Chapter 21

Commentary: How Social is Social Cognition?

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It is a pleasure to be invited to write a commentary for this edited collection of essays. They converge on a question of fundamental importance to developmental cognitive neuroscience: are there special mechanisms in the typical brain that are dedicated to processing *social* information? In my own earlier work I postulated the existence of distinct neural mechanisms dedicated to "mindreading" or "empathizing" that we use for a specific aspect of social cognition: predicting agentive events (Baron-Cohen, 1995, 2003). In my later work I postulated a "systemizing mechanism" that we use for predicting non-agentive events (Baron-Cohen, 2006). In this commentary on the field of developmental social cognition (and its relevance to autism) I begin by summarizing these two mechanisms. I then consider whether there is any relationship between the social and non-social mechanisms.

Empathizing (or Mindreading) Mechanisms

If a change is perceived to be *self-generated* or *self-propelled* (that is, there is no apparent external cause), the brain interprets it as agentive: an agent with a *goal* (Baron-Cohen, 1994; Heider & Simmel, 1944; Perrett et al., 1985). Goal detection is one such basic mechanism we use to make sense of the social world. Humans have a suite of such specialized pieces of "hardware" for dealing with the complex social world. We can think of the "empathizing system" as comprising basic instruments that come compiled to help the normal infant make sense of the social world (Baron-Cohen 1995, 2003, 2005). The empathizing system is postulated to have six key components:

1 ID (the intentionality detector) automatically interprets or represents an agent's self-propelled movement as a goal-directed movement, a sign of its agency, or

an entity with *volition* (Premack, 1990), and is evident from at least 12 months of age (Gergeley, Nadasdy, Gergely, and Biro, 1995).

2 EDD (the eye-direction detector) automatically interprets eye-like stimuli as "*looking* at me" or "looking at something else." Cells in the superior temporal sulcus that respond to an averted or direct gaze have been identified via single-cell recording (Perrett et al., 1985). The EDD is active in early infancy (Connellan, Baron-Cohen, Wheelwright, Ba'tki, and Ahluwalia, 2001; Vecera & Johnson, 1995).

3 SAM (the shared attention mechanism) automatically represents whether the self and another agent are perceiving the *same* event, by building "triadic" representations. SAM is active from 9 months of age (Scaife & Bruner, 1975).

4 TOMM (the theory-of-mind mechanism) allows an *epistemic* mental state to be represented (Leslie, 1987), enabling understanding of false belief (Wimmer & Perner, 1983), and the relationships between mental states. TOMM is firmly established by 4 years of age (Wellman, 1990).

5 TED (the emotion detector) represents *affective* states (Baron-Cohen, 2005). Infants can represent affective states from as early as 3 months of age (Walker, 1982). TED allows the detection of the basic emotions (Ekman, Friesen, & Ellsworth, 1972).

6 TESS (the empathizing system) allows an empathic reaction to another's emotional state (Baron-Cohen, 2005).

The neural circuitry of empathizing has been investigated extensively (Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999; Frith & Frith, 1999; Happé et al., 1996). Key brain areas involved in empathizing include the amygdala, the orbito and medial frontal cortex, and the superior temporal sulcus. Autism, one of the subjects of this book, has been shown to involve delays and deficits in empathizing (Baron-Cohen, 2002).

The Systemizing Mechanism

The above mechanisms would enable one to make sense of agentive change. But how do we make sense of non-agentive change? Non-agentive change is any change that is *not* self-propelled and where there is a *pattern* to the change. The brain therefore engages in pattern detection. Some change occurs with total (100 percent) regularity. Other change occurs with a lower frequency, but there is still a pattern to be discerned. Systemizing involves such pattern (or law) detection via observation of *input–operation–output* relationships (Baron-Cohen, 2002). Systemizing is the search for structure in data, to test whether the changing data are part of a system. Systems may be mechanical, natural, abstract, collectible, motoric, and even social (for example, the law).

Systems that are 100 percent lawful (for example, an electrical light switch, or a mathematical formula) have zero (or minimal) variance, and can therefore be predicted and controlled 100 percent. A computer might be an example of a 90 percent lawful system: the variance is wider, because the operating system may work differently depending on which other software is installed, and so on. The weather may be a system with only moderate lawfulness. While some aspects of agentive behavior are lawful (for example, ballroom dancing), most human behavior is low in lawfulness: the variance is maximal. For example, there is no one-to-one mapping between facial expression and the underlying mental state that might be causing such changes in the face (Baron-Cohen, Golan, Wheelwright, & Hill, 2004). Nor do situations predict the subtlety of emotions, since in the same situation different people react differently. Systemizing works only when the same patterns keep repeating with regularity.

Individual Differences in the Systemizing Mechanism (SM)

The systemizing theory proposes that we all have a systemizing mechanism (SM), and this is set at different levels in different individuals, for biological reasons. These different levels are broadly as follows:

1 *Below average*: those individuals who have little or no drive to systemize. For such individuals, their SM rarely looks for patterns, and thus rarely notices patterns and can cope with absence of pattern. We do not know much about people who systemize only at such an extremely low level, though they would be expected to avoid subjects like mathematics, science, and technology.
2 *Average*: those individuals who systemize at levels within the average range. The two sexes show subtle differences within the average range. Thus, males on average perform higher on tests of map reading (a navigational system) (Kimura, 1999), on the Systemizing Quotient (Baron-Cohen, Richler, Bisarya, Gurunathan, and Wheelwright, 2003), and "intuitive physics" (understanding mechanical systems) (Lawson, Baron-Cohen, & Wheelwright, 2004).
3 *Above average*: those individuals who systemize at more than average. These would be individuals who would be capable of working professionally in a systemizing field (an engineer, an accountant, and son on). People with Asperger syndrome (AS) (Asperger, 1944; Kanner, 1943) can be considered above average in systemizing in that they become "obsessed" with a particular system (Hermelin, 2002). They also score higher than average on the systemizing auotient (SQ) (Baron-Cohen et al., 2003), and on tests of intuitive physics and attention to detail (Baron-Cohen, Wheelwright, Scahill, Lawson, & Spong, 2001; Jolliffe and Baron-Cohen, 1997; Lawson et al., 2004; Shah & Frith, 1983). Indeed, some people with AS may achieve extremely high levels in systemizing domains such as mathematics, physics, or computer science (Baron-Cohen et al., 1999), or art (Myers, Baron-Cohen, & Wheelwright, 2004), showing superior attention to detail (O'Riordan, Plaisted, Driver, & Baron-Cohen, 2001; Plaisted, O'Riordan, & Baron-Cohen, 1998b).

4 *Extreme systemizing*: those individuals who are extreme at systemizing. Individuals with classic autism have been postulated to be extreme at systemizing, resulting in them coping only with highly predictable, patterned environments, producing highly repetitive behavior to produce predictability, and resisting any change to their system. On the picture-sequencing task their performance is above average on sequences that contain temporal or physical-causal (that is, systemizable) information (Baron-Cohen, Leslie, & Frith, 1986), and, in contrast to their difficulties on the false-belief task, their performance is normal or even above average on two equivalent systemizing tasks – the false-photograph task (Leslie & Thaiss, 1992) and the false-drawings task (Charman & Baron-Cohen, 1992). Their obsessions cluster in the domain of systems (Baron-Cohen & Wheelwright, 1999); and, given a set of colored counters, they show their hyper-systemizing as extreme "pattern imposition" (Frith, 1970).

It is well established that autism arises for genetic reasons (Bailey et al., 1995; Folstein & Rutter, 1988; Gillberg, 1991). There is some evidence for systemizing co-segretating with autism: thus, fathers and grandfathers of children with autism are twice as likely to work in the occupation of engineering (a clear example of a systemizing occupation) (Baron-Cohen, Wheelwright, Stott, Bolton, & Goodyer, 1997), and students in the natural sciences (engineering, mathematics, physics) have a higher number of relatives with autism than do students in the humanities (Baron-Cohen et al., 1998).

Questions for Future Research: How Do Empathizing and Systemizing Mechanisms Overlap?

The social deficits in autism could arise because of deficits in the empathizing mechanisms, and the non-social features of autism could arise from the systemizing mechanism being set too high. One question is whether having their SM set too high could explain not just why people with autism prefer either no change, or systems that change in highly lawful or predictable ways (such as mathematics, physics, repetition, objects that spin, routine, music, machines, collections), but also why they become disabled when faced with systems characterized by less lawful change (such as social behavior, conversation, people's emotions, or fiction). We need research to test whether there are two independent anomalies in autism (in the SM and in the empathizing mechanisms) or if there is a relationship between an individual's level of SM and the development of his or her empathy system.

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