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Theory of mind in normal development and autism

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A theory of mind remains one of the quintessential abilities that makes us human (Whiten, 1993). By theory of mind we mean being able to infer the full range of mental states (beliefs, desires, intentions, imagination, emotions, etc.) that cause action. In brief, having a theory of mind is to be able to reflect on the contents of one's own and other's minds. Difficulty in understanding other minds is a core cognitive feature of autism spectrum conditions. The theory of mind difficulties seem to be universal among such individuals. This paper describes some of the manifestations of this abnormality, and emphasizes how developmentally appropriate tests are needed in order to reveal it. Throughout the paper, the terms 'theory of mind', 'mindreading', and 'understanding other minds' are used synonymously.

The mental-physical distinction

I start this review with the mental-physical distinction since many consider that this distinction is a fundamental cornerstone of our theory of mind, and one that is not explicitly taught by parents or teachers. The test for this distinction involves the child listening to stories in which one character is having a mental experience (e.g., thinking about a dog) whilst a second character is having a physical experience (e.g., holding a dog). The experimenter then asks the subject to judge which operations the two characters can perform (e.g., which character can stroke the dog?). Whilst 3-4 year old normal children can easily make these judgments, thereby demonstrating their good grasp of the ontological distinction between mental and physical entities and events (Wellman & Estes, 1986), children with classic autism have been found to be significantly impaired

at making such judgments (Baron-Cohen, 1989a). This is despite having a mental age at least equivalent to a 4 year old level.

Understanding of the functions of the brain

This test was also originally devised by Wellman and Estes, and involves asking the child what the brain is for. They found that normal 3-4 year olds already know that the brain has a set of mental functions, such as dreaming, wanting, thinking, keeping secrets, etc., Some also knew it had physical functions (such as making you move, or helping you stay alive, etc.). In contrast, children with autism (but who again had a mental age above a 4 year old level) appear to know about the physical functions, but typically fail to mention any mental function of the brain (Baron-Cohen, 1989a). In these studies, mental age is usually assessed in terms of verbal abilities, since non-verbal mental age tends, if anything, to be higher than verbal mental age. In this way, one is able to check that the deficit is not due to insufficient mental age.

The appearance-reality distinction

Flavell and colleagues (Flavell, Green & Flavell, 1986) found that children from about the age of 4 years old normally are able to distinguish between appearance and reality, that is, they can talk about objects which have misleading appearances. For example, they may say, when presented with a candle fashioned in the shape of an apple, that it looks like an apple but is really a candle. Children with autism, presented with the

same sorts of tests, tend to commit errors of realism, saying the object really is an apple, or really is a candle, but do not capture the object's dual identity in their spontaneous descriptions (Baron-Cohen, 1989a). Given that to do this requires being able to simultaneously keep track of what an object looks like, versus what it actually is - how you perceive or think about it subjectively, versus how it is objectively - it is an additional clue that in autism there is a deficit in the development of a theory of mind.

First-order false belief tasks

These tasks relate to the understanding that different people can have different thoughts about the same situation. They are called first-order tests because they only involve inferrring one person's mental state. (See below for discussion of second-order tests). Normal 4 year olds can keep track of how different people might think different things about the world (Wimmer & Perner, 1983). We have similarly found that, when interpreting well-known stories such as Little Red Riding Hood or Snow White, even 4 year olds will say things like "Little Red Riding Hood *thinks* that it's her grandmother in the bed, but really it's the wicked wolf!"; or "Snow White *thinks* the old woman is giving her a nice juicy apple. She doesn't *know* that it's really her wicked step-mother all dressed up, and that the apple is poisoned!". A large number of studies have demonstrated that children with autism have difficulties in shifting their perspective to judge what someone else might think, instead simply reporting what they themselves know (Baron-Cohen, Leslie & Frith, 1985; Baron-Cohen, Leslie & Frith, 1986; Leekam

& Perner, 1991; Perner, Frith, Leslie & Leekam, 1989; Reed & Peterson, 1990; Swettenham, 1996; Swettenham, Baron-Cohen, Gomez & Walsh, 1996).

"Seeing leads to knowing" tests

Another corner stone of typically developing children's theory of mind is understanding where knowledge comes from, so that they can work out who knows what, and more importantly, who doesn't know what. Typically developing 3 year olds can understand the seeing-leads-to-knowing principle, in that when given a story about 2 characters, one of whom looks into a box and the other of whom touches a box, they can infer that the one who looked, will know what's in the box, whilst the other one will not (Pratt & Bryant, 1990). In contrast, children with autism are virtually at chance on this test, as likely to indicate one character as the other when asked "Which one knows what's in the box?" (Baron-Cohen & Goodhart, 1994; Leslie & Frith, 1988).

Tests of recognizing mental state words

By 4 years old, normally developing children can also pick out words from a word list that refer to what goes on in the mind, or what the mind can do. These words include "think", "know", "dream", "pretend", "hope", "wish", and "imagine". These are easily distinguished from other kinds of (non-mental) verbs like "jump", "eat", or "move". Children with autism have much more difficulty in making this judgment (Baron-Cohen et al., 1994).

Tests of production of the same range of mental state words in their spontaneous speech

The previous finding dovetails with reports that children with autism produce fewer mental state words in their spontaneous descriptions of picture stories involving action and deception, and in their conversational discourse, compared to their normal counterparts (Baron-Cohen et al., 1986; Tager-Flusberg, 1992).

Tests of the production of spontaneous pretend play

Many studies have reported a lower frequency of pretend play in the spontaneous play of children with autism (Baron-Cohen, 1987; Lewis & Boucher, 1988; Ungerer & Sigman, 1981; Wing, Gould, Yeates & Brierley, 1977). This might reflect a failure to reflect on one's own imagination - a mindreading deficit (Leslie, 1987).

Tests of understanding more complex causes of emotion (such as beliefs)

Emotions can be caused by situations (such as falling over causes you to cry, or being given a present causes you to feel happy). But emotions can also be caused by mental states such as desires and beliefs (Harris, Johnson, Hutton, Andrews & Cooke, 1989). Thus, you can be happy because you got what you wanted, or because you think you are getting what you wanted. Harris and colleagues found that normal 4-6 year olds

understand all 3 types of emotional causation. In contrast, studies show that children with autism with this mental age have difficulty with mental states as causes of emotion (Baron-Cohen, 1991; Baron-Cohen, Spitz & Cross, 1993).

Tests of inferring from gaze-direction when a person is thinking, or what a person might want

Why do we spend so much time looking at people's eyes? We now know that from gaze-direction, children as young as 4 years old can work out when someone is thinking about something (e.g., gaze directed upwards and away, at nothing in particular, strongly signifies the person is thinking (Baron-Cohen & Cross, 1992)). Gaze-direction also allows young normal children to work out which of several objects a person wants, or might be interested in, or might be referring to (Baldwin, 1991; Bruner, 1983; Butterworth & Jarrett, 1991). Children with autism, in contrast, are relatively blind to such information from gaze-direction, even though they can answer the explicit question "What is Charlie looking at?" (Baron-Cohen, 1989c; Baron-Cohen, Baldwin & Crowson, 1997a; Baron-Cohen, Campbell, Karmiloff-Smith, Grant & Walker, 1995; Baron-Cohen & Cross, 1992; Hobson, 1984; Leekam, Baron-Cohen, Brown, Perrett & Milders, 1997). Mentalistic interpretation of the eyes of another person does not seem to come naturally to them.

Tests of being able to monitor one's own intentions

We have covered a number of tests of understanding other people's thoughts, but another important class of mental states is intentions. Working out why people behave as they do is all about keeping track of people's intentions, since tracking actions alone gives a description of what people do, but not why they do it. In a novel test of this, 4 year old normal children were asked to shoot a toy gun at one of six targets, stating their intended target. Then, unbeknownst to the child the outcome was manipulated by the experimenter, such that sometimes the child hits their chosen target, and sometimes they did not. Normally developing 4 year olds could correctly answer the question "Which one did you mean to hit?", even when they did not get what they intended, but children with autism often made the error of answering by reference to the actual outcome (Phillips, Baron-Cohen & Rutter, 1998).

Tests of deception

Deception is relevant to understanding other minds simply because it involves trying to make someone else believe that something is true when in fact it is false. In other words, it is all about trying to change someone else's mind. A number of studies show that by the age of 4 years old the normally developing child is showing both an interest in deception, and beginning to practice it (Sodian, Taylor, Harris & Perner, 1992). Children with autism, when studied under experimental conditions, have been shown to have difficulties both in production of deception, but also in understanding when someone else is deceiving them (Baron-Cohen, 1992; Sodian & Frith, 1992; Yirmiya, Solomonica-Levi & Shulman, 1996).

Tests of understanding metaphor, sarcasm, jokes, and irony

Some studies have tested if children with autism understand figurative speech through story comprehension. Figurative speech requires an understanding of the speaker's intentions, in order to move beyond the literal level of simply mapping words onto their referents. Examples of figurative language include sarcasm ("How clean your room looks today!", uttered by an exasperated parent to her child), and metaphor ("she's got a sharp tongue!"). Results suggest that this more advanced mindreading test (pitched at the level of a normal 8 year old) reveals the subtle mindreading deficits in individuals with high-functioning autism. They may confuse the intentions of the speaker (Happe, 1994). A similar finding using a simpler test comes from a study of normal preschoolers based on testing if they can understand someone's intention to joke. Children as young as 3 years old heard utterances like "This is a shoe", spoken by the experimenter whilst pointing at a cup, and were asked why the experimenter said that. Whereas even normal children referred to the speaker "joking" and "pretending", in their explanation, children with autism tended to refer to the speaker having got it wrong ("it's not a shoe, it's a cup" etc.,) (Baron-Cohen, 1997).

Tests of pragmatics

Understanding figurative speech and humour is just a subset of pragmatics, or the use of language appropriate to the social context. Aspects of language in autism are

considered in more detail elsewhere (Tager-Flusberg, 1993), but pragmatics includes at least the following:

- tailoring one's speech to a particular listener;
- adapting the content of one's speech to what your listener already knows or needs to know;
- respecting conversational maxims (Grice, 1975/1957) such as being truthful, relevant, concise, and polite;
- turn-taking appropriately so that there is space for both participants in the dialogue;
- being sensitive to the other person's contribution to the conversation;
- recognizing what is the wrong or right thing to say in a particular context;
- staying on topic; and
- appropriately helping your listener to follow when a topic change is occurring.

Almost every aspect of pragmatics involves sensitivity to speaker and listener mental states, and hence mindreading, though it is important to note that pragmatics also involves using context. Two experimental studies of pragmatics in children with autism have included (1) a test of whether the Gricean maxims of conversational relevance can be recognized (Baron-Cohen, 1988; Tager-Flusberg, 1993), and a test of recognizing when someone said the wrong thing (faux pas) (Baron-Cohen, O'Riordan, Stone, Jones & Plaisted, 1999a). In the first task, the child has to work out which of two possible replies would be an inappropriate answer to a question. In the second study, the child has to identify if anyone said anything they should not have said, based on hearing a short story.

Both studies suggest that children with autism have difficulties in this area (Surian, Baron-Cohen & Van der Lely, 1996).

Tests of imagination

We discussed the relevance of pretend play earlier, and this is one possible way that imagination can be expressed. More broadly, imagination is relevant to theory of mind since it involves an unreal world that exists purely in your mind, and being able to reflect on this virtual world. The virtual world is the content of one's mental state of imagining. One study of children with autism investigated the ability to draw pictures of unreal or impossible objects (such as two-headed people), and found that children with autism were either reluctant or less able to produce such drawings (Scott & Baron-Cohen, 1996).

Correlation with real-life social skills

One might raise the concern that theory of mind tasks simply measure aspects of social cognition under laboratory conditions, and as such have no relevance to social impairment in the real world. For this reason, Frith and colleagues have examined the correlation of theory of mind skills in children with autism in relation to real-world behaviour, as measured by a modified version of the Vineland Adaptive Behaviour Scale (Frith, Happe & Siddons, 1994). They report that these are indeed significantly correlated, providing some measure of validity of the tests.

Second-order false belief tests

The universality of theory of mind deficits in autism have been questioned simply because a proportion of children with autism or the related condition of Asperger Syndrome pass first-order tests. First-order tests, including most of those reviewed above, involve simply inferring one person's mental state, e.g., what John thinks. Happe points out that this need not challenge the universality claim, since there are no reported cases of autism spectrum disorder who pass first order theory of mind tests at the right mental age. Thus, an individual with high-functioning autism or Asperger Syndrome, who by definition has normal intelligence, should be able to pass such tests at 3-4 years of age. Typically however, they are older than this when they pass such tests. In children with autism, Happe finds that on average a verbal mental age of 9 years old is needed before passing of such tests is seen, and that the youngest mental age of an individual with autism passing such tests is 5.5 years (Happe, 1995).

As one might expect, as a result of a delay in acquiring first-order theory of mind competence, these individuals often fail second-order false belief tests (Baron-Cohen, 1989b). Second-order tests involve considering embedded mental states, e.g., what John thinks that Mary thinks. Whereas first-order tests correspond to a 4 year old mental age level, second-order tests correspond to a 6 year old mental age level. Second-order tests can be another way of revealing if there is a *specific developmental delay* in theory of mind at a later point in development. However, some individuals with high-functioning

autism or Asperger Syndrome may pass even second-order false belief tests by their teens (Bowler, 1992; Happe, 1993; Ozonoff, Pennington & Rogers, 1991). Those who can pass such second-order tests however may have difficulties on the more advanced theory of mind tests described earlier, such as inferring bluff and double bluff in story characters - an 8 year mental age level test - (Happe, 1994), or in decoding complex mental states from the expression in the eye-region of the face (Baron-Cohen, Jolliffe, Mortimore & Robertson, 1997b; Baron-Cohen, Wheelwright & Jolliffe, 1997c).

An even more dramatic demonstration of this is the deficit on this task reported in an Oxbridge University Mathematics Professor with Asperger syndrome, who had won the equivalent of the Nobel Prize (the Field Medal) (Baron-Cohen, Wheelwright, Stone & Rutherford, 1999b).

Conclusions

Mindreading deficits in autism spectrum conditions appear to be early occurring (from at least the end of the first year of life, if one includes joint attention[1] deficits) and universal (if one tests for these either at the right point in development, or in the case of high-functioning, older subjects by using sensitive, age-appropriate tests). Parents of children with autism spectrum conditions, may also show difficulties in attributing

[1] Joint attention involves monitoring what you and another person are simultaneously attending to. It is discussed elsewhere (Baron-Cohen, 1989c; Leekam et al., 1997).

mental states when just the eye-region of the face is available (Baron-Cohen & Hammer, 1997), suggesting that genetic reasons may underlie this.

The brain basis of the theory of mind deficit in autism is being investigated using both functional neuroimaging and studies of acquired brain damage [Baron-Cohen, 1999 #1203;Happe, 1996 #1082;(Stone, Baron-Cohen & Knight, 1999; Stone, Baron-Cohen, Young & Calder, submitted). These suggest that key neural regions for normal mindreading are the amygdala, orbito-frontal cortex, and medial frontal cortex. Finally, much of the basic research in this field may have clinical applications in the areas of either intervention or early diagnosis (Baron-Cohen et al., 1996; Hadwin, Baron-Cohen, Howlin & Hill, 1996; Howlin, Baron-Cohen & Hadwin, 1999)[2].

[2] This recent book reports materials used in a study to train mindreading skills, using explicit methods, in children with autism. Results show training does improve performance, but with limited generalisation.

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