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Atypical Social Cognition

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In developmental psychology, arguably one of the most important findings of the last century was that children become able to represent explicitly the mental states of others at around 3–4 years of age (Wimmer & Perner, 1983). In a now seminal study, young children were introduced to a character, Maxi, who was enjoying a bar of chocolate. Having eaten half of his chocolate bar, Maxi put the remainder in the cupboard and went outside to play. While Maxi was outside, his mother found the chocolate and moved it from the cupboard to a drawer. Maxi returns to the kitchen, and the child was asked the crucial test question, "Where will Maxi look for his chocolate?" Typical 4-year-olds answered the question correctly (i.e., "in the cupboard"), suggesting that preschoolers could attribute mental states (in this case, a false belief) to others, and could use these to predict their behavior: that is, they had a "theory of mind" (cf. Premack & Woodruff, 1978). This capacity for understanding *false* beliefs was taken as the hallmark of a theory of mind because beliefs involve representations of reality, and as such, can either be true or false (Dennett, 1978). Younger children, however, performed *worse* than chance, consistently reporting that Maxi would look in the drawer, where the chocolate really is. Their failure on this task could not be due to difficulties remembering the story sequence or the current or previous location of the chocolate. Instead, their difficulties were attributed to a fundamental difficulty understanding that others will act on the basis of their beliefs, rather than on the actual state of affairs.

These findings inspired a new research area focusing on the development of social cognition – one which sought to understand the fundamental ways in which children come to adopt an "intentional stance" (Dennett, 1996), to understand one's own and others' mental states. They also spawned a huge body of work on the *atypical* development of social cognition. This latter work was driven partly by the prospect that a primary cognitive "deficit" in social cognition might explain some – or all – of the defining features of autism spectrum conditions. It was also motivated in part by the possibility that the case of autism could serve as fertile testing ground for theories of how typical children come to know about and act upon the social world. In this chapter, I begin by describing autism and then provide a comprehensive survey and analysis of work on the theory of mind hypothesis, particularly false-belief understanding, in autism, detailing the reasons why researchers have become dissatisfied with the false-belief task as the gold standard for assessing theory of mind. Finally, I turn to more recent work in autism, which goes beyond false-belief attribution and investigates the potential preconditions or "building blocks" for later social cognition, outlining the additional challenges faced by such investigations.

AUTISM: DEFINING FEATURES AND CASE EXAMPLES

Autism is a common neurodevelopmental condition or spectrum of related conditions, which currently include autistic disorder, Asperger syndrome, and pervasive developmental disorder – not otherwise specified (PDD-NOS) (APA, 2000). Although autism is now considered a highly heritable disorder of neural development (Levy, Mandell, & Schultz, 2009), specific genes and biological markers have yet to be identified. The diagnosis of autism therefore relies on a constellation of behavioral symptoms in early childhood, including often severe difficulties in social interaction and verbal and nonverbal communication, and limitations in behavioral flexibility (APA, 2000). There is, however, striking variability in the extent to which individuals manifest these behaviors, and show problems in terms of intellectual functioning and language ability.

Take Jonathan, for example. He is an 8-year-old boy who was diagnosed with autism at the age of 3 years, although many symptoms (especially, limited eye contact) were noticed by his parents much earlier. His speech was severely delayed; he could say single words by the age of 4 and began putting words together at age 6. Although much improved, his speech still contains recurring grammatical errors. He is extremely rigid – he needs his world to operate in a highly predictable way, and becomes very distressed when things are changed or don't follow his normal routine (taking exactly the same route to school, for example). His current obsession is with the "Tellie Tubbies," a popular television show for toddlers, and he will spend hours alone in his room talking gibberish to toy versions of the characters. Despite these difficulties, Jonathan enjoys going to school, where he is in a mainstream classroom receiving 1:1 support for half of the week. He is extremely sensitive to sounds, which makes it difficult for him to concentrate in an often noisy class. But he is interested in his peers – in fact, he'd desperately like to have a friend, and indeed makes many attempts to relate to other children. Sadly, these interactions, which lack the fluidity and natural ease of typically developing children's social exchanges, are often unsuccessful.

Now consider Adam, also aged 8, and also diagnosed with autism at the age of 3. Unlike Jonathan, Adam's scores on standardized tests of intellectual functioning place him in the mild learning disability range. This is probably an underestimate of his true intellectual capacity, however, as his very poor language skills undoubtedly hinder his performance on such tests. Much of what Adam says is repetitive or "echolalic" – he will repeat verbatim what has just been said to him or TV jingles or film scripts he has heard previously. He does use language to communicate about the things he is interested in, which currently include carwashes, bus washes, and washing machines (his family has the cleanest car in town!). But, again, these conversations are almost exclusively one-sided and have a scripted quality to them. In addition, and most unusually, Adam also has echopraxia, meaning that he will copy facial expressions, and emphatic or descriptive gestures. He attends a special unit – which is attached to a mainstream school – specifically for children with autism, where he shows little interest in his peers and seldom interacts with them, instead appearing content to play on his own.

It is easy to see how Jonathan and Adam, the two case examples, broadly share the core diagnostic features of autism. Yet they are also strikingly different in terms of degree of symptoms (especially interest in other people) and communicative difficulties. This variability in autism is the norm rather than the exception. A large proportion of children with autism (around 50%) have an additional learning disability, and difficulties with receptive and expressive language vary enormously. For some children, language is limited or absent altogether, while for others, speech can be fluent, but even so, their use of language to communicate in social contexts (e.g., conversations) can be odd, awkward, and often one-sided. Furthermore, "stereotyped" and inflexible behaviors range from hand-flapping and finger-twisting to idiosyncratic special interests (e.g., prime numbers, train timetables, drain pipes) and an "insistence on sameness."

EXPLAINING CORE AUTISTIC BEHAVIORS: THE "THEORY OF MIND HYPOTHESIS"

There have been numerous attempts to try to pinpoint the underlying cause(s) of these symptoms. In his first descriptions of autism, Kanner (1943) suggested that we must "assume that these children have come into the world with innate inability to form the usual biologically provided affective contact with people" (p. 50). Although there was a time when practitioners of psychoanalysis – the prevailing dogma of the day – mistakenly believed that autism was an emotional illness caused by "faulty mothering" (Bettelheim, 1967), psychologists in the 1970s and 1980s became increasingly aware that a causal explanation could not lie at the level of behavior: the overt behavioral symptoms of people with autism change with age and ability and, moreover, the same behavior can be shown by different individuals for different reasons.

Research on autism took a turn following Premack and Woodruff's (1978) seminal article, "Does the Chimpanzee Have a Theory of Mind," which had resonated with researchers in London, who questioned whether atypicalities at the level of cognition, specifically difficulties in understanding other minds, might explain the core problems in sociability in autism. In a landmark study, Baron-Cohen, Leslie, and Frith (1985) put this possibility to the test. They administered a simplified version of the Maxi task (known as the "Sally-Ann task") to typically developing preschool children, older children with Down syndrome, and children with autism. Four- and 5-year-old typical children and children with Down syndrome responded correctly to the false-belief question, that Sally would look in the box where she mistakenly believes the marble to be. Yet 80% of their sample of children with autism answered incorrectly – that Sally would look in the basket, where the marble really is, despite the fact that the verbal mental age of these children was well beyond the 4- to 5-year-old level, when success on this task typically occurs.

This striking finding was taken as evidence that false-belief understanding – considered the hallmark of theory of mind at the time – is impaired in autism, which led the authors to propose that the core features of autism could be explained by a single primary cognitive deficit in the ability to understand other minds, thus placing individuals with autism "at a grave disadvantage when having to predict the behavior of other people" (p. 43) (see also Baron-Cohen, 1993, 1995; Baron-Cohen et al., 1985; Frith et al., 1991; Leslie, 1987, 1991). Indeed, Leslie (1987, 1991) and Leslie and Thaiss (1992) argued strongly that individuals with autism specifically lack the modular Theory of Mind Mechanism (ToMM), which in the typically developing child enables the formation of propositional attitudes [e.g., of the form, "X believes that (…)"], and provides insight into others' behavior.

These findings have since generated a huge body of work investigating the possibility that difficulties in theory of mind might play a causal role in the development of autism. In support of this position, a multitude of studies have demonstrated that many persons with autism perform poorly on tasks that require a representational understanding of other minds relative to appropriately matched comparison individuals (see Baron-Cohen et al., 2000, and Tager-Flusberg, 2001, 2007, for reviews), including those tapping the understanding of deception (Baron-Cohen, 1992; Russell, Mauthner, Sharpe, & Tidwell, 1991; Sodian & Frith, 1992), knowledge (Baron-Cohen & Goodhart, 1994; Leslie & Frith, 1988), complex emotions, such as surprise (Baron-Cohen, Spitz, & Cross, 1993), intention (Phillips, Baron-Cohen, & Rutter, 1998; Williams & Happé, 2010), in addition to recognition, comprehension, and expression of mental-state terms (Baron-Cohen et al., 1994; Tager-Flusberg, 1992; Ziatas, Durkin, & Pratt, 1998).

Importantly, according to the hypothesis, not *all* social behaviors should be equally affected by difficulties in theory of mind. Uta Frith and her colleagues sought to elucidate precisely those behaviors that on the surface appeared the same but in fact were functionally different. For example, Attwood, Frith, and Hermelin (1988) demonstrated that children with autism showed specific problems using expressive gestures (those that communicate an emotional/mental state: e.g., putting the hand to the mouth in embarrassment) but had no problems understanding and using gestures for instrumental purposes (those which influence the behavior of another person: e.g., finger on lips signals "be quiet").

Similarly, Sodian and Frith (1992) showed that the cognitive processes underpinning the ability to perform sabotage and the ability to deceive were fundamentally distinct. In the sabotage condition, children were shown a box with some sweets in it, and were introduced to two characters – a "nice" boy and a "not-so-nice" boy. If the nice boy saw a sweet in the box, then he would put another sweet in the box, and the child could take them home. If, however, the not-so-nice boy saw a sweet in the box, he would try to take it. The child therefore had to devise a way of preventing the not-so-nice boy from stealing the sweet. Sodian and Frith (1988) showed that typical children *and* children with autism were able to sabotage (using a padlock and key) the not-so-nice boy's attempts to take the sweet. In the deception condition, the padlock and key were removed, leaving the children with no physical means of preventing the boy from taking the sweet. Instead, children were required to use their mentalizing skills to trick the not-so-nice boy into thinking that the box was locked. Typical children were overwhelmingly able to "lie" to ensure that the thief did not take their sweet but autistic children of similar mental age could not. Despite broad similarities in the structure of the task, this "fine cuts" method was able to pinpoint those skills with which children with autism had the most difficulty: those that relied most heavily on representing other minds.

Taken together, these findings were exciting. The so-called theory of mind hypothesis seemed to capture what Kanner (1943) first described as "autistic aloneness." Certainly, a limited ability to realize fully what it means to have a mind and to think, know, believe, and feel differently from others should affect one's capacity to predict others' behavior and therefore relate to others socially. It should also influence one's ability to communicate effectively (see Happé, 1993). Indeed, links were made between successful theory of mind task performance and autistic individuals' use of language in a social context (or "pragmatic" skills) (Eisenmajer & Prior, 1991), in addition to "real-life" social difficulties, including the ability to make or keep secrets, offer important information, and recognize surprise and embarrassment (Frith, Happé, & Siddons, 1994; Hughes, Soares-Boucaud, Hochmann, & Frith, 1997; Tager-Flusberg, 2000). Leslie (1987, 1991) argued that a core impairment in "metarepresentation" in autism could also account for the limited imaginative or pretend play in autism during early childhood (see also Baron-Cohen, 1987).

CHALLENGES TO THE THEORY OF MIND HYPOTHESIS

It soon became evident, however, that the theory of mind hypothesis fell short of explaining the full range of autistic behaviors, or even the social features specifically, in all individuals with autism. To begin, the percentage of individuals with autism passing the false-belief task varied considerably among studies. In Baron-Cohen et al.'s (1985) original study, 20% of children with autism passed the critical false belief question.[1] In subsequent studies, this percentage varied from 15% (Reed & Peterson, 1990) to 90% (Dahlgren & Trillingsgaard, 1996). Later studies showed, however, that while some individuals with autism could pass first-order false-belief tasks, they failed more difficult, second-order false-belief attributions (i.e., of the form "Mary thinks that John thinks the ice-cream van is in the park"; Perner & Wimmer, 1985) despite being significantly older than the age at which such tasks are typically passed (6–7 years) (Baron-Cohen, 1989; Perner, Leekam, & Wimmer, 1987; but see Bowler, 1992), and also scored lower than verbal mental age-matched typical individuals on other advanced theory of mind tasks, such as Francesca Happé's (1994) Strange Stories (see also White et al., 2009). On this basis, Baron-Cohen (1989a) proposed that the development of theory of mind is initially delayed in autism rather than completely absent.

One major criticism of these initial studies was that the veracity of the theory of mind hypothesis in many respects hinged on the validity of the false-belief task as the gold standard for assessing theory of mind. Having a theory of mind was portrayed as an "all or nothing" skill, manifested by success or failure on first-order false-belief tasks. Bloom and German (2000) cautioned researchers regarding the ubiquity of the false-belief task as the "litmus test" for theory of mind for two reasons.

First, they suggested that passing the false-belief task required more than simply the capacity for theory of mind. Indeed, in the typical literature, studies had begun to reveal that 3-year-olds could fail standard false-belief tasks not solely due to limitations in representing others' mental states but to difficulties in a set of domain-general processes known collectively as "executive function." On the false-belief task, correctly predicting the protagonist's action relies on the child suppressing his or her own prepotent (albeit mistaken) knowledge of current reality while at the same time keeping track of the protagonist's actions and the location of the object in question. Experimental manipulations of the false-belief task in which the executive demands were reduced (e.g., by making current reality less salient) were shown to enhance typical 3-year-olds' performance (Carlson, Moses, & Hix, 1998; Cassidy, 1998; Hala & Russell, 2001; Leslie & Polizzi, 1998). The possibility that false-belief task performance might be constrained by additional limitations in executive function was a real possibility for children with autism, who showed difficulties in core components of executive function, including the abilities to plan ahead, to switch flexibly between tasks, and to generate novel, flexible behavior (e.g., Ozonoff, Pennington, & Rogers, 1991) – an issue that we shall return to in the sections below.

Second, Bloom and German (2000) further suggested that the emphasis on the false-belief task was misguided because theory of mind encompassed much more than simply understanding false belief. Most critically, they stressed that typically developing 3-year-olds and individuals with autism – both of whom had been characterized as showing "a deficit in theory of mind" – were in reality very different to one another. Typical 3-year-olds showed other early-emerging putative "precursory" mentalizing behaviors, like initiating and responding to bids for joint attention (i.e., looking where someone is looking), engaging in imaginary play, and social referencing (i.e., the ability to use social signals to guide action in novel situations) – behaviors that, by diagnostic definition, are limited in autism. Indeed, this objection posed a real challenge for the theory of mind hypothesis: how could an impairment in theory of mind – as indexed by performance on false-belief tasks *typically passed at the age of 4 years* – explain the earliest symptoms of autism including atypicalities in social responsiveness and reciprocity, gaze behavior, joint attention, and imitation often detected during infancy (e.g., Dawson & Adams, 1984; Klin et al., 1992; Mundy & Sigman, 1989; Volkmar et al., 1987).

In response to these challenges, subsequent theoretical accounts have broadened the definition of theory of mind in order to provide a causal explanation of the *development* of autism. Baron-Cohen (1995) proposed a more extensive "mindreading" system, which included not only a module for understanding mental states, such as think, believe, know, but also other early-emerging "precursor" modules, including innate mechanisms for eye-gaze detection and shared attention. Like other theorists (e.g., Bretherton, 1991; Tomasello, 1995; but see Moore & Corkum, 1994), Baron-Cohen (1994, 1995) suggested that the early appearance of joint visual gaze, and of shared attentiveness, may mark the beginning of an implicit understanding of mind, and may be a precursor for the ability to represent the full range of mental states. On his view, one of these modules – the Shared Attention Mechanism – is specifically "damaged" in autism, which, as a result, fails to trigger the subsequent development of the modular ToMM.

Tager-Flusberg (2001) proposed an alternative model. She interpreted the earliest symptoms of autism within a componential account of theory of mind, which encompasses a sociocognitive system that allows for mental-state reasoning, in addition to a socioperceptual system that includes eye-gaze perception, face recognition, emotion recognition, and imitation. Both systems are held to be fundamentally impaired in autism, and dissociations among systems may be present in other neurodevelopmental conditions (e.g. Williams syndrome; Tager-Flusberg & Sullivan, 2000). Similarly, others have postulated further that the social difficulties in autism extend beyond the processing of mental-state stimuli to include the on-line processing of social stimuli, including faces, voices, and gestures (e.g. Klin et al., 2002; Klin, Jones, Schultz, & Volkmar, 2003).

The need to explain some of the earliest manifestations of autism combined with the need to move away from the false-belief test as the pinnacle of theory of mind produced a flurry of research on the origins and developmental unfolding of this understanding, including the putative component skills – or "building blocks" – essential for a fully-fledged theory of mind. In the next section, I provide a brief overview of recent contributions to understanding those processes that might be necessary for the typical emergence of theory of mind, and relate these to what we know so far about autism.

BEYOND FALSE BELIEF: EARLY-EMERGING SIGNS OF UNDERSTANDING OTHER MINDS

Typically developing human infants appear to come into the world interested in, and attuned to, other people. Within the first few hours of life, infants can distinguish between a moving schematic face and a scrambled face (Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991), and are also able to recognize their mother's face within a few days of birth (Bushnell, Saï, & Mullin, 1989). Newborns are also exquisitely sensitive to others' gaze, preferring to look at faces with direct than averted eye gaze (Farroni, Csibra, Simion, & Johnson, 2002) or eyes closed (Bakti, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). And they also appear to have an inbuilt "life detector" (cf. Troje & Westhoff, 2006): 2-day-old infants can discriminate between biological vs non-biological (random) movement, and they look longer at an upright point-light walker compared with the same walker turned upside down (Simion et al., 2008). Indeed, researchers have suggested that biological motion detection is an adaptive mechanism designed to facilitate interaction with conspecifics, directing attention towards another agent and sets up the processing of other important cues (like eye-gaze direction and facial expressions). Some (Klin & Jones, 2008, 2009) have suggested further that the later development of a theory of mind is predicated on an early-emerging "theory of body."

These early-emerging skills are impressive. But typical infants are not only able to detect another agent; they are able to extract causality from the spatiotemporal cues of schematic events (e.g., Leslie & Keeble, 1987; Schlottmann & Surian, 1999), and can further perceive an agent's actions as directed at or about an agent, object, or situation. Woodward (1998) showed that 6-month-old infants can interpret an action (in this case, a grasping hand) as directed to the goal of acquiring a specific object. By 12 months, infants expect agents to achieve their goals in a rational (i.e., the most efficient) way (Gergely, Nádasdy, Csibra, & Bíró, 1995), and are more likely to attribute goals to computer-generated animations that appear to move by themselves than to non-self-propelled agents (Gergely & Csibra, 2003).

Self-propelled motion has been proposed by some authors to be the critical cue for goal-directed agency (Baron-Cohen, 1995; Leslie, 1994; Premack, 1990), although evidence that infants can interpret computer-generated animations as goal-directed even when the cause of the object's movement is not apparent (Csibra et al., 1999) suggests that infants' early understanding of goals might not be mentalistic. Indeed, Csibra and Gergely (1998) have proposed that the infant adopts a "teleological stance" – a non-mentalistic bias to construe an event in terms of goals. This bias extends to non-human phenomena, including simple animated shapes (such as interacting triangles; Heider & Simmel, 1944; Scholl & Treboulet, 2000), which are not only self-propelled but also react to each others' movement, thus showing non-mechanical contingency or "causation-at-a-distance." Interpreting such actions as goal-directed further warrants the attribution of mental states such as agency, intentions, desires, and emotions to such shapes. Indeed, viewing the contingent silent movements of geometric shapes evokes rich anthropomorphic descriptions about their goals, thoughts, and feelings (Heider & Simmel, 1944), and activates regions of the brain (like the posterior superior temporal sulcus) that are normally recruited for theory of mind (Abell et al., 2000; Castelli et al., 2000, 2002).

Infants are also highly attuned very early on to attend to ostensive, communicative signals. Three-month-old infants show an early sensitivity for eye-gaze direction, particularly mutual gaze; they smile less when an adult looks away, and resume smiling when the adult re-initiates eye contact (Hains & Muir, 1996). Also, 4-month-olds rapidly shift their own gaze towards a target only when such shifts are preceded by a period of mutual eye gaze (Farroni et al., 2003). Such sensitivity appears to hold special significance during infant–adult interactions. In one study, Senju and Csibra (2008) examined 6-month-old infants' gaze following as they observed a person looking toward a toy located on either the left or the right. Infants followed the adult's eye movement only when it was preceded by direct eye contact, suggesting an early awareness of the ostensive nature of gaze cues. In another study, 9-month-olds observed a face either always looking towards an object or always looking away from it. Infants preferred to look at an adult making object-directed shifts in eye gaze but, again, only when such shifts were preceded by direct gaze (Senju, Csibra, & Johnson, 2008). These findings suggest that the perception of someone "looking at me" influences subsequent processing of another's socio-communicative intentions.

From the age of 9 months, children begin to *use* eye-gaze direction as an indicator of another's interest or attention: they track spontaneously another's eye gaze to determine precisely what s/he is looking at ("joint attention"). Some theorists (e.g., Corkum & Moore, 1998) are cautious in their interpretation of this phenomenon, suggesting that it might result from a learned association between the direction of an adult's gaze and interesting (and therefore rewarding) events in the world. Yet others afford a rich interpretation to joint attention behavior, suggesting instead that such behavior plays a formative role in children's linguistic (Baldwin, 1995; Tomasello, 2003) and sociocognitive (Baron-Cohen, 1995) development. Indeed, 4-year-olds use eye-gaze direction as a cue to understand the intentions and desires of others (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995), and even 15-month-olds can detect a disparity between eye gaze and subsequent action (Onishi & Baillargeon, 2005). This ability not only developmentally precedes an understanding of complex mental states, such as false belief (Pellicano & Rhodes, 2003), but also is held to afford a "window into the mind" of others (Baron-Cohen, 1995).

Whatever their explanation individually, these foundational abilities to detect another agent, to ascribe intentions and goals to that agent, and also to detect and respond to that agent's ostensive signals (cf. Frith & Frith, 2010) together provide the basis for the development of successful social interactions, and therefore of theory of mind.

ATYPICALITIES IN EARLY-EMERGING THEORY OF MIND IN AUTISM

Consequently, much research in the past decade has focused on whether these early-emerging components of theory of mind follow an atypical trajectory in autism. The detection and analysis of biological motion, which might be critical in how we distinguish living creatures from other objects, does appear to be different in autism. School-age children and adolescents (e.g., Blake et al., 2003; Koldewyn et al., 2010; Jones et al., 2011 for review see Kaiser & Shiffrar, 2009) show a selective atypicality in the perception of biological motion, despite showing typical sensitivity to perceiving non-biological movement and form. And this reduced sensitivity to point-light displays of human movement is evident from an early age. Klin and colleagues showed typically developing toddlers, toddlers with developmental delay but not autism, and toddlers with autism, a point-light animation of biological motion of a children's game (e.g., "pat-a-cake" or "peek-a-boo") on one side of the screen combined with the soundtrack of the actor's vocalizations. On the other side of the screen, children viewed an upside-down version of the same animation. Unlike both comparison groups, the group of toddlers with autism failed to show a looking preference for the upright biological motion, instead looking equally at both sides of the screen. The instance in which toddlers with autism did preferentially attend to biological motion was during one specific animation, pat-a-cake. Here, autistic toddlers were captured by a *non-social* audiovisual contingency – the synchrony between the sound of the clapping and the point-light movements of the hands. Klin et al. (2009; see also Klin & Jones, 2008) suggest that these young children show a lack of preferential attention towards biological motion combined with a heightened sensitivity to cross-modal synchrony. The authors suggest that this combination of atypicalities veers children on an altered developmental trajectory from very early on in life, leading them to focus instead on what one might call "socially-irrelevant" information. Although the underlying mechanism, which fails to orient infants towards more relevant, social information, is poorly understood, the possibility that this fundamental (and evolutionarily old) behavior might develop differently in autism offers exciting opportunities for future research.

Despite showing reduced sensitivity to the perception of biological motion, the ability to detect animacy appears to be intact in autism (Celani, 2002; New et al., 2009), while the evidence with respect to perception of causality is somewhat mixed. Studies assessing the latter ability have used Michotte's (1963) launching and reaction events showing the ambiguous movements of two geometric objects (shapes A and B). In launch events, one object (shape A) moves toward a stationary object (shape B). If shape B moves immediately after contact with shape A, typical adults report that "A pushes B" or "A hits B and sets it in motion." In reaction events, shape A approaches shape B, which begins to move *before* contact with shape A; adults attribute intentionality to the animations, including reports of "A chases B" or "B escapes from A." Even 6-month-old infants are sensitive to the causal roles of the agents in habituation paradigms (Schlottman, Surian, & Ray, 2009).

One might expect children with autism, who purportedly show difficulties in theory of mind, to show reduced sensitivity to reaction events specifically, since these appear to automatically trigger psychological attributions. Yet Ray and Schlottman (2007) showed that school-age children with autism had difficulty perceiving launch but (rather paradoxically) not reaction causality. Another study by the same group reported, however, that older children and young people with autism showed no difficulty perceiving either type of causality (Congiu, Schlottmann, & Ray, 2010), despite showing reduced sensitivity to artificial animal movements, strengthening the evidence for atypical biological motion in autism. It is important to note that children with autism in both studies were much older than the age at which perceptual causality typically emerges. These null findings therefore suggest either that initial difficulties might be overcome with age or, alternatively, that older children were using alternative strategies for perceiving such causality.

Difficulty attributing intentional mental states to others upon observing their actions seems, however, to be especially difficult for people with autism. In the classic Heider and Simmel (1944) experiment, participants observed two triangles (one big, one small) and a small circle moving around a larger rectangle, and immediately imbued the triangles' ambiguous movements with social meaning. Typical children and adults find it irresistible to attribute identities ("friend", "bully"), goal-directed actions ("hiding", "trapping"), and mental and emotional states ("angry", "is surprised") to the otherwise ambiguous movements of the triangles. The narratives of individuals with autism, however, are far less mentalistic. Despite being able to pass standard false-belief tasks, they tend not to attribute social meaning to the animated shapes, at least to the same extent as typically developing individuals do (Abell, Happé, & Frith, 2000; Klin, 2000; Klin & Jones, 2006; Zwickel et al., 2010). Furthermore, autistic individuals show different neural activation patterns in the "social brain network" than typical individuals when observing the movement patterns that evoke mental-state attribution (Castelli et al., 2000, 2002).

Atypical patterns of reciprocal eye gaze are also a striking feature of autism. Indeed, this feature forms part of the diagnostic criteria for autism (APA, 2000), and may be one of its earliest (detectable) manifestations (e.g., Baron-Cohen et al., 1996; Zwaigenbaum et al., 2005) (see Nation & Penny, 2008, and Senju & Johnson, 2009, for recent reviews). Children with autism engage less in direct eye-to-eye contact (Sigman, Mundy, Sherman, & Ungerer, 1986) and fixate less on the eyes during spontaneous viewing of faces than typically developing children do (e.g., Pelphrey et al., 2002; but see Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009). Furthermore, they tend not to monitor the target of another person's gaze during joint visual attention (e.g., Leekam, Hunnisett, & Moore, 1998). In tasks that ask children to indicate which chocolate a character Charlie wants, or is going to take, from the direction of his eye gaze, children with autism do not use this information as a mentalistic cue (Baron-Cohen et al., 1995), and autistic adults show difficulties inferring another's mental state from viewing expressions in the eyes (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). This "failure" to understand the mentalistic significance of the eyes is thought to be instrumental in causing autistic children's theory of mind difficulties (Baron-Cohen, 1995).

Individuals with autism are not completely insensitive to eye-gaze direction, however. Children with autism show basic knowledge about eyes and seeing (Tan & Harris, 1991), can detect also whether someone is "looking at me" or "looking at not-me" (Baron-Cohen et al., 1995), and are able to follow line of sight (Leekam et al., 1997). Also, children with autism automatically shift their visual attention in response to an eye-gaze cue similar to typical children (e.g., Chawarska, Klin & Volkmar, 2003; Kylliäinen & Hietanen, 2004; Senju, Tojo, Dairoku, & Hasegawa, 2004).

On this basis, some researchers (Baron-Cohen, 1995) have claimed that there is a dissociation between detecting and interpreting eye-gaze direction in autism. Baron-Cohen (1995) argues that eye-gaze discrimination per se is intact in autism: individuals with autism are able to detect the presence of eyes, understand that eyes are for 'seeing,' and can determine direction of eye gaze in non-mentalistic contexts. The real difficulty in autism, instead, is thought to lie in the *interpretation* of directional information from eye gaze during joint (triadic) interactions. In particular, individuals with autism are unable to establish that the self and other are attending to the same object/event, and consequently fail to use gaze direction as an indicator of another's mental state – his/her attention, goals, motives or desires.

SPONTANEOUS THEORY OF MIND IN AUTISM

Together, these and other findings have led some authors (e.g., Frith & Happé, 1999) to suggest that people with autism might lack an "intuitive" or spontaneous theory of mind. These authors argued that success by individuals with autism on traditional false-belief tasks does not provide unequivocal evidence that these individuals have in fact developed a theory of mind. Consistent with this view, individuals with autism who pass standard false-belief tasks tend to perform poorly on more naturalistic tasks like the Heider and Simmel (1944) animated figures (Abell et al., 2000; Castelli et al., 2002; Klin, 2000), and still remain confused by everyday social interactions that require mentalizing (Frith, Happé, & Siddons, 1994). For example, Frith et al. (1991) suggested that cognitively able autistic individuals may have learned or extracted explicit rules about certain social situations, such as "When something in the world changes, people who just happen not to have seen the change occur behave (for some reason) as if they do not know about these changes" (p. 436). These "passers" could therefore be using such alternative (and considerably more effortful) compensatory routes to task success (Eisenmajer & Prior, 1991; Frith et al., 1991; Happé, 1995; Holroyd & Baron-Cohen, 1993; Ozonoff et al., 1991).

Separate sources of evidence favor the possibility that individuals with autism who pass classic false-belief tasks might be "hacking" out the solution using alternative strategies. Neuroimaging studies have provided indirect evidence for this claim, with reports of less activation in "social brain" regions (e.g. medial prefrontal cortex and temporoparietal junction, Mitchell, Banaji, & Macrae, 2005; Saxe & Kanwisher, 2003; see Frith & Frith, 2003, and Saxe, Carey, & Kanwisher, 2004, for reviews) combined with greater activation in neural regions associated with general problem- solving skills in adults with autism (e.g., Castelli et al., 2002; Happé et al., 1996). More direct evidence comes from a recent eye-tracking study of a paradigm used previously with infants, who are shown a scenario similar to the classic Maxi task. Infants seem to look longer – and therefore show surprise or "violation of expectation" – when Maxi reaches into the location in which the chocolate is currently hiding (the drawer), suggesting that infants show evidence of *implicit* mentalizing ability (Onishi & Baillargeon, 2005; Surian et al., 2007). Frith (2003) suggested that although explicit rule-based mentalizing can be learned in autism, spontaneous mentalizing ability, as shown by infants' eye movements in their second year, might never be accomplished.

To test this possibility, Senju et al. (2009) presented a similar task to adults with Asperger syndrome, who were all able to pass standard theory of mind tasks, and tracked their eye movements as they watched the scenario play out. Typical adults, like typical 25-month-olds (Southgate et al., 2007), immediately looked to the empty box for the ball, where the protagonist falsely believed it to be. Adults with Asperger syndrome, however, reportedly had "mindblind eyes": they looked equally at both boxes, suggesting that they were unable to predict implicitly where the protagonist should look for the ball. Although older and more able individuals with autism may be able to solve standard false-belief tasks, these findings indicate that there is an "absence of *spontaneous* mentalizing in autism" – the sort of processes automatically used by typical infants, toddlers, and children to successfully navigate everyday social interaction, and which might require the integrity of those developmentally early-emerging building blocks of social cognition, including the perception of causality and animacy, sensitivity to biological motion, and the ability to recognize communicative intent using ostensive cues.

Another study from the same group, however, suggests that the story might not be so straightforward. Zwickel, White, Coniston, Senju, and Frith (2010) tracked the eye movements of adults with autism as they watched several Heider and Simmel-type animations. Despite attributing less intentionality to the animate shapes than typical individuals, adults with autism showed *similar* fixation patterns to typical adults; they spent more time watching the triangles rather than other part of the display, and spent an equal amount of time focusing on each triangle, which was especially important for animations involving theory of mind, such as "mocking." They further showed that adults with autism could adopt the visuospatial perspective of another agent – both implicitly and explicitly.

These recent data suggest that the (implicit) abilities to detect social agents and to appreciate how the world looks to another person – spontaneous abilities thought to be potential building blocks for later social cognition – are not lacking in autism. Zwickel et al. (2010) suggest that these particular implicit abilities might be intact in autism because they were "fundamental survival skills" in an evolutionary sense, long before attributing mental states to potential predators became relevant. That said, data from young children with autism suggest that another early-emerging (and evolutionarily "old") skill, spontaneous detection of biological motion, is impoverished (Klin & Jones, 2009). It will be critical to try and assess all of these abilities from the earliest possible ages because it is certainly possible that the reportedly intact spontaneous agency detection and visuospatial perspective-taking skills in adults with autism (Zwickel et al., 2010) may have initially followed a delayed and/or different developmental trajectory.

These investigations are in the early stages, and future work may delineate a clearer picture of precisely which early-emerging sociocognitive building blocks are atypical in autism. This goal of determining how and when infants with autism might begin to follow a different developmental trajectory to that of typically developing infants, however, is difficult to achieve since autism is not usually diagnosed until 2–3 years of age (and in some children, much later). Investigators studying the behaviors of infant siblings of children with autism, who are at a higher risk of developing autism themselves, are optimistic that such studies will provide these important clues (e.g., see Rogers, 2009; Tager-Flusberg, 2010; Yirmiya & Charman, 2010).

Whatever the difficulties in emergent mentalizing skills, atypicalities in these alone, however, will not explain fully the real-life functioning of individuals with autism. There is vast variability both in the extent to which individuals with autism pass traditional theory of mind tests and in their competence during everyday tasks that rely on mentalizing, including making and keeping friends, turn-taking during conservations, and responding to others' needs. Understanding this variability in autism, and further deepening our knowledge of the way that social cognition develops – typically or atypically – requires moving beyond a narrow understanding of theory of mind itself. In the final section of this chapter, I discuss the possibility that the emergence of social cognition may be critically dependent on other non-theory of mind functions.

BEYOND THEORY OF MIND: THE ROLE OF OTHER CONTRIBUTING FACTORS

Contemporary developmental approaches (e.g., Bishop, 1997; Karmiloff-Smith, 1998, 2009; Pennington, 2006) emphasize the dynamic nature of developing systems, where interactions among domains are likely to be the norm. On this view, it is not surprising to suggest that other functions might play a critical role in the development of theory of mind both in typically developing children and in children with autism. In this section, I shall discuss the relationship between children's growing theory of mind and two such functions, language and executive control.

Language and theory of mind

It is well-documented that performance on standard false-belief tasks is correlated with typical children's language ability (for a recent meta-analysis, see Milligan, Astington, & Dack, 2007). False-belief tasks are, of course, highly verbal in nature, and so it is perhaps unremarkable that children who have better language skills tend to pass false-belief tasks from an earlier age. Many researchers, however, have suggested that there is a functional relationship between language and false-belief understanding, although the underlying nature of the relationship is hotly debated. Some theorists have claimed strongly that syntactic development, specifically children's mastery of sentential complements – namely, a tensed proposition embedded under a mental (e.g., *think/believe/know*) or communication (e.g., *said*) verb (e.g., Marc *thinks* [that] his keys are in the kitchen) – might be a necessary prerequisite of a representational theory of mind (e.g., de Villiers & de Villiers, 2000; Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003). Sentences containing complements are unique because the whole sentence can be true (e.g., Marc thinks X) even though the embedded clause may be false (e.g., his key are not in the kitchen). Once the child acquires the ability to understand sentential complements, it allows him/her "to entertain the possible worlds of other minds, by a means that is unavailable without embedded propositions" (de Villiers, 2000, p. 90).

Other researchers, however, have emphasized the important use of language for sociocommunicative purposes. They suggest that language facilitates the development of an explicit theory of mind because conversation with others enables a constant exchange of differing points of view: i.e., it allows children to talk about the mind (Harris, 1996, 2005; Peterson & Siegal, 1995, 1999, 2000). Evidence for these models comes from studies of atypical development, especially children with hearing impairment. Children who are born deaf but grow up in hearing families show impoverished performance on tasks of false-belief attribution purportedly because, unlike children born deaf and raised by deaf parents, they lack the conversational input that is necessary for the typical development of theory of mind (Peterson & Siegal, 1995, 1999, 2000).

Language delay and deviance are one of the defining characteristics of autism. It is not surprising, therefore, that poor verbal ability has been cited as one explanation for autistic children's poor performance on false-belief tasks, and even their delayed development of theory of mind. Indeed, Happé's (1995) review of theory of mind showed that a certain level of verbal ability was necessary for children with autism to succeed on standard false-belief tasks, which was considerably higher than that of typically developing children. An abundance of cross-sectional (e.g., Charman & Baron-Cohen, 1992; Fisher, Happé, & Dunn, 2005; Leekam & Perner, 1991) and some longitudinal (Pellicano, 2010; Steele et al., 2003; Tager-Flusberg & Joseph, 2005) work has since shown that language ability, especially grammatical ability, is significantly related to autistic children's performance on standard false-belief tasks. Whether the mechanism involves mastery of sentential complements or conversation with others (and it will possibly be a combination of both skills), these findings suggest that early language skills might play an important role in facilitating autistic children's understanding of the representational nature of mind.

Executive function in theory of mind

The emergence of another critical function – children's growing self-control or "executive function" – has been offered as an additional explanation of autistic children's (limited) performance on false-belief tasks. Executive function is an umbrella term for a set of higher-order processes, including working memory, inhibitory control, and cognitive flexibility, closely associated with the prefrontal cortex, that are necessary for regulating and controlling behavior, especially in new situations. It shows a protracted developmental trajectory, which begins in early infancy and continues well into adolescence (Diamond, 2002) and shows a boost in development around the preschool period (Carlson, 2005; Diamond, 2002; Hughes, 1998a; Luciana & Nelson, 1998; Zelazo & Müller, 2002) – precisely when typical preschoolers are beginning to show an explicit awareness of others' minds. They begin, that is, to succeed at tasks that require them to hold information "in mind" and work with it, in addition to inhibiting a salient or prepotent response – two essential features of executive tasks (Pennington et al., 1997).

Typical children's progress in theory of mind has been shown to be intimately tied to improvements in executive function in development. Numerous studies have reported robust correlations between individual differences in tasks tapping theory of mind and tasks tapping several components of executive function, independent of age and general intellectual functioning, in preschoolers (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Carlson, Moses, & Claxton, 2004b; Frye, Zelazo, & Palfai, 1995; Hughes, 1998a, 1998b), and in toddlers (Carlson, Mandell, & Williams, 2004a; Hughes & Ensor, 2007).

The most clear-cut explanation of this relationship is that false-belief prediction tasks used to index theory of mind place considerable demands on children's executive function and, hence, that executive function is thought to contribute to the *expression* of theory of mind rather than to its development (Carlson & Moses, 2001; Leslie, 1994; Leslie & Polizzi, 1998; Moses, 2001; Russell et al., 1991). The executive demands of the classic false-belief task are manifold. Any difficulties keeping track of the protagonist's actions and the whereabouts of the object, and/or inhibiting reference to one's more salient, current (and true) belief could therefore severely limit autistic children's performance on false-belief tasks (see Russell, Saltmarsh, & Hill, 1999, and Russell, Hala, & Hill, 2003, for discussion).

Despite potential difficulties with the false-belief task, however, several theorists have provided good reasons to suppose that there is a more fundamental relationship between these two cognitive domains, where functioning in one domain is critical to the *emergence* of functioning in the other. Such theorists diverge as to the nature of the functional link. Some assert that the abilities to monitor one's actions and to act with volition are critical for reflecting on the mental states of self and other: i.e., that theory of mind emerges from executive function (e.g., Russell, 1996; see also Moses, 2001, and Pacherie, 1997). Conversely, others suggest that the causal arrow is in the opposite direction: children's growing ability to regulate their behavior is dependent on their developing metarepresentational capacity underlying theory of mind (e.g., Perner, 1998; Perner & Lang, 1999).

The very co-occurrence of problems in theory of mind and executive function in autism is suggestive of a link between these domains. Several cross-sectional studies have reported significant correlations between theory of mind (as generally tapped by false-belief understanding) and components of executive function, independent of age, verbal ability, and nonverbal ability (Colvert, Custance, & Swettenham, 2002; Joseph & Tager-Flusberg, 2004; Ozonoff et al., 1991; Pellicano, 2007, 2010). To examine the nature of the association between these skills, Ozonoff et al. (1991) calculated the extent of "impairments" within each cognitive domain by calculating the percentage of individuals with autism who scored below the mean score of the typically developing group. Although difficulties in executive function were near-universal in their sample, theory of mind problems were present in only half of the autism group. On this basis, Ozonoff et al. (1991) suggested both that atypicalities in executive function are primary in autism and that a third factor was required to explain the link between these skills.

Pellicano (2007) re-examined Ozonoff et al.'s (1991) suggestion by investigating the pattern of associations between theory of mind and executive function in 4–7-year-old children with autism, but this time using a more conservative definition of "impairment": the percentage of children with autism who scored more than one standard deviation below the mean of the typically developing group. In her sample, no child with impaired executive function also possessed intact theory of mind – precisely the pattern of results predicted by Russell (1996). Pellicano (2007) therefore concluded that good executive skills are a necessary, but not sufficient, precondition for the development of theory of mind in autism.

Recent longitudinal data have further strengthened this claim. Tager-Flusberg and Joseph (2005) tested children with an autism spectrum condition on numerous theory of mind (including false-belief tests) and executive function tasks at intake and re-evaluated their theory of mind skills 1 year later. Children's early executive skills predicted developmental changes in theory of mind independent of language and initial theory of mind scores, suggesting, akin to Pellicano (2007), that executive function is critical for children's developing theory of mind. Pellicano (2010) extended these findings in a 3-year prospective study of autistic children's cognitive skills to show that, like Tager-Flusberg and Joseph (2005), children's executive abilities at intake were predictive of improvements in theory of mind over the 3-year period. Critically, however, she also showed that predictive relations did not exist in the reverse direction: i.e., early theory of mind did not predict developmental changes in executive function. These findings show the strongest support yet for the notion that early executive skills might play a critical role in shaping the development of theory of mind in children with autism.

Since Bloom and German's (2000) plea for researchers to abandon the false-belief task as the cornerstone of theory of mind, there has been considerable interest in the way that other functions, especially language and executive function, might influence children's performance on false belief and other tests of theory of mind, but also, and more critically, how these functions might shape the development of an explicit representation of other minds. Certainly, findings from the autism literature suggest that both language and executive function might be important limiting and enabling factors in the (a)typical developmental trajectory of theory of mind. The nature of the relationship, of course, could be mediated by a third factor, such as social interaction (cf. Hughes, 1998b; Luria, 1966). Both good language skills and good executive function capacity might enable children with and without autism to participate in effective social exchanges, especially with peers, which could result in multiple cascading events on children's emerging sociocognitive skills.

Future research in this area will surely elucidate the precise determinants of explicit belief attribution. The data as they stand, however, already suggest that any theoretical model of sociocognitive development – in autism or in typical children – must delineate how internal (e.g., language, executive function) and external (e.g., social interaction) factors might influence children's developmental trajectories. In so doing, such a model must also identify a means by which key internal factors like executive function shape the development of important early-emerging theory of mind behaviors other than those directly related to false-belief prediction. Some authors have already proposed such a relationship, suggesting that early executive abilities, such as inhibitory control or attentional flexibility, may in fact be critical for the development of joint attention (e.g., Mundy & Newell, 2007; Nichols, Fox, & Mundy, 2005) and pretend play (e.g., Jarrold, 2003).

CONCLUSION

It has been almost three decades since researchers proposed that atypicalities in understanding other minds could explain the core sociocommunicative symptoms of autism. During this time, the field has witnessed an explosion of research on the topic, with more recent research dedicated to going both beyond false belief – by identifying the necessary preconditions for the emergence of theory of mind in both typical and atypical development – and beyond theory of mind – to specify the role of other critical functions, which might shape the developmental trajectory of mental-state attribution.

The broadening of the definition of theory of mind to extend beyond false-belief understanding does introduce a degree of circularity in which the first signs of autism (poor gaze monitoring, failure to orient towards social stimuli) are, by definition, components of poor theory of mind (see Hughes & Leekam, 2004, for discussion). Further refinement of the theory will therefore necessitate an understanding and delineation of the underlying *mechanisms* responsible for the development of an implicit theory of mind, and how these might be different in autism, in addition to specifying which of these mechanisms might then be necessary for the emergence of an explicit theory of mind. Are the developmental origins of sociocognitive atypicalities in autism rooted in fundamental difficulties identifying what is relevant versus what is irrelevant in the social world (e.g., detection of another agent) (Klin et al., 2009)? Or are they due to a fundamental lack of interest in the social world (cf. Dawson et al., 2005)? Furthermore, can individuals (with autism) develop an explicit awareness of other minds, created perhaps through compensatory executive function and language skills, despite experiencing atypicalities in early-emerging intuitive mentalizing skills? And if so, is there genuinely a difference at the representational level for those who develop theory of mind via the usual route (implicit → explicit) compared to those who do not?

Researchers will also need to grapple with the pervasiveness of the disadvantage in social cognition in autism. As noted earlier, there are some "islets" of social ability in individuals with autism (e.g., Attwood et al., 1988; Sodian & Frith, 1992). These individuals can attribute judgments of attractiveness and trustworthiness to photographs of faces (White et al., 2006), and acquire culturally transmitted knowledge about stereotypes (Hirschfeld et al., 2007). Other studies have shown, however, that autistic individuals' sociocognitive atypicalities might extend beyond truly "mentalistic" contexts. For example, Pellicano and Macrae (2009) showed that mutual eye gaze does not facilitate basic person-perception judgments (gender categorization) for children with autism, like it does for typically developing children (see also Akechi et al., 2009), rendering it possible that "someone looking at you" does not modulate broader social (in this case, person-construal) processes in autism, rather than failing to do so in mentalistic contexts alone.

Understanding the breadth of weaknesses and strengths in social cognition in autism is critically important for practical efforts aimed at improving the functional outcomes of individuals with autism, and ultimately their well-being. Specifically, it should direct attention towards identifying how we might alleviate the often-profound social difficulties in autism by pinpointing the most promising candidates for intervention. Can we train individuals with autism to attend to (or be motivated by) another agent? Can the spontaneous, implicit theory of mind atypicalities be overcome by compensations in other areas? If so, which other areas should these be? If we can answer these questions experimentally then we might be able to enhance the life experience of people with autism and discover something crucial about social cognition more generally.

There is, however, one final cautionary tale to tell. Several recent studies have attempted to promote social behavior in autism using oxytocin, a hormone that is particularly important in forming parent–child bonds (see Bartz & Hollander, 2008, for review). For example, Andari et al. (2010) asked adults with autism and typical adults to play a computerized ball-tossing game (a game of "catch") with three other virtual players. Typical adults quickly established alliances with some players and not with others, while adults with autism failed to interact selectively with the most socially cooperative player. The experimenters then randomly selected half of the autistic adults to receive a nasal spray of oxytocin. They found that those who had inhaled oxytocin began to cooperate selectively, and subsequently avoid certain players – precisely like typical adults, but quite unlike those adults with autism who were administered a saline placebo. In many respects, this study was extremely successful, with adults with autism exhibiting increased levels of social behavior and affect under oxytocin. Yet one might also suggest that, prior to oxytocin, adults with autism behaved impartially, tossing the ball equally among players, while under oxytocin, this impartiality disappeared, and autistic adults played the game like typical adults, displaying a potentially worrying partiality (Dawson, 2010). These findings highlight the need for caution: making individuals with autism more like us might not be uncomplicatedly a good thing.

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NOTE

1 False-belief tasks usually consist of only a few experimental trials, where chance performance on each trial is 50% (where the protagonist initially left the object or where it really is now). One should therefore not necessarily expect ***all*** persons with autism to fail false-belief tasks; some individuals may "pass" due to random responding.

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