

2 Sex differences in mind

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Why should the topic of sex differences in mind have any relevance to the theme of conflict, the focus on this book and lecture series? In my view, there are two links.

First, some consider that the male and female mind are so intrinsically different that conflict in some form – for example, mutual misunderstanding – is inevitable. I will argue that there are interesting differences between the *average* male and female mind but that recognizing these need not lead to conflict and instead could lead to mutual respect of difference. In using the word ‘average’, I am from the outset recognizing that such differences may have little to say about individuals, a point I will return to. In addition, the features that define the average male and female mind are not like chalk and cheese. The average male and female mind contains both chalk *and* cheese, as it were. The differences are subtle, and are to do with the relative proportions of chalk and cheese in the typical male and female mind. Fear not. I will get away from this metaphor quite soon, and define the qualities that we can quantify. But it does mean that because the male mind is not all chalk, and the female mind all cheese, the two sexes are not destined to be mystified by the other.

Second, the field of sex differences in psychology in the 1960s and 1970s, was so conflict-ridden as to make an open-minded debate about any possible role of biology contributing to psychological sex differences impossible. Those who explored the role of biology – even whilst acknowledging the importance of culture – found themselves accused of defending an essentialism that perpetuated inequalities between the sexes, and of oppression. Not a climate in which scientists can ask

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questions about mechanisms in nature. Today, the pendulum has settled sensibly in the middle of the nature–nurture debate, and scientists who care deeply about ending inequality and oppression can at the same time also talk freely about biological differences between the male and female brain and mind.

The conflict that characterized the 1960s and 1970s has not entirely evaporated, as witnessed by the global reactions in the media to Harvard President Professor Lawrence Summers' comments in 2005 when he was understood to have said in a public lecture that women were innately less suited to high positions in science. My own view is that the field of sex differences in mind needs to proceed in a fashion that is sensitive to this history of conflict by cautiously looking at the evidence and being careful not to overstate what can be concluded. What we will see in this lecture is that whilst males as a group show a stronger interest in systems, which is at the heart of science, when it comes to individuals, there are great female scientists and there are great male scientists. Once again, the evidence says nothing about individuals. As we will see, the data actually require us to look at each individual on their own merits, as individuals may or may not be typical for their sex.

Systemizing and empathizing

'Empathizing' is the drive to identify another person's emotions and thoughts and to respond to these with an appropriate emotion. Empathizing allows you to *predict* a person's behaviour and to care about how others feel. In this essay, I review the evidence that, in general, females spontaneously empathize to a greater degree than do males. 'Systemizing' is the drive to analyze the variables in a system in order to derive the underlying rules that govern its behaviour. Systemizing also refers to the drive to construct systems. Systemizing allows one to *predict* the behaviour of a system and to control it. I review the evidence that, on average, males spontaneously systemize to a greater degree than do females.¹

¹ S. Baron-Cohen, S. Wheelwright, J. Lawson, *et al.*, 'The exact mind: empathising and systemising in autism spectrum conditions', in: U. Goswami (ed.), *Handbook of Cognitive Development*. Oxford: Blackwell, 2002.

Table 2.1: *Main types of analyzable systems*

- | |
|---|
| <ul style="list-style-type: none">• Technical systems (e.g., a computer, a musical instrument, a hammer)• Natural systems (e.g., a tide, a weather front, a plant)• Abstract systems (e.g., mathematics, a computer program, syntax)• Social systems (e.g., a political election, a legal system, a business)• Organizable systems (e.g., a taxonomy, a collection, a library)• Motoric systems (e.g., a sports technique, a performance, a musical technique) |
|---|

Empathizing is close enough to the standard English definition to need little introduction, and I will come back to it shortly. But systemizing is a new concept and needs a little more definition. By a ‘system’ I mean something that takes inputs and deliver outputs. To systemize, one uses ‘if-then’ (correlation) rules. The brain zooms in on a detail or parameter of the system and observes how this varies. That is, it treats a feature of a particular object or event as a variable. Alternately, a person actively, or systematically, manipulates a given variable. One notes the effect(s) of operating on one single input in terms of its effects elsewhere in the system (the output). The key data structure used in systemizing is [input-operation-output]. If I do *x*, *a* changes to *b*. If *z* occurs, *p* changes to *q*. Systemizing therefore requires an exact eye for detail.

There are at least six kinds of systems that the human brain can analyze or construct, as shown in Table 2.1. Systemizing is an inductive process. One watches what happens each time, gathering data about an event from repeated sampling, often quantifying differences in some variables within the event and observing their correlation with variation in outcome. After confirming a reliable pattern of association – that is, generating predictable results – one forms a rule about how a particular aspect of the system works. When an exception occurs, the rule is refined or revised. Otherwise, the rule is retained. Systemizing works for phenomena that are ultimately lawful, finite and deterministic. The explanation is exact, and its truth-value is testable. (‘The light went on because the switch was in the down position.’) Systemizing is of almost no use for predicting moment-to-moment changes in a person’s behaviour. To predict human behaviour, empathizing is

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required. Systemizing and empathizing are wholly different kinds of processes.

Empathizing involves the attribution of mental states to others and involves an appropriate affective response to the other's affective state. It includes not only what is sometimes called 'theory of mind', or mentalizing,² but also encompasses the common English words 'empathy' and 'sympathy'. Although systemizing and empathizing are in one way similar because they are processes that allow us to make sense of events and make reliable predictions, they are in another way almost the opposite of each other. Empathizing involves an imaginative leap in the dark in the absence of complete data. ('Maybe she didn't phone me because she was feeling hurt by my comment.') The causal explanation is at best a 'maybe', and its truth may never be provable. Systemizing is our most powerful way of understanding and predicting the law-governed inanimate universe. Empathizing is our most powerful way to understand and predict the social world. Ultimately, empathizing and systemizing depend on separate, independent regions in the human brain.

The main brain types

In this essay I will argue that systemizing and empathizing are two key dimensions that define the male and female brain. We all have both systemizing and empathizing skills. One can envisage five broad types of brain, as Table 2.2 shows. This essay concerns itself primarily with those on the extreme male brain end of the spectrum. Individuals who have this psychological profile may be talented systemizers, but they are often, at the same time, 'mind-blind'.³ The evidence reviewed here suggests that not all men have the male brain and not all women have the female brain. Expressed differently, some women have the male brain, and some men have the female brain. My central claim here is only that *more* males than females have a brain of type S, and *more* females than males have a brain of type E. I will review the evidence

² J. Morton, A. Leslie and U. Frith, 'The cognitive basis of a biological disorder: autism', *New Scientist* **14**, 1995, 434–8.

³ S. Baron-Cohen, *Mindblindness: An Essay on Autism and Theory of Mind*. Boston, MA: MIT Press, 1995.

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Table 2.2: *The main brain types*

Profile	Shorthand Equation	Type of Brain
Individuals in whom empathizing is more developed than systemizing.	E>S	'female' (or Type E)
Individuals in whom systemizing is more developed than empathizing.	S>E	'male' (or Type S)
Individuals in whom systemizing and empathizing are both equally developed.	S=E	'balanced' (or Type B)
Individuals in whom systemizing is hyperdeveloped while empathizing is hypodeveloped (the autistic end of the spectrum). They may be talented systemizers, but at the same time, they may be 'mind blind'.	S>>E	extreme male brain
Individuals who have hyperdeveloped empathizing skills, while their systemizing is hypodeveloped – they may be 'system blind'.	E>>S	extreme female brain (postulated)

supporting these profiles. In the final section of this essay, I will highlight the role of culture and biology in these sex differences.

The female brain: empathizing

What is the evidence for female superiority in empathizing? In the studies summarized here, sex differences of a small but statistically significant magnitude have been found.

- *Sharing and turn taking.* On average, girls show more concern for fairness, while boys share less. In one study, boys showed fifty times greater competition, as compared to girls, while girls showed twenty times greater turn taking, as compared to boys.⁴

⁴ W. R. Charlesworth and C. Dzur, 'Gender comparisons of preschoolers' behavior and resource utilization in group problem solving', *Child Development* **58**, 1987, 191–200.

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- *Rough and tumble play or 'rough housing'* (wrestling, mock fighting, etc.). Boys show more of this than do girls. Although such activity is often playful, it can hurt or be intrusive. Lower empathizing levels are necessary to engage in rough and tumble play.⁵
- *Responding empathically to the distress of other people*. Girls from the age of one year show greater concern for others through sad looks, sympathetic vocalizations and comforting as compared to boys. Also, more women than men report frequently sharing the emotional distress of their friends. Women also show more comforting, even to strangers, than men do.⁶
- *Using a 'theory of mind'*. As early as three years of age, little girls are ahead of boys in their ability to infer what people might be thinking or intending.⁷
- *Sensitivity to facial expressions*. Women are better at decoding non-verbal communication, picking up subtle nuances from tone of voice or facial expression, or judging a person's character.⁸
- *Empathy*. Women score higher than men on questionnaires designed to measure empathic response.⁹
- *Values in relationships*. More women than men value the development of altruistic, reciprocal relationships, which by definition require empathizing. In contrast, more men value power, politics and competition.¹⁰ Girls are more likely to endorse cooperative items on a questionnaire and to rate the establishment of intimacy as more important than the establishment of dominance. In contrast, boys are more likely than girls to endorse competitive items and to rate social status as more important than intimacy.¹¹
- *Disorders of empathy*. Disorders such as psychopathic personality disorder or conduct disorder are far more common among males.¹²

⁵ E. E. Maccoby, *The Two Sexes: Growing Up Apart, Coming Together*. Cambridge, MA: Belknap Press/Harvard University Press, 1998.

⁶ M. L. Hoffman, 'Sex differences in empathy and related behaviors', *Psychological Bulletin* **84**, 1977, 712–22.

⁷ F. G. Happe, 'The role of age and verbal ability in the theory of mind task performance of subjects with autism', *Child Development* **66**, 1995, 843–55.

⁸ J. A. Hall, 'Gender effects in decoding nonverbal cues', *Psychological Bulletin* **85**, 1978, 845–58.

⁹ M. H. Davis, *Empathy: A Social Psychological Approach*. Ed. J. Harvey, Brown & Benchmark Social Psychology Series. Boulder, CO: Westview Press, 1994.

¹⁰ A. Ahlgren and D. W. Johnson, 'Sex differences in cooperative and competitive attitudes from the 2nd through the 12th grades', *Developmental Psychology* **15**, 1979, 45–9.

¹¹ G. P. Knight and C.-C. Chao, 'Gender differences in the cooperative, competitive, and individualistic social values of children', *Motivation and Emotion* **13**, 1989, 125–41.

¹² K. A. Dodge, 'Social cognition and children's aggressive behavior', *Child Development* **51**, 1980, 162–70; R. J. Blair, 'A cognitive developmental approach to morality: investigating the psychopath', *Cognition* **57**, 1995, 1–29.

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- *Aggression.* Even in normal quantities, this can only occur with reduced empathizing. Here again, there is a clear sex difference. Males tend to show far more 'direct' aggression (pushing, hitting, punching, etc.), while females tend to show more 'indirect' (relational, covert) aggression (gossip, exclusion, cutting remarks, etc.). Direct aggression may require an even lower level of empathy than indirect aggression. Indirect aggression needs better mind-reading skills than does direct aggression because its impact is strategic.¹³
- *Murder.* This is the ultimate example of a lack of empathy. Daly and Wilson analyzed homicide records dating back over 700 years from a range of different societies. They found that 'male-on-male' homicide was thirty to forty times more frequent than 'female-on-female' homicide.¹⁴
- *Establishing a 'dominance hierarchy'.* Males are quicker to establish such hierarchies. This in part reflects their lower empathizing skills because often a hierarchy is established by one person pushing others around to become the leader.¹⁵
- *Language style.* Girls' speech is more cooperative, reciprocal and collaborative. In concrete terms, this is also reflected in girls being able to continue a conversational exchange with a partner for a longer period. When girls disagree, they are more likely to express their different opinion sensitively, in the form of a question rather than an assertion. Boys' talk is more 'single-voiced discourse'; that is, the speaker presents only his own perspective. The female speech style is more 'double-voiced discourse'; girls spend more time negotiating with their partner, trying to take the other person's wishes into account.¹⁶
- *Talk about emotions.* Women's conversations involve much more talk about feelings, while men's conversations tend to be more object- or activity-focused.¹⁷
- *Parenting style.* Fathers are less likely than mothers to hold their infants in a face-to-face position. Mothers are more likely to follow through the child's choice of topic in play, while fathers are more likely to impose their own topic. Also, mothers fine-tune their speech more often to match their children's understanding.¹⁸

¹³ N. R. Crick and J. K. Grotpeter, 'Relational aggression, gender, and social-psychological adjustment', *Child Development* **66**, 1995, 710–22.

¹⁴ M. Daly and M. Wilson, *Homicide*. New York: Aldine de Gruyter, 1988.

¹⁵ F. F. Strayer, 'Child ethology and the study of preschool social relations', in: H. C. Foot, A. J. Chapman and J. R. Smith (eds.), *Friendship and Social Relations in Children*. Chichester: John Wiley & Sons, 1980.

¹⁶ P. M. Smith, *Language, the Sexes, and Society*. Oxford: Blackwell, 1985.

¹⁷ D. Tannen, *You Just Don't Understand: Women and Men in Conversation*. New York: William Morrow & Company, 1990.

¹⁸ T. G. Power, 'Mother- and father-infant play: a developmental analysis', *Child Development* **56**, 1985, 1514–24.

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- *Face preference and eye contact.* From birth, females look longer at faces, particularly at people's eyes, whereas males are more likely to look at inanimate objects.¹⁹

Females have also been shown to have better language ability than males. It seems likely that good empathizing would promote language development²⁰ and vice versa, so these factors may not be independent.

The male brain: systemizing

The relevant domains to explore for evidence of systemizing include any fields that are in principle rule-governed. Thus, chess and football are good examples of systems, but faces and conversations are not. As noted previously, systemizing involves monitoring three elements: input, operation and output. The operation is what was done or what happened to the input in order to produce the output. What is the evidence for a stronger drive to systemize in males?

- *Toy preferences.* Boys are more interested than girls in toy vehicles, weapons, building blocks and mechanical toys, all of which are open to being 'systemized'.²¹
- *Adult occupational choices.* Some occupations are almost entirely male. These include metal-working, weapon-making, musical instrument-making, and the construction industries, such as boat-building. The focus of these occupations is on creating systems.²²
- *Maths, physics and engineering.* These disciplines all require high systemizing and are largely male-dominated. The Scholastic Aptitude Math Test (SAT-M) is the mathematics part of the test administered nationally to college applicants in the United States. Males on average score fifty points higher than females on this test.²³ Considering only

¹⁹ J. Connellan, S. Baron-Cohen, S. Wheelwright, *et al.*, 'Sex differences in human neonatal social perception', *Infant Behavior and Development* **23**, 2000, 113–18.

²⁰ S. Baron-Cohen, D. A. Baldwin and M. Crowson, 'Do children with autism use the speaker's direction of gaze strategy to crack the code of language?' *Child Development* **68**, 1997, 48–57.

²¹ K. D. Jennings, 'People versus object orientation in preschool children: do sex differences really occur?' *Journal of Genetic Psychology* **131**, 1977, 65–73.

²² D. C. Geary, *Male, Female: The Evolution of Human Sex Differences*. Washington, DC: American Psychological Association, 1998.

²³ C. P. Benbow, 'Sex differences in mathematical reasoning ability in intellectually talented preadolescents: their nature, effects, and possible causes', *Behavioral and Brain Sciences* **11**, 1988, 169–232.

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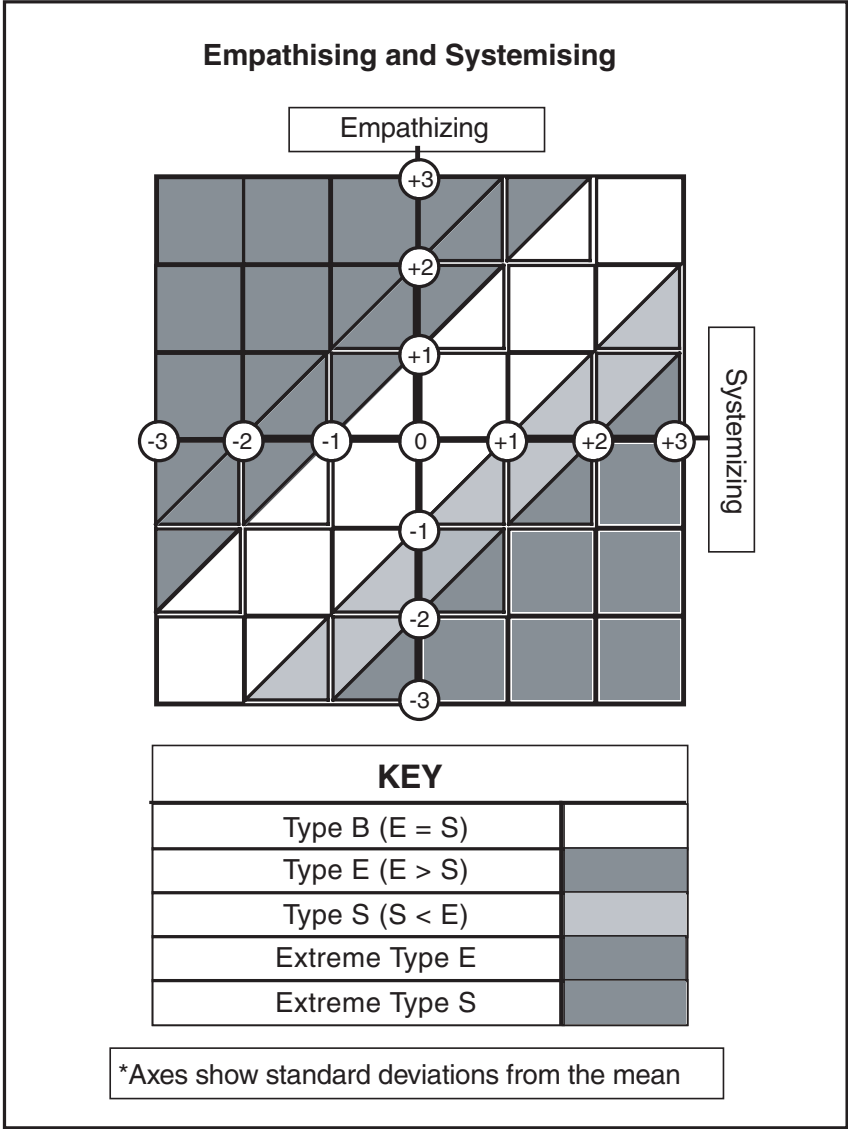


FIGURE 2.1: Schematic diagram of different types of human brain in relation to their empathizing and systemizing abilities. See Table 2.2 for further elaboration of these types.

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individuals who score above 700, the sex ratio is 13:1 (men to women).²⁴

- *Constructional abilities.* On average men score higher than women in an assembly task in which people are asked to put together a three-dimensional (3-D) mechanical apparatus. Boys are also better at constructing block buildings from two-dimensional blueprints. Lego bricks can be combined and recombined into an infinite number of systems. Boys show more interest than girls in playing with Lego. Boys as young as three years of age are also faster at copying 3-D models of outsized Lego pieces. Older boys, from the age of nine years, are better than girls at imagining what a 3-D object will look like if it is laid out flat. Boys are also better at constructing a 3-D structure from just an aerial and frontal view in a picture.²⁵
- *The Water Level Task.* Originally devised by the Swiss child psychologist Jean Piaget, the Water Level Task involves a bottle that is tipped at an angle. Individuals are asked to predict the water level. Women more often draw the water level aligned with the tilt of the bottle and not horizontal, as is correct.²⁶
- *The Rod and Frame Test.* If a person's judgement of vertical is influenced by the tilt of the frame, he or she is said to be 'field dependent'; that is, their judgement is easily swayed by extraneous input in the surrounding context. If they are not influenced by the tilt of the frame, they are said to be 'field independent'. Most studies indicate that females are more field dependent; i.e., women are relatively more distracted by contextual cues, and they tend not to consider each variable within a system separately. They are more likely than men to state erroneously that a rod is upright if it is aligned with its frame.²⁷
- *Good attention to relevant detail.* This is a general feature of systemizing and is clearly a necessary part of it. Attention to relevant detail is superior in males. One measure of this is the Embedded Figures Test. On average, males are quicker and more accurate in locating a target object from a larger, complex pattern.²⁸ Males, on average, are also better at detecting a particular feature (static or moving) than are women.²⁹

²⁴ D. C. Geary, 'Sexual selection and sex differences in mathematical abilities', *Behavioral and Brain Sciences* **19**, 1996, 229–84.

²⁵ D. Kimura, *Sex and Cognition*. Cambridge, MA: MIT Press, 1999.

²⁶ M. A. Wittig and M. J. Allen, 'Measurement of adult performance on Piaget's water horizontality task', *Intelligence* **8**, 1984, 305–13.

²⁷ H. A. Witkin, H. B. Lewis, M. Hertzman, *et al.*, *Personality Through Perception*. New York: Harper & Brothers, 1954.

²⁸ R. Elliot, 'Interrelationship among measures of field dependence, ability, and personality traits', *Journal of Abnormal and Social Psychology* **63**, 1961, 27–36.

²⁹ D. Voyer, S. Voyer and M. Bryden, 'Magnitude of sex differences in spatial abilities: a meta-analysis and consideration of critical variables', *Psychological Bulletin* **117**, 1995, 250–70.

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- *The Mental Rotation Test.* This test provides another example in which males are quicker and more accurate. This test involves systemizing because it is necessary to treat each feature in a display as a variable that can be transformed (e.g., rotated) and then predict the output, or how it will appear after transformation.³⁰
- *Reading maps.* This is another everyday test of systemizing, because features from 3-D input must be transformed to a two-dimensional representation. In general, boys perform at a higher level than girls in map reading. Men can also learn a route by looking at a map in fewer trials than women, and they are more successful at correctly recalling greater detail about direction and distance. This observation suggests that men treat features in the map as variables that can be transformed into three dimensions. When children are asked to make a map of an area that they have only visited once, boys' maps have a more accurate layout of the features in the environment. More of the girls' maps make serious errors in the location of important landmarks. Boys tend to emphasize routes or roads, whereas girls tend to emphasize specific landmarks (the corner shop, the park, etc.). These strategies of using directional cues versus using landmark cues have been widely studied. The directional strategy represents an approach to understanding space as a geometric system. Similarly, the focus on roads or routes is an example of considering space in terms of another system, in this case a transportation system.³¹
- *Motoric systems.* When people are asked to throw or catch moving objects (target-directed tasks), such as playing darts or intercepting balls flung from a launcher, males tend to perform better than females. In addition, on average men are more accurate than women in their ability to judge which of two moving objects is travelling faster.³²
- *Organizable systems.* People in the Aguaruna tribe of northern Peru were asked to classify a hundred or more examples of local specimens into related species. Men's classification systems included more sub-categories (i.e., they introduced greater differentiation) and were more consistent among individuals. Interestingly, the criteria that the Aguaruna men used to decide which animals belonged together more closely resembled the taxonomic criteria used by Western (mostly

³⁰ D. W. Collins and D. Kimura, 'A large sex difference on a two-dimensional mental rotation task', *Behavioral Neuroscience* **111**, 1997, 845–9.

³¹ L. A. M. Galea and D. Kimura, 'Sex differences in route-learning', *Personality and Individual Differences* **14**, 1993, 53–65.

³² W. Schiff and R. Oldak, 'Accuracy of judging time to arrival: effects of modality, trajectory, and gender', *Journal of Experimental Psychology: Human Perception and Performance* **16**, 1990, 303–16.

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male) biologists.³³ Classification and organization involves systemizing because categories are predictive. With more fine-grained categories, a system will provide more accurate predictions.

- *The Systemizing Quotient*. This is a questionnaire that has been tested among adults in the general population. It includes forty items that ask about a subject's level of interest in a range of different systems that exist in the environment, including technical, abstract and natural systems. Males score higher than females on this measure.³⁴
- *Mechanics*. The Physical Prediction Questionnaire (PPQ) is based on an established method for selecting applicants to study engineering. The task involves predicting which direction levers will move when an internal mechanism of cog wheels and pulleys is engaged. Men score significantly higher on this test, compared with women.³⁵

Culture and biology

At age one year, boys strongly prefer to watch a video of cars going past, an example of predictable mechanical systems, than to watch a film showing a human face. Little girls show the opposite preference. Young girls also demonstrate more eye contact than do boys at age one year.³⁶ Some investigators argue that, even by this age, socialization may have caused these sex differences. Although evidence exists for differential socialization contributing to sex differences, this is unlikely to be a sufficient explanation. Connellan and colleagues showed that among one-day-old babies, boys look longer at a mechanical mobile, which is a system with predictable laws of motion, than at a person's face, an object that is next to impossible to systemize. One-day-old girls show the opposite profile.³⁷ These sex differences are therefore present very early in life. This raises the possibility that, while culture and socialization may partly

³³ S. Atran, 'Core domains versus scientific theories: evidence from systematics and Itzaj-Maya folkbiology', in: L. A. Hirschfeld and S. A. Gelman (eds.), *Mapping the Mind: Domain Specificity in Cognition and Culture*. Cambridge: Cambridge University Press, 1994.

³⁴ S. Baron-Cohen, J. Richler, D. Bisarya, *et al.*, '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, Series B*. **358**, 2003, 361–74.

³⁵ J. Lawson, S. Baron-Cohen and S. Wheelwright, unpublished data, 2002.

³⁶ S. Lutchmaya and S. Baron-Cohen, 'Human sex differences in social and nonsocial looking preferences at 12 months of age', *Infant Behavior and Development*. In press.

³⁷ See n. 19.

determine the development of a male brain with a stronger interest in systems or a female brain with a stronger interest in empathy, biology may also partly determine this. There is ample evidence to support both cultural determinism and biological determinism.³⁸ For example, the amount of time a one-year-old child maintains eye contact is inversely related to the prenatal level of testosterone.³⁹ The evidence for the biological basis of sex differences in the mind is reviewed elsewhere.⁴⁰

Autism: an extreme form of the male brain

Autism is diagnosed when a person shows abnormalities in social development and communication and displays unusually strong obsessional interests from an early age.⁴¹ Asperger Syndrome (AS) has been proposed as a variant of autism. It is seen in children who have normal or high IQ scores and who develop speech at the normal developmental age. Today, approximately one in 200 children have one of the 'autistic spectrum conditions', which include AS.⁴² Autism spectrum conditions are far more common in males than females. Among individuals with high-functioning autism (HFA) or AS, at least ten males are affected for every one female. These conditions are also strongly heritable⁴³ and neurodevelopmental in origin. Considerable evidence supports structural and functional differences in certain regions of the brain. For example, the amygdala is abnormal in size in many individuals with autistic spectrum disorders, and it may not respond in the usual fashion to cues of emotional expression.⁴⁴

³⁸ A. H. Eagly, *Sex Differences in Social Behavior: A Social-Role Interpretation*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1987; C. Gouchie and D. Kimura, 'The relationship between testosterone levels and cognitive ability patterns', *Psychoneuroendocrinology* **16**, 1991, 323–34.

³⁹ S. Lutchmaya, S. Baron-Cohen and P. Raggatt, 'Foetal testosterone and eye contact in 12 month-old infants', *Infant Behavior and Development*. In press.

⁴⁰ S. Baron-Cohen, *The Essential Difference: Men, Women, and the Extreme Male Brain*. New York: Basic Books, 2003.

⁴¹ Task Force on DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*. 4th edn. Washington, DC: American Psychiatric Association, 1994.

⁴² U. Frith (ed.), *Autism and Asperger Syndrome*. Cambridge: Cambridge University Press, 1991.

⁴³ A. Bailey, P. Bolton and M. Rutter, 'A full genome screen for autism with evidence for linkage to a region on chromosome 7q', *Human Molecular Genetics* **7**, 1998, 571–8.

⁴⁴ S. Baron-Cohen, H. A. Ring, E. T. Bullmore, *et al.*, 'The amygdala theory of autism', *Neuroscience and Biobehavioral Reviews* **24**, 2000, 355–64.

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The extreme male brain (EMB) theory of autism was first informally suggested by Hans Asperger in 1944. According to the 1991 translation by Uta Frith, he wrote, 'The autistic personality is an extreme variant of male intelligence. Even within the normal variation, we find typical sex differences in intelligence. . . . In the autistic individual, the male pattern is exaggerated to the extreme.'⁴⁵ In 1997 this controversial hypothesis was re-examined.⁴⁶ We can now test the EMB theory empirically, as the female brain (E>S), the male brain (S>E), and the balanced brain (E=S) have been defined. According to the EMB theory, people with autism or AS should always fall in the dark-grey zone as illustrated in Figure 2.2.

Evidence for the extreme male brain theory

Initial tests are beginning to provide positive proof of this theory.⁴⁷ A number of studies utilizing different approaches and standard instruments indicate that people with autism show markedly impaired empathizing. Some of the convergent lines of evidence are summarized here.

- *Mind reading*. Girls score better than boys on standard 'theory of mind' tests, and children with autism or AS tend to perform even worse than do normal boys.⁴⁸ Children with autism have specific delays and difficulties in the development of 'mind reading', and they are unable to make sense of or predict another's feelings, thoughts and behaviour. Autism has been referred to as a condition of 'mindblindness'.⁴⁹
- *The Empathy Quotient*. On this questionnaire, females score higher than males, and people with AS or HFA score even lower than males.⁵⁰

⁴⁵ See n. 42.

⁴⁶ S. Baron-Cohen and J. Hammer, 'Is autism an extreme form of the "male brain"?' in: C. Rovee-Collier and L. P. Lipsitt (eds.), *Advances in Infancy Research*. Vol. 11. Greenwich, Conn: Ablex Publishing, 1997.

⁴⁷ S. Baron-Cohen, S. Wheelwright, V. Stone, *et al.*, 'A mathematician, a physicist, and a computer scientist with Asperger syndrome: performance on folk psychology and folk physics test', *Neurocase* 5, 1999, 475–83; S. Baron-Cohen, 'The cognitive neuroscience of autism: evolutionary approaches', in: M. S. Gazzaniga (ed.-in-chief), L. Cosmides and J. Tooby (eds.), *The New Cognitive Neurosciences*. 2nd edn. Cambridge, MA: MIT Press; 2000.

⁴⁸ See n. 7.

⁴⁹ See n. 3.

⁵⁰ See n. 34.

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sarcastic

stern



suspicious

dispirited

preoccupied

grateful



insisting

imploring

FIGURE 2.2: The 'Reading the Mind in the Eyes' Test. Subjects are asked to select the most fitting of the four words to match the expression in the eyes.

- *The 'Reading the Mind in the Eyes' Test* (Figure 2.2). Females score higher on this test than males, but people with AS do not even score as well as males.⁵¹
- *The Complex Facial Expressions Test*. Similar to the other tests mentioned, females score higher than males, and people with AS score even lower than do males.⁵²

⁵¹ S. Baron-Cohen, T. Jolliffe, C. Mortimore, *et al.*, 'Another advanced test of theory of mind: evidence from very high functioning adults with autism or Asperger syndrome', *Journal of Child Psychology and Psychiatry and Allied Disciplines* **38**, 1997, 813–22.

⁵² S. Baron-Cohen, S. Wheelwright and T. Jolliffe, 'Is there a "language of the eyes"? Evidence from normal adults and adults with autism or Asperger syndrome', *Visual Cognition* **4**, 1997, 311–31.

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- *Eye contact.* Females make eye contact more often and maintain it for longer periods of time than do males. People with autism or AS make less eye contact than males.⁵³
- *Language development.* Girls develop vocabulary faster than boys, and children with autism are even slower than males to develop vocabulary.⁵⁴
- *Pragmatics.* Females tend to be superior to males at chatting with others and at understanding the pragmatics of conversation. It is precisely this aspect of language which people with AS find most difficult.⁵⁵
- *The Faux-Pas Test.* Females are better than males at judging what would be socially insensitive or potentially hurtful or offensive. People with autism or AS have even lower scores on tests of this than do males.⁵⁶
- *The Friendship Questionnaire (FQ).* This instrument assesses empathic styles of relationships. Women score higher than males on this questionnaire, and adults with AS score even lower than do normal males on the FQ.⁵⁷

There also exists a growing body of evidence that supports the superior systemizing abilities of individuals with autism spectrum disorders.

- *Islets of ability.* Some people with autism spectrum disorders have 'islets of ability' in mathematical calculation, calendrical calculation, syntax acquisition, music, or precise memory for railway timetable information.⁵⁸ For high-functioning individuals, this can lead to considerable achievement in mathematics, chess, mechanical knowledge, and other factual, scientific, technical or rule-based subjects. All of these areas are highly systemizable domains, and most are also domains that are more interesting to males than to females in the general population.

⁵³ See n. 39; J. Swettenham, S. Baron-Cohen, T. Charman, *et al.*, 'The frequency and distribution of spontaneous attention shifts between social and nonsocial stimuli in autistic, typically developing, and nonautistic developmentally delayed infants', *Journal of Child Psychology and Psychiatry and Allied Disciplines* **39**, 1998, 747–53.

⁵⁴ S. Lutchmaya, S. Baron-Cohen and P. Raggatt, 'Foetal testosterone and vocabulary size in 18- and 24-month-old infants', *Infant Behavior and Development* **24**, 2002, 418–24.

⁵⁵ S. Baron-Cohen, 'Social and pragmatic deficits in autism: cognitive or affective?' *Journal of Autism and Developmental Disorders* **18**, 1988, 379–402.

⁵⁶ S. Baron-Cohen, M. O'Riordan, V. Stone, *et al.*, 'Recognition of faux pas by normally developing children and children with Asperger syndrome or high-functioning autism', *Journal of Autism and Developmental Disorders* **29**, 1999, 407–18.

⁵⁷ S. Baron-Cohen and S. Wheelwright, 'The friendship and relationship questionnaire', *Journal of Autism and Developmental Disorders*. In press.

⁵⁸ S. Baron-Cohen and P. Bolton, *Autism: The Facts*. Oxford: Oxford University Press, 1993.

Sex differences in mind

- *Attention to detail.* People with autism also tend to pay extra-fine attention to detail. For example, on the Embedded Figures Test (EFT) males score higher than females, and people with AS or HFA score even higher than males. This is not a systemizing test *per se*, but it is a measure of detailed local perception, which is a prerequisite for successful systemizing.⁵⁹ On visual search tasks, males demonstrate better attention to detail than do females, and people with autism or AS have even faster, more accurate visual search skills.⁶⁰
- *Preference for rule-based, structured, factual information.* People with autism are strongly drawn to structured, factual and rule-based information. A male bias for this kind of information is also found in the general population.
- *Intuitive physics.* Males score higher than females on tests of intuitive physics. People with AS tend to score higher than males on such tests.⁶¹
- *Toy preference.* In general, boys prefer construction-type and vehicle toys more than girls do. Clinical reports suggest that children with autism or AS demonstrate a very strong preference towards these types of toys as well.⁶²
- *Collecting.* Boys engage in more collecting or organizing of items than girls, and people with autism show this characteristic to an even greater extent.⁶³
- *Obsessions with closed systems.* Most individuals with autism are naturally drawn to predictable things, such as computers. Unlike people, computers follow strict laws. Computers are closed systems; that is, all the variables are well defined within the system, and they are knowable, predictable and, in principle, controllable. Other individuals with autism may not make computers their target of understanding but may latch on to a different, equally closed system, such as bird migration or train-spotting.⁶⁴

⁵⁹ T. Jolliffe and S. Baron-Cohen, 'Are people with autism or Asperger syndrome faster than normal on the Embedded Figures Test?' *Journal of Child Psychology and Psychiatry and Allied Disciplines* **38**, 1997, 527–34.

⁶⁰ M. O'Riordan, K. C. Plaisted, J. Driver, *et al.*, 'Superior visual search in autism', *Journal of Experimental Psychology: Human Perception and Performance* **27**, 2001, 719–30.

⁶¹ S. Baron-Cohen, S. Wheelwright, V. Scahill, *et al.*, 'Are intuitive physics and intuitive psychology independent? A test with children with Asperger syndrome', *Journal of Developmental and Learning Disorders* **5**, 2001, 47–78.

⁶² See n. 35.

⁶³ See n. 40.

⁶⁴ S. Baron-Cohen and S Wheelwright, "‘Obsessions’ in children with autism or Asperger syndrome: a content analysis in terms of core domains of cognition", *British Journal of Psychiatry* **175**, 1999, 484–90.

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- *The Systemizing Quotient*. As noted previously in this essay, males score higher on this test, and people with autism and AS score even higher than normal males on this instrument.⁶⁵

Finally, some evidence rooted in biology and genetics supports the EMB theory of autism.

- *The Autism Spectrum Quotient (the AQ)*. Males in the general population score higher than females, and people with AS or HFA score highest of all on this instrument.⁶⁶
- *Sexually dimorphic somatic markers*. Finger-length ratio is a sexually dimorphic somatic marker. In general, males tend to have a longer ring finger compared to their second finger, which is different than the ratio in females. People with autism or AS show an even greater difference in the ratio of ring-finger to second- finger length.⁶⁷
- *Puberty*. Males with autism are reported to show precocious puberty, which correlates with increased levels of circulating testosterone.⁶⁸
- *Familiality of talent*. Males are over-represented in occupations such as engineering, which require good systemizing but where a mild impairment in empathizing is not necessarily an impediment to success.⁶⁹ There is a higher rate of autism in the families of those talented in fields such as mathematics, physics, and engineering, as compared to those who are most talented in the humanities.⁷⁰ These findings suggest that the extreme male cognitive style is, in part, inherited.

Conclusions and future research

The above evidence suggests that the male brain is characterized by type S (where S>E), the female brain by type E (where E>S), and the autistic brain is an extreme of the male brain (S>>E). Referring to

⁶⁵ See n. 34.
⁶⁶ S. Baron-Cohen, S. Wheelwright, R. Skinner, *et al.*, '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**, 2001, 5–17 [published correction appears in *Journal of Autism and Developmental Disorders* **31**, 2001, 603].
⁶⁷ J. T. Manning, S. Baron-Cohen, S. Wheelwright, *et al.*, 'The 2nd to 4th digit ratio and autism', *Developmental Medicine and Child Neurology* **43**, 2001, 160–4.
⁶⁸ S. Tordjman, P. Ferrari, V. Sulmont, *et al.*, 'Androgenic activity in autism', *American Journal of Psychiatry* **154**, 1997, 1626–7.
⁶⁹ S. Baron-Cohen, S. Wheelwright, C. Stott, *et al.*, 'Is there a link between engineering and autism?' *Autism* **1**, 1997, 101–8.
⁷⁰ S. Baron-Cohen, P. Bolton, S. Wheelwright, *et al.*, 'Does autism occur more often in families of physicists, engineers, and mathematicians?' *Autism* **2**, 1998, 296–301.

Figure 2.1, development of an autism spectrum condition indicates that an individual's brain type is shifted towards the lower-right quadrant. For males, it is a small degree of shift, from type S to extreme type S. For females, the movement is greater, from type E to extreme type S. The causes of this shift remain unclear, but candidate factors include both genetic differences and prenatal testosterone levels.⁷¹

The model in Figure 2.1 predicts that the extreme female brain (EFB) exists. How would such individuals behave? By definition, their brain type is in the upper-left quadrant of Figure 2.1. Their ability to empathize is significantly better than other people in the general population, but their systemizing abilities are impaired. This category would include people who have difficulty understanding mathematics, physics, mechanical objects, chemistry and the like as systems⁷² but who are extremely accurate at tuning in to others' feelings and thoughts. Would such a profile carry with it any disability? A person with EFB would be 'system-blind'. In our society, there remains considerable tolerance for such individuals. It is hoped that people who are 'mind-blind' will also enjoy the same tolerance by society.

We know something about the neural circuitry of empathizing,⁷³ but at present we know very little about the neural circuitry of systemizing. Research will hopefully begin to reveal the key brain regions involved in systems processing.

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⁷¹ See n. 43.

⁷² See n. 1.

⁷³ S. Baron-Cohen, H. A. Ring, S. Wheelwright, *et al.*, 'Social intelligence in the normal and autistic brain: an fMRI study', *European Journal of Neuroscience* 11, 1999, 1891–8.

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FURTHER READING

- S. Baron-Cohen, *The Essential Difference: Men, Women and the Extreme Male Brain*. Harmondsworth/London/New York: Penguin/Allen Lane/ Basic Books, 2003.
- D. Geary, *Male, Female: The Evolution of Human Sex Differences*. Washington, DC, and London: American Psychological Association, 1998.
- D. Kimura, *Sex and Cognition*. Cambridge, MA: MIT Press, 1997.