Sex Differences in Social Development: Lessons from Autism

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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 behavior and to care about how others feel. In this chapter, I review the evidence that, in general, females empathize spontaneously 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 behavior. Systemizing also refers to the drive to construct systems. Systemizing allows one to *predict* the behavior 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]

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 that needs a little more definition. By a "system" I mean something that takes inputs and delivers 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 6 kinds of systems that the human brain can analyze or construct, as shown in Table 1.

Table 1. Main Types of Analyzable Systems

- **Technical** systems (eg, a computer, a musical instrument, a hammer)
- **Natural** systems (eg, a tide, a weather front, a plant)
- **Abstract** systems (eg, mathematics, a computer program, syntax)
- **Social** systems (eg, a political election, a legal system, a business)
- **Organizable** systems (eg, a taxonomy, a collection, a library)
- **Motoric** systems (eg, a sports technique, a performance, a musical technique)

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 behavior. To predict human behavior, empathizing is 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 it 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 chapter I will argue that systemizing and empathizing are 2 key dimensions that define the male and female brains,. We all have both systemizing and empathizing skills. One can envisage 5 broad types of brains, as Table 2 shows. This chapter concerns itself primarily with those on the

Table 2. 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) — 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 — may be "system blind"	E>>S	Extreme female brain (postulated)

*E=empathizing; S=systemizing; B=balanced

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 (systemizing) and *more* females than males have a brain of type E (empathizing). I will review the evidence supporting these profiles. In a later section of this chapter, I will highlight the roles 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 50 times greater competitiveness, as compared with girls, while girls showed 20 times greater turn-taking, as compared with boys.[4]
- *Rough and tumble play or roughhousing* (eg, wrestling, mock fighting). 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 1 year show greater concern for others through sad looks, sympathetic vocalizations and comforting as compared with 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 3 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 nonverbal 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 and conduct disorder are far more common among males.[12, 13]
- *Aggression.* Even in normal quantities, aggression can only occur with reduced empathizing. Here again, there is a clear sex difference. Males tend to show far more "direct" aggression (eg, pushing, hitting, punching), while females tend to show more "indirect" (eg, relational, covert) aggression (eg, gossip, exclusion, cutting remarks). 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.[14]
- *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 30 to 40 times more frequent than "female-on-female" homicide.[15]
- *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.[16]
- *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 opinions sensitively, in the form of questions rather than as assertions. 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.[17]

- *Talk about emotions.* Women's conversations involve much more talk about feelings, while men's conversations tend to be more object- or activity-focused.[18]
- *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 with the child's choice of topic during playtime, while fathers are more likely to impose their own topic. Also, mothers fine-tune their speech more often than fathers to match their children's understanding.[19]
- *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.[20]

Females have also been shown to have better language ability than males. It seems likely that good empathizing would promote language development[21] 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 3 elements: input, operation and output. The operation is what was done or what happened to the input in order to produce the output.

- *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."[22]
- *Adult occupational choices.* Some occupations are almost entirely male-dominated. These include metalworking, weapon making, the manufacture of musical instruments and the construction industries, such as boat-building. The focus of these occupations is on creating systems.[23]
- *Math, physics and engineering.* These disciplines all require high levels of systemizing and are largely male-dominated. The Scholastic Aptitude Math Test is the mathematics part of the test administered nationally to college applicants in the United States. Males, on average, score 50 points (out of 800) higher than females on this test.[24] Considering only individuals who score above 700, the sex ratio is 13:1 (males to females).[25]

- *Constructional abilities.* On average men score higher than women on an assembly task in which people are asked to put together a 3-dimensional (3-D) mechanical apparatus. Boys are also better at constructing block buildings from 2-dimensional blueprints. Lego® bricks can be combined and recombined into an infinite number of systems. Boys show more interest than girls in playing with Legos. Boys as young as 3 years of age are also faster at copying 3-D models of outsized Lego pieces. Older boys, from the age of 9 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.[26]
- *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.[27]
- *The Rod and Frame Test.* If a person's judgment of vertical is influenced by the tilt of the frame, he or she is said to be "field dependent"; that is, their judgment 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; ie, 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.[28]
- *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 (EFT). On average, males are quicker and more accurate in locating a target object from a larger, complex pattern.[29] Males, on average, are also better at detecting a particular feature (static or moving) than are women.[30]
- *The Mental Rotation Test.* This test provides another example in which males are quicker and more accurate than females. This test involves systemizing because it is necessary to treat each feature in a display as a variable that can be transformed (ie, rotated) and then to predict the output, or how it will appear after transformation.[31]

- *Reading maps.* This is another everyday test of systemizing, because features from 3-D input must be transformed into a 2-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 on the map as variables that can be transformed into 3-D. When children are asked to make a map of an area that they have visited only once, boys' maps show 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 (eg, the corner shop, the park). 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.[32]
- *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 2 moving objects is traveling faster.[33]
- *Organizable systems.* People in the Aguaruna tribe of northern Peru were asked to classify 100 or more examples of local specimens into related species. Men's classification systems included more subcategories (ie, 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 male) biologists.[34] 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 40 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.[35]

- *Mechanics.* The Physical Prediction Questionnaire 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.[36]

Culture and Biology

At age 1 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 1 year.[37] 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 *1-day-old* babies, boys look longer at a mechanical mobile, which is a system that has 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.[20] These sex differences are therefore present very early in life. This raises the possibility that, while culture and socialization may partly determine the development of a male brain that has a stronger interest in systems or a female brain that has a stronger interest in empathy, biology may also partly determine this. There is ample evidence to support both cultural determinism and biological determinism.[38, 39] For example, the amount of time a 1-year-old child maintains eye contact is inversely related to the prenatal level of testosterone.[40] The evidence for the biological basis of sex differences in the mind is reviewed elsewhere.[41, 42]

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.[43] Asperger's 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.[44] Autistic spectrum conditions are far more common in males than in females. Among individuals with high-functioning autism (HFA) or AS, at

least 10 males are affected for every one female. These conditions are also strongly heritable[45] 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.[46]

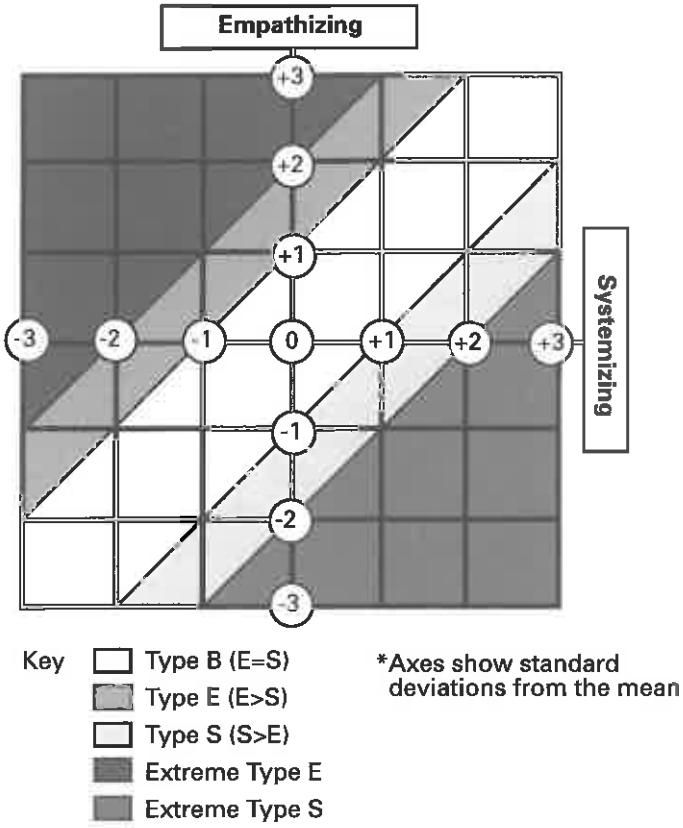
The extreme male brain (EMB) theory of autism was first informally suggested by Hans Asperger in 1944. According to the 1991 translation by Uta Frith, he wrote, "The autistic personality is an extreme variant of male intelligence. Even within the normal variation, we find typical sex differences in intelligence....In the autistic individual, the male pattern is exaggerated to the extreme."[44] In 1997 this controversial hypothesis was reexamined.[47] We can now test the EMB theory empirically, as the "female brain" (E>S), the "male brain" (S>E), and the "balanced brain" (S=E) have been defined (see Table 2). According to the EMB theory, people with autism or AS should always fall in the dark gray zone as illustrated in Fig 1.

Evidence for the Extreme Male Brain Theory

Initial tests are beginning to provide positive proof of this EMB theory.[48, 49] 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.[7] 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 behaviors. Autism has been referred to as a condition of "mindblindness."[3]
- *The Empathy Quotient.* On this questionnaire, females score higher than males, and people with AS or HFA score even lower than males.[35]
- *The "Reading the Mind in the Eyes" test.* Females score higher on this test than do males, but people with AS do not even score as well as males.[50]

Fig 1. A model of empathizing and systemizing.



- *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.[51]
- *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 do males.[40, 52]
- *Language development.* Girls develop vocabulary faster than boys, and children with autism are even slower than males to develop vocabulary.[53]

- *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 that people with AS find most difficult.[54]
- *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.[55]
- *The Friendship Questionnaire.* This instrument assesses empathic styles of relationships. Females score higher than males on this questionnaire, and adults with AS score even lower than do normal males on this instrument.[56]

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

- *Islets of ability.* Some people with autistic spectrum disorders have "islets of ability" in mathematical calculation, calendrical calculation, syntax acquisition, music or memory for railway timetable information to a precise degree.[57] 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. Even music or drawing technique can be systemized and occasionally can become an islet of ability.[58]
- *Attention to detail.* People with autism also tend to pay extra-fine attention to detail. For example, on the 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.[36]
- *Collecting.* Boys engage in more collecting or organizing of items than girls, and people with autism show this characteristic to an even greater extent.[41]
- *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.[62]
- *The Systemizing Quotient.* As noted previously in this chapter, males score higher on this test, and people with autism and AS score even higher than do normal males on this instrument.[35]

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

- *The Autism Spectrum Quotient.* Males in the general population score higher than females, and people with AS or HFA score highest of all on this instrument.[63]
- *Sexually dimorphic somatic markers.* Finger-length ratio is a sexually dimorphic somatic marker. In general, males tend to have a longer ring finger compared with 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.[64]
- *Familiality of talent.* Males are overrepresented in occupations, such as engineering, which require good systemizing but where a mild impairment in empathizing is not necessarily an impediment to success.[65] There is a higher rate of autism in the families of those talented in fields such as mathematics, physics and engineering, as compared with those who are most talented in the humanities.[66] These findings suggest that the extreme male cognitive style is, in part, inherited.

Conclusions and Future Research

The evidence in this chapter 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 (where S>>E). Referring to Fig 1, development of an autistic 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.[45]

The model in Fig 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 Fig 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 systems[1] 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, considerable tolerance remains 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,[67] 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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