knickmeyer, R., & Wheelwright, S. (2006). The Autism-Spectrum Quotient (AQ)—Adolescent version. *Journal of Autism & Developmental Disorders, 36*, 343–350.

Baron-Cohen, S., Knickmeyer, R., & Belmonte, M. K. (2005). Sex differences in the brain: Implications for explaining autism. *Science, 310*, 819–823.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind'? *Cognition, 21*, 37–46.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1986). Mechanical, behavioural and Intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology, 4*, 113–125.

Baron-Cohen, S., Lutchmaya, S., & Knickmeyer, R. (2004). *Prenatal testosterone in mind: Amniotic fluid studies*. Cambridge, MA: MIT/Bradford Books.

Baron-Cohen, S., O'Riordan, M., Jones, R., Stone, V., & Plaisted, K. (1999). A new test of social sensitivity: Detection of faux pas in normal children and children with Asperger syndrome. *Journal of Autism and Developmental Disorders, 29*, 407–418.

Baron-Cohen, S., Richler, J., Bisarya, D., Gurunathan, N., & Wheelwright, S. (2003). The Systemising Quotient (SQ): An investigation of adults with Asperger Syndrome or High-Functioning Autism and normal sex differences. *Philosophical Transactions of the Royal Society, 358*, 361–374.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test-revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, 42*, 241–252.

Baron-Cohen, S., Wheelwright, S., Scahill, V., Lawson, J., & Spong, A. (2001). Are intuitive physics and intuitive psychology independent? *Journal of Developmental and Learning Disorders, 5*, 47–78.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders, 31*, 5–17.

Baron-Cohen, S., Wheelwright, S., Stone, V., & Rutherford, M. (1999). A mathematician, a physicist, and a computer scientist with Asperger Syndrome: Performance on folk psychology and folk physics test. *Neurocase, 5*, 475–483.

Corcoran, R., & Frith, C. (1997). Conversational conduct and the symptoms of schizophrenia. *Cognitive Neuropsychiatry, 1*, 305–318.

Davis, M. H. (1994). *Empathy: A social psychological approach*. Colorado: Westview Press.

Dodge, K. A. (1993). Social-cognitive mechanisms in the development of conduct disorder and depression. *Annual Review of Psychology, 44*, 559–584.

Fonagy, P. (1989). On tolerating mental states: Theory of mind in borderline personality. *Bulletin of the Anna Freud Centre, 12*, 91–115.

Frith, U. (1989). *Autism: Explaining the enigma*. Oxford: Basil Blackwell.

Golan, O., Baron-Cohen, S., Wheelwright, S., & Hill, J. J. (2006). Systemising empathy: Teaching adults with Asperger Syndrome to recognise complex emotions using interactive multimedia. *Development and Psychopathology, 18*, 589–615.

Goldenfeld, N., Baron-Cohen, S., & Wheelwright, S. (2005). Empathizing and systemizing in males, females and autism. *Clinical Neuropsychiatry, 2*, 338–345.

Grandin, T. (1996). *Thinking in pictures*. Vancouver, WA: Vintage Books.

Happe, F. (1996). *Autism*. UCL Press.

Jolliffe, T., & Baron-Cohen, S. (1997). Are people with autism or Asperger's Syndrome faster than normal on the Embedded Figures Task? *J. Child Psychol. Psychiatry, 38*, 527–534.

Jolliffe, T., & Baron-Cohen, S. (2001). A test of central coherence theory: Can adults with high-functioning autism or Asperger Syndrome integrate fragments of an object. *Cognitive Neuropsychiatry, 6*, 193–216.

Kanner, L. (1943). Autistic disturbance of affective contact. *Nervous Child, 2*, 217–250.

Leslie, A. M. (1987). Pretence and representation: The origins of "theory of mind." *Psychological Review, 94*, 412–426.

Mottron, L., Burack, J. A., Iarocci, G., Belleville, S., & Enns, J. T. (2003). Locally orientated perception with intact global processing among adolescents with high-functioning autism: Evidence from multiple paradigms. *Journal of Child Psychology and Psychiatry, 44*, 904–913.

O'Riordan, M., Plaisted, K., Driver, J., & Baron-Cohen, S. (2001). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance, 27*, 719–730.

Ozonoff, S., Pennington, B., & Rogers, S. (1991). Executive function deficits in high-functioning autistic children: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry, 32*, 1081–1106.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief, and communication. *Child Development, 60*, 689–700.

Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998). Enhanced visual search for a conjunctive target in autism: A research note. *Journal of Child Psychology and Psychiatry, 39*(777–783).

Pratt, C., & Bryant, P. (1990). Young children understand that looking leads to knowing (so long as they are looking into a single barrel). *Child Development, 61*, 973–983.

Rimland, B. (1964). *Infantile Autism: The syndrome and its implications for a neural theory of behaviour.* New York: Appleton-Century-Crofts.

Rumsey, J., & Hamberger, S. (1988). Neuropsychological findings in high-functioning men with infantile autism, residual state. *Journal of Clinical and Experimental Neuropsychology, 10*, 201–221.

Russell, J. (1997). How executive disorders can bring about an inadequate theory of mind. In J. Russell (Ed.), *Autism as an executive disorder.* Oxford: Oxford University Press.

Rutter, M. (1978). Diagnosis and definition. In M. Rutter & E. Schopler (Eds.), *Autism: A reappraisal of concepts and treatment* (pp. 1–26). New York: Plenum Press.

Scaife, M., & Bruner, J. (1975). The capacity for joint visual attention in the infant. *Nature, 253*, 265–266.

Shah, A., & Frith, U. (1983). An islet of ability in autism: A research note. *Journal of Child Psychology and Psychiatry, 24*, 613–620.

Shah, A., & Frith, U. (1993). Why do autistic individuals show superior performance on the block design test? *Journal of Child Psychology and Psychiatry, 34*, 1351–1364.

Sodian, B., & Frith, U. (1992). Deception and sabotage in autistic, retarded, and normal children. *Journal of Child Psychology and Psychiatry, 33*, 591–606.

Swettenham, J., Baron-Cohen, S., Charman, T., Cox, A., Baird, G., Drew, A., Rees, L., & Wheelwright, S. (1998). The frequency and distribution of spontaneous attention shifts between social and nonsocial stimuli in autistic, typically developing, and non-autistic developmentally delayed infants. *Journal of Child Psychology and Psychiatry, 9*, 747–753.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13*, 103–128.

Wing, L. (1997). *The Autistic Spectrum*. London: Pergamon.