DEVELOPMENTAL PSYCHOPATHOLOGY

Volume 1: Theory and Methods

Editors

DANTE CICCHETTI

AND

DONALD J. COHEN

A Wiley-Interscience Publication

John Wiley & Sons, Inc.

New York • Chichester • Brisbane • Toronto • Singapore

CHAPTER 12

Theory of Mind and Face-Processing: How Do They Interact in Development and Psychopathology?

SIMON BARON-COHEN

My intention in this chapter is to focus on just two topics: (a) the development, in the child, of an understanding of mental states (or "theory of mind"), and (b) the development of face-processing. Let me begin by addressing the question of why theory of mind and face-processing are of special interest.

WHY FOCUS ON THEORY OF MIND AND FACE-PROCESSING?

A number of reasons guided my selection of these two topics. First, these are two of the most exciting growth areas in the field of social cognition, probably because both are being studied at multiple levels—face-processing, in terms of computational theory (Bruce, 1988) and neurobiology (Perrett et al., 1985), and theory of mind, in developmental psychology (Astington, Harris, & Olson, 1988; Wellman, 1990), primatology, and artificial intelligence (Whiten, 1991). Second, both of these areas are vulnerable to impairment (Baron-Cohen, Tager-Flusberg, & Cohen, 1993; Ellis & Young, 1989). I shall explore what psychopathology can teach us about the normal processes underlying these two abilities, and vice versa, thus illustrating a key principle of developmental psychopathology (Cicchetti, 1984). The major relevant clinical syndromes are autism and prosopagnosia, although I discuss other disorders briefly along the way.

My third reason for selecting these two areas is that they have remained almost entirely unconnected. Although a sizable body of research has studied emotion-recognition in facial expressions (Ekman & Friesen, 1971; Hobson, 1986), no work has looked at whether the broader range of mental states that we attribute to others (thoughts, desires, goals, and so on) is influenced to some degree by information contained in their faces. My main aim here will be to suggest that there are important, but hitherto unacknowledged, connections between face-processing and theory of mind. I begin by reviewing the literature on theory of mind.

UNDERSTANDING MENTAL STATES

When we attribute mental states such as thoughts, beliefs, desires, and intentions to ourselves and others, we employ what Premack and Woodruff (1978) called a theory of mind. What is a theory of mind for? Might it have a biological basis? If so, why might it have evolved? We will consider, later, some evidence from autism that suggests a theory of mind may have a biological basis, but the function and evolutionary value of a theory of mind have recently been considered by Cheney and Seyfarth (1990), who invited us to imagine some possible scenarios in evolutionary history:

> (I)magine a group of baboons in which individuals are extremely skilled at judging behavioral contingencies . . . but unable to identify the motives or knowledge of others. . . . Imagine further that among these baboons . . . adult males solicit each other for support in alliances. . . . If male baboons are incapable of recognizing the motives of other animals . . . [they] will always be vulnerable to those who *cheat*. . . .
>
> Now imagine that into this group of nonintentional baboons comes a mutant male capable of attributing states of mind to others. . . . (H)e recognizes a distinction between an animal's behavior and the motives that underlie it. As a result, he recognizes that however much a solicitor *seems* likely to reciprocate, this may not actually be his intention. Such knowledge will not necessarily make the mutant male any less vulnerable to cheaters on his first interaction with them, but is certainly likely to make him more sceptical in subsequent interactions. . . . In short, the new male will have a competitive advantage over others in his group, because in being able to assess his companions' motives, he is better able to predict their behaviour. (pp. 249–251, italics added)

This chapter was written while the author was supported by grants from the Mental Health Foundation and the Medical Research Council. I am grateful to Ruth Campbell, Uta Frith, and Dante Cicchetti for comments on the first draft of this chapter. Correspondence should be addressed to the author.

Figures 12.3 and 12.4 originally appeared in the Fairburn System of Visual References (1978). Efforts at tracing this publisher have been unsuccessful, but their source is gratefully acknowledged.

This example underscores important adaptive advantages that possession of a theory of mind confers on an individual: the capacity to recognize deception, and the capacity to predict how a person will behave on the basis of his or her mental states. Having a concept of another persons' knowledge or belief also opens up the possibility of manipulating what they believe (practicing persuasion and deception). Cheney and Seyfarth (1990) suggested that the capacity to *teach* is a further adaptive advantage conferred by possession of theory of mind:

> Suppose there exists a group of macaques in which one animal . . . suddenly develops a new method for acquiring and preparing food. . . . (I)f the inventor can attribute ignorance to others . . . there is an immense amount to be gained. An inventor who possesses a theory of mind can selectively *transmit* her knowledge to kin. . . . She can also selectively *withhold* her knowledge from rivals. . . . (S)he need not depend on the relatively slow process of observational learning to transmit her skill but instead can engage in active pedagogy. Once again, an individual capable of attribution would seem to have a clear selective advantage over others. (p. 251, italics added)

These are just some of the major benefits that ensue from possession of a theory of mind. Others include the ability to: predict behavior on the basis of beliefs, judge intended meanings in language, and show empathy (Baron-Cohen, 1988; Dennett, 1978b; Happé, 1993).

Given the apparent importance of a theory of mind, a recent wave of research in developmental psychology has attempted to trace its development. One starting point has been to ask whether infants understand that actions are *caused* by mental states. Infants can distinguish animate movement from inanimate movement (Gelman & Spelke, 1981)—they are sensitive to the difference between internal and external causation of movement—but it is still unresolved whether they recognize the internal causes of animate movement as *mental* states (Premack, 1990; Wellman, 1990). By the time toddlers start to talk, however, it is clear that they talk about actions in terms of mental states. From as early as 18 to 24 months, normal children refer to a range of mental states: desires, beliefs, thoughts, dreams, pretense, and so on (Shatz, Wellman, & Silber, 1983; Wellman, 1990). This suggests that, at the very least, they have what Bretherton, McNew, and Beeghly-Smith (1981) called an *implicit* theory of mind. Studies with slightly older children have focused on obtaining evidence for an *explicit* theory of mind. These studies are reviewed next.

Developing a Theory of Mind: A Review

Research into the development of a theory of mind gathered considerable momentum following Premack and Woodruff's (1978) "Does the Chimpanzee Have a 'Theory of Mind'?", a provocative article that reviewed a series of fascinating experiments suggesting that chimpanzees can take into account an actor's mental states. For example, in one experiment, a chimpanzee watched a film of an actor struggling to obtain bananas that were inaccessible. The film was frozen at the point of the struggle, and the animal was given a choice of photographs indicating various outcomes. Typically, the chimpanzee chose the picture showing the solution to the actor's frustration (stepping onto a box in order to reach the bananas). This led Premack and Woodruff to conclude that "the chimpanzee solves problems such as the present one . . . by imputing states of mind to the human actor" (p. 518).

Understanding Belief

In the discussion that followed, several commentators raised the criticism that the solution of such tasks does not necessarily require any reasoning about mental states (Dennett, 1978a). Instead, they proposed that the "acid test" of when an organism is judging another's mental state arises in situations of *false belief*, in which the subject is exposed to current reality but another person is exposed to only partial (or wrong) information about reality. Under such conditions, it is possible to separate, unambiguously, judgments based on the subjects' *own* mental state (their true belief) from judgments based on the other persons' different mental state (their false belief). Thus, suppose a subject knows that (a) the key is in the hallway but (b) Dante *thinks* it's in the bedroom. If asked where Dante would look for the key, the subject should judge that Dante will look in the *wrong* place—the bedroom.

Within developmental psychology,[1] Wimmer and Perner (1983) employed such a test and showed that not until around 4 years of age do normal children pass such a test. An adaptation of their test (Baron-Cohen, Leslie, & Frith, 1985) is illustrated in Figure 12.1.

The test involves appreciating that, because Sally was absent when her marble was moved from its original location, she won't *know* it was moved, and therefore must still *believe* it is in its original location. On the belief question ("Where will Sally look for her marble?"), 85% of normal children answered correctly. All subjects passed a memory control question ("Where was the marble in the beginning?") and a reality control question ("Where is the marble really?"), as well as a naming question ("Which doll is Sally?"), thus ruling out the possibility that the normal 3-year-olds' failure on the belief question was caused by such factors as inattention, memory or language overload, or lack of motivation. The result replicated that of Wimmer and Perner (1983), and later studies essentially confirmed the finding that false beliefs are not well understood until 4 years of age (Perner, Leekam, & Wimmer, 1987).

In recent years, the finding that age 4 is a turning point in understanding false beliefs has been challenged by a number of investigators. Thus, whereas Wimmer and Perner (1983) argued that the false belief data indicated the presence of a conceptual *deficit* in younger normal children, newer studies (Fravel, Lewis, & Doherty, 1991; Wellman, 1990) suggested that when simpler experimental methods are employed, normal children younger than 4 years of age do show some evidence of understanding false belief. The age at which there is a genuine conceptual limitation on young children's understanding of other minds' beliefs remains controversial.

[1] Research into children's developing theory of mind has its roots in Piaget's work and in the philosophy of mind and language (see Perner & Wilde-Astington, 1991.)

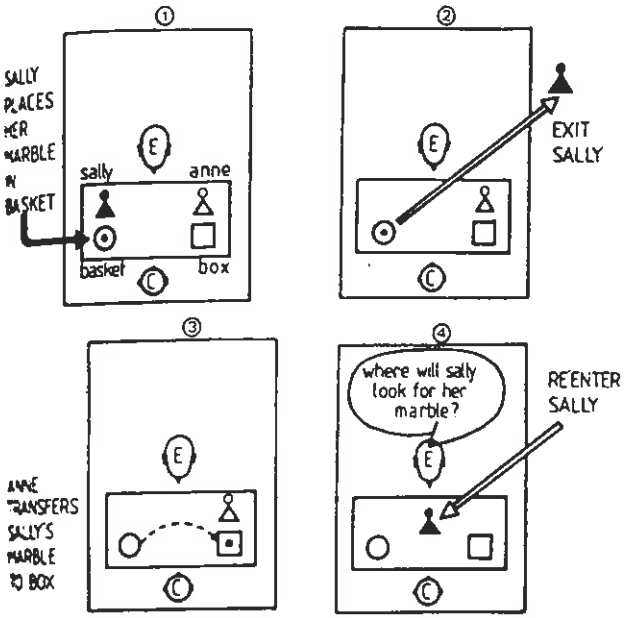

Figure 12.1 A simple test for children's understanding of false belief. From "Does the Autistic Child Have a 'Theory of Mind'?" by S. Baron-Cohen, A. M. Leslie, and U. Frith, 1985, *Cognition, 21*, pp. 37–46. Copyright 1985 by Elsevier Science Publishers BV. Reprinted by permission.

Understanding Desire and Intention

Desire is often thought to be *the* other key mental state, next to belief, in our folk psychology (Dennett, 1978b). With beliefs and desires, all kinds of behavior become interpretable. For example, when watching a movie and trying to understand why John Wayne suddenly dived under a table, we might refer to his *belief* that the loud noise he heard was a gunshot and his *desire* to stay alive. Several studies have shown that, for normal children, desire is understood earlier than belief—in fact, desire is clearly understood by normal 2-year-olds (Wellman, 1990). The "terrible twos" have been interpreted as evidence of this age group's growing awareness of the frustrating difference between their own and their parents' desires (Wellman, 1990).

A mental state closely related to desire is intention. The two states are distinguishable, as Astington and Lee (1991) and Phillips (1993) made clear: it is possible to desire something and yet to have no intention of fulfilling that desire. (One might desire to visit a friend in Australia, but have no intention of going there.) Intention is related to desire in that one way of fulfilling one's desires is to formulate an intention—a plan of action—to fulfill them. Desires are sometimes fulfilled fortuitously (your Australian friend might turn up on your doorstep unexpectedly), but the principal means for fulfilling desires is with intentional actions. When do young children grasp the concept of intention?

A large part of the literature on children's understanding of mentality centers on their appreciation of the distinction between intentional and accidental acts and on their judgments of responsibility and blame. Understanding intention has also been studied separately from moral development. Some early studies in this area (Berndt & Berndt, 1975; King, 1971; Smith, 1978) found a significant change around 4 years of age in the ability to distinguish acts "done on purpose" from accidental acts. Children younger than this were reported to err on the side of assuming that *everything* was intentional—an echo of Piaget's (1929) findings.

More recent studies by Astington and Lee (1991) extended this work by investigating young children's ability to distinguish outcomes that appear the same but differ in the crucial respect of the actor's intention. Thus, in one story, a girl intends to feed her breadcrumbs to the birds, and then she does so; in another story, a girl accidentally drops some bread crumbs. The birds end up being fed just the same. In such a test, the child is asked, "Which girl *meant* to feed the birds?" These findings are broadly similar to the earlier studies: chance performance occurs before age 4.

Understanding Pretense

Children begin to produce pretend play from as early as 10 to 18 months of age (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). Experiments with verbal children also show that, as soon as they can answer questions, they seem to understand that pretense is distinct from reality (Wellman, 1990). This is clearly a complex achievement. In terms of the acquisition of different mental state concepts, understanding pretense may even predate understanding desire (Baron-Cohen, 1991a; Gopnik & Slaughter, 1991), although longitudinal data on this are needed.

Pretense was, for a long time, studied as part of symbolic development (McCune-Nicholich, 1981; Piaget, 1962). In an important article rethinking the nature of pretense, Leslie (1987) put forward a theory that focused on children's understanding of pretense as a mental state. He argued that the logical properties of pretense resembled the logical properties of other mental states (such as belief), and, on these grounds, children's understanding of pretense might reflect an important stage in the origins of a theory of mind.

Part of Leslie's claim also centered on the sort of cognitive architecture that would be needed to support comprehension not only of pretense but of all mental states. His suggestion was that a capacity for *metarepresentation* would be minimally required. He defined metarepresentation as the ability to represent an agent's mental attitude toward a proposition. (For details of the component parts of this system, see Leslie, 1987; Leslie & Roth, 1993; for counter-arguments, see Perner, 1988, 1991, 1993.) The implication is that pretense might mark not only a developmental stage in the acquisition of a theory of mind, but a qualitative change in the sort of representational mechanisms available to cognition.

Understanding Perception

Piaget and Inhelder's (1956) "three-mountains task" broke new ground in suggesting that children between 4 and 6 years old were unable to select a picture that showed how a view would appear to different people at different locations. Such children, Piaget and Inhelder reported, tended to attribute their

own spatial perspective to other people—an error that became the hallmark of Piaget's concept of "childhood egocentrism."[2]

Flavell, Shipstead, and Croft (1978) challenged this view by employing far simpler experimental techniques. They distinguished between two levels of visual perspective-taking. The first they called Level 1—the ability to infer *what* another person can see. This appears to be present by age 2 (Flavell, Everett, Croft, & Flavell, 1981; Flavell et al., 1978; Lempers, Flavell, & Flavell, 1977). Thus, 2-year-olds can put things out of or bring things into sight, when requested to do so. Level 2 of visual perspective-taking is the ability to infer *how* the object appears to another person. This ability seems to take longer to develop; in fact, not until 3 to 4 years of age do children reliably pass Level 2 tasks. For example, when shown a picture of a turtle that appears either right-side up or upside-down (depending on the location of the viewer), young 3-year-olds fail to identify correctly which of these two perspectives the experimenter would have (Flavell et al., 1981).

Before moving on to consider abnormalities in the development and use of a theory of mind, it is worth noting that relatively little work has looked at later normal development of this ability. Perner and Wimmer (1985) studied slightly older children for the ability to attribute beliefs about beliefs to others (so-called *second-order belief attribution*), and found this appears for the first time at around 6 years of age. Riviere (1993), using a simpler paradigm, found this ability appearing slightly earlier—in 5-year-olds. Leekam (1991) reported on related developments in the use and comprehension of figurative speech such as irony and sarcasm. Studies that tap adult levels of functioning in this domain are still needed. In the next section, I consider what happens when a theory of mind fails to develop normally.

ABNORMALITIES IN THE COMPREHENSION OF MENTAL STATES

Autism

Autism is a developmental disorder characterized by severe social and communication abnormalities (Baron-Cohen, 1988; Frith, 1989; Kanner, 1943; Rutter, 1983). A sizable body of work documents the deficits in understanding mental states in children with autism (Baron-Cohen, Tager-Flusberg, & Cohen, 1993). For example, on tests of false belief comprehension, children with autism make more errors than both normal and mentally handicapped children of a younger mental age (Baron-Cohen, 1989a, 1989b; Baron-Cohen, Leslie, & Frith, 1985, 1986; Leekam & Perner, 1991; Leslie & Frith, 1988; Perner, Frith, Leslie, & Leekam, 1989; Reed & Petersen, 1990). This deficit appears to relate to the symptoms these children show in social and communicative development (Baron-Cohen, 1988; Happé, 1993; Frith, Happé, & Siddons, 1994).

Most children with autism fail tests of belief understanding, but a minority of them, ranging from 20–35% in different samples, do pass. When these subjects are given a more taxing test of belief understanding (comprising understanding second-order, nested beliefs, or *beliefs about beliefs* ("Anne thinks Sally thinks x"))—these being well within the comprehension of normal 6- to 7-year-old children (Perner & Wimmer, 1985)—even most teenagers with autism fail outright (Baron-Cohen, 1989b; Ozonoff, Pennington, & Rogers, 1991). It appears, then, that although most children with autism do not understand beliefs even at the level of normal 3- to 4-year-old children, some do; but these show impaired understanding of beliefs at the level of normal 6- to 7-year-old children. Something is going wrong in the development of the concept of belief in children with autism. This has been discussed in terms of specific developmental deviance and delay in autism (Baron-Cohen, 1989b, 1991a, 1992a).

An inability to understand others' beliefs reveals itself most dramatically on tests of deception in autism (Sodian & Frith, 1992). As discussed earlier, because deception entails belief manipulation, performance is consistent with difficulties in belief comprehension. Thus, in the Penny Hiding Game (Gratch, 1964), a simple test of deception, children with autism fail to hide the clues that enable the guesser to infer the whereabouts of the penny (Baron-Cohen, 1992b; Oswald & Ollendick, 1989). For example, they leave the empty hand open, or they hide the penny in full view of the guesser, or they show the guesser where the penny is, before the guesser has guessed. Subjects with mental handicap and normal 3-year-old children make far fewer errors of this sort.

When children with autism are asked how a story character will feel when given something the children either *want* or do not want, no impairments are found, relative to a mental-age matched control group without autism (Baron-Cohen, 1991b). Understanding these simple aspects of desire thus seems to be within their ability, although more complex aspects of desire and intention pose problems for them (Phillips, 1993). On tests of understanding *perception*, children with autism have been tested at both levels of visual perspective-taking (Baron-Cohen, 1989d, 1991c; Hobson, 1984; Leslie & Frith, 1988; Reed & Petersen, 1990; Tan & Harris, 1991) and appear to show no deficits. However, in studies of *pretense* (Baron-Cohen, 1987; Ungerer & Sigman, 1981), children with autism seem to produce significantly less spontaneous pretend play than mentally handicapped control groups. Similarly, on tests of understanding *knowledge*, children with autism make more errors than control groups (Baron-Cohen & Goodhart, 1994; Leslie & Frith, 1988; Perner et al., 1989).

The indication from these studies is that not *all* mental states pose difficulties for children with autism: certain aspects of perception and desire do not; pretense, knowledge, intention, and belief do. Explaining this specific pattern of intact and impaired comprehension is currently the focus of debate (Baron-Cohen, Tager-Flusberg, & Cohen, 1993). However, the claim that these deficits are specific to autism appears less controversial, and relies on experimental evidence from other clinical groups. Other childhood clinical populations tend to pass false belief tests. These populations include children with Down syndrome (Baron-Cohen et al., 1985), mental handicap of unknown etiology (Baron-Cohen, 1989b), language impairment (Leslie & Frith, 1988), conduct disorder (Frith et al.,

[2] Light and Nix (1983) showed, however, that even the notion that children are biased to select their *own* view is not correct: rather, children are biased to select a "good" view.

deafness (Sellars & Leslie, 1990), William's Syndrome iloff-Smith, 1992), and callosal agenesis (Temple & oya, 1990). Further clinical populations remain to ed, but the deficit does seem to be autism-specific. That disorders leave the development of a theory of mind ely intact is some confirmation for Fodor's (1987, 2–133) view that a theory of mind is so important that it en innately *built in* to the human mind and is a universal. nd Harris (1991) provided some cross-cultural data in rt of this view.

rmal Development of a Theory of Mind in Clinical Groups

n seems to reflect the most severe disruption to the normal ition of a theory of mind—these children often do not ar- t the fundamental stage of appreciating that mental states s beliefs even *exist*—but there are other disorders in which en reach this basic level but show difficulties in the *accu- se* of a theory of mind. Thus, in schizophrenia, some have d that symptoms of paranoia (Baron-Cohen, 1989e) are an ssion of inaccurate attribution of beliefs to others (for ex- , the paranoid delusion: "The man on the television *knows* I am thinking"). This comparison with autism may be of derable theoretical value (Frith & Frith, 1991). Similarly, nduct disorder (Dodge, 1980), aggressive behavior is often ted to be the outcome of inaccurate attribution of inten- to others ("You *deliberately* bumped into me").

third disorder in which it has been hypothesized that abnor- heory of mind development may occur is narcissistic person- disorder (Fonagy, 1989). In these patients, it is argued—on asis of clinical rather than experimental studies—that the ng lack of empathy such individuals show may reflect not a of awareness that other people have minds, but a psychologi- efense against confronting the contents of other people's s.

nally, patients with semantic-pragmatic disorder (Bishop,) are thought to have particular difficulties in accurately ifying a speaker's communicative intent and taking into ac- t a listener's informational needs—what the listener needs to for an utterance to be understood. These subjects may well op considerably with autism (Baron-Cohen, 1988; Lister- & Bowler, 1992), but it is possible that the two conditions lso distinguishable. Future work is needed to establish the t to which they are indeed separable disorders, and to what t deficits in theory of mind use differ between them.

o summary, the impressive ability of even very young normal dren to use a theory of mind, apparently effortlessly, and the ese consequences of its impairment in autism, suggest the ex- ce of a specialized cognitive mechanism for understanding al states. The studies from autism have been enriched by and en have challenged models of the normal development of a ry of mind (Baron-Cohen, 1990, 1991c, 1995). A theory of d is a strong candidate for a modular mechanism in the brain is, 1991)—a mechanism that is neurologically and informa- lly independent. It is assumed to be biological in origin because autism has a biological basis (Rutter, 1983) and (b) because it appears to be universal (Avis & Harris, 1991). In the next section, I review the development of face-processing, before considering the interesting question as to whether face-processing may play a role in the functioning of our theory of mind.

FACE-PROCESSING

Normal Face-Processing in Childhood: A Brief Review

Any parent can relate how faces seem to hold a particular fascination for infants, almost from birth. In the scientific literature, it is 30 years since the simple but important experiments (Fantz, 1961, 1963) showing that newborn infants prefer a drawing of a human face over other kinds of drawings. Newborns also are more interested in tracking schematic face-patterns than either scrambled faces or blank head outlines (Goren, Sarty, & Wu, 1975; Johnson, Dziurwiec, Bartrip, & Morton, 1991; Maurer & Young, 1983). By 2 months, infants prefer looking at (and not just tracking) a real face rather than a drawing of a face (Lewis, 1969), and a regularly arranged schematic face rather than a scrambled face (Caron, Caron, Caldwell, & Weiss, 1973; Fantz, 1961, 1963).[3]

Why should infants show such a strong preference for faces? Morton and Johnson (1991) suggested that, for newborns and 1-month-old infants, a preference for faces appears to be driven by an innate mechanism that guides the infants' attention toward conspecifics' faces. They call this mechanism "Conspec," and they argue that it ensures that the neonate attends to faces—and, therefore, likely caregivers. To quote Morton and Johnson (1991): "The information contained within Conspec need only be sufficient to select the parents' face from the set of likely stimuli in the species-typical environment. It need not be species- or even class-specific" (p. 85). Conspec information, they argue, is available without the organism having to be exposed to specific stimuli.

Which aspects of the face do infants attend to? One aspect seems to be the *movement* properties. They prefer to look at moving rather than stationary heads (Carpenter, 1974; Sherrod, 1979), and movement such as nodding and changing facial expression causes them to smile and imitate (Meltzoff, 1990). In contrast, faces that remain entirely stationary have the effect of provoking distress in infants, even as young as 2 months of age (Field, 1979; Tronick, Als, Adamson, Wise, & Brazelton, 1978). Precisely which parts of the face are preferred seems to vary with age. Thus, 1-month-old infants appear to attend to the contour of the head, 2-month-olds focus more on the eyes, and 5-month-olds attend to the nose-mouth area of the face (Caron et al., 1973).

The importance of the *eyes* over other parts of the face is suggested by a range of studies. Parents report their subjective experience of obtaining eye contact after their babies are about 4 weeks of age (Berger & Cunningham, 1981). Two- to 3-month-olds look longer at a face when its eyes are open rather than closed, and they show strongest preference for a face with its eyes moving (Maurer, 1985), but show no comparable preference

[3] After this, a different response pattern can often be found (see Morton & Johnson, 1991).

for a face with an open rather than a closed mouth. Maurer and Barrera (1981, study 1) also found that 2-month-olds looked less than half as long at a face in which eyes and eyebrows were omitted than at a naturally drawn face or at a face in which mouth and nose were omitted. There was no significant difference between how long they looked at a drawing of a complete face versus one with the mouth and nose omitted. These results, shown in Figure 12.2, strongly suggest that the preference for faces is actually a preference for the eyes (or eye region), and is not influenced to the same degree by the nose and mouth. (In Maurer and Barrera's second study, they demonstrated that this preference for the eyes was not affected by the position of the eyes.)

Most studies assume that the main function underlying infants' fascination with the face is to ensure that they learn to recognize people's *identities*. Thus, Morton and Johnson (1991) emphasized that one key ability that becomes available after the maturation of a new mechanism (which they called "Conlern") at 2 months of age is the ability to distinguish between one face and another. "Conlern is a device that acquires and retains specific information about the visual characteristics of individual conspecifics" (Johnson & Morton, 1991, p. 90). These authors then discussed the possibility that this second mechanism is neurologically and informationally dissociable from the earlier (Conspec) mechanism. Conlern, then, is held responsible for children's rapid acquisition of expertise in identity recognition.

This emphasis on the identity-recognition function of face-processing in the early infancy period would in no way lead one to think of any connection between face-processing and theory of mind. However, in the next section, I explore some arguments suggesting that face-processing may play a role in the development and use of a theory of mind.

Could Face-Processing Play a Role in the Development of a Theory of Mind?

Evidence from Joint Attention

One function of face-processing that appears to entail some early use of a theory of mind is seen in *joint attention* (Bruner, 1983). The earliest of these behaviors appears to be *deictic gaze*: the infant spontaneously looks across in the direction of another person's gaze, in order to check what the person is looking at. Scaife and Bruner (1975) found that 30–40% of infants showed this skill by 2 to 7 months, 60–70% by 8 to 10 months, and 100% by 11 months (Scaife & Bruner, 1975). Presumably, the information being used by the infant to judge what another person is looking at is derived from the *direction of the eyes*. The infant appears to be reading this information from the eyes very much as it reads information from the index finger later, recognizing that it *points* (or refers) to things (Butterworth, 1991).

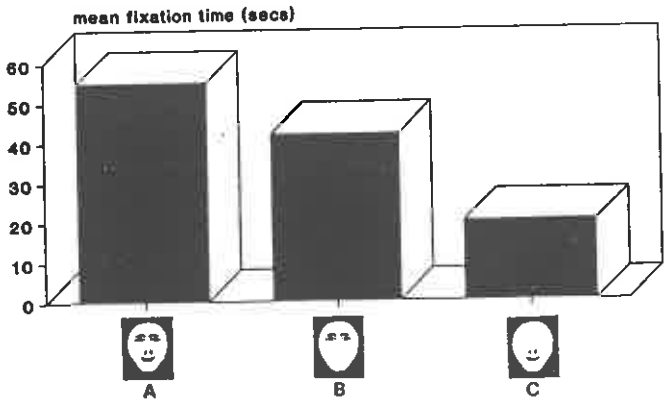

Figure 12.2 The mean length of fixation on facelike drawings by 2-month-olds. Adapted from data in Maurer (1985).

Other joint-attention behaviors include giving, showing, and pointing out objects to others; all of these behaviors appear by 10 to 14 months of age (Bates et al., 1979). The production of these three behaviors directs other people to *look at* objects. They all involve face-processing in that the child makes eye contact, then alternates the gaze with a look at the target of the other person's gaze, and then resumes eye contact. This sequence is known as *gaze alternation* (Gomez, 1991). Exactly the same pattern of gaze alternation is seen in children's comprehension of these gestures.

The link I wish to draw between joint attention and theory of mind requires one critical premise: what children are doing during joint attention is not simply computing what is in someone's visual field or calculating the geometry of objects in the environment; rather, they are computing what that person is *attending to* (Baron-Cohen, 1989c, 1989d, 1991c). Having computed this, they then either *monitor* the person's attention (during deictic gaze and in comprehension of another person's showing and pointing gestures) or *direct* it (in pointing things out with the index finger or the eyes, or showing objects to another person). Given that attention itself is a mental state, joint attention could be viewed as comprising an early stage in the development of a theory of mind.

There is some evidence in support of the premise that joint-attention behaviors entail the child's possessing a concept of attention. First, in producing pointing and showing behaviors, the child does not seem to be simply trying to get the person to move his or her head in the appropriate direction or to change his or her visual field. Rather, the child appears to clearly intend the person to look at a *particular* object: the child will repeat the gesture insistently if the person looks at the wrong thing (Baron-Cohen, 1989d). If we define attention as *selective perception*, the infant's attempt to direct the person's perception to a particular object justifies the use of the term *attention*. Second, the child appears to then check how the person reacts (smiles, looks alarmed, or gives other responses) to the pointing or showing gesture. As in social referencing (Sorce, Emde, Campos, & Klinnert, 1985), the other person's *appraisal* of the particular object being pointed out, shown, or reacted to, seems to be a critical part of the goal of the behavior (Baron-Cohen, 1991c; Hobson, 1990). The child is therefore not just directing the person to look in a given direction but rather to *selectively attend* to a particular object of interest (concern, delight, and so on).

One possible function of eye-processing then, from about 9 months of age on, is to monitor and direct other people's attention. The important work by Perrett et al. (1985), showing that a specialized group of cells in the temporal cortex of macaque monkeys responds selectively to gaze, opens up lines of

ific research that may specify the brain bases of such cog- mechanisms and cognitive deficits. In a recent study, we computation of eye direction to be easily within the abil- normal 3-year-olds (Baron-Cohen & Cross, 1992). Sub- were asked which of two children, in a photograph of en's faces, was looking at them. Each pair contained one looking straight ahead and one looking slightly away (see e 12.3). Available cues were either eye direction or eye di- on plus nose direction, but it was apparent that even 3-year- ormal children could make this distinction, and, from the of Butterworth and his colleagues (Butterworth, 1991), it ely that this skill is present in infancy.

ence from Goal Detection

cond possible function of eye contact (and thus, of face- essing) that relates to the use of a theory of mind is in *goal tion*—the ability to judge another person's goal. Goal de- on is a fundamental part of our understanding of action: ecognize actions as being *goal-directed.* Because people al- *look at* the object they act on, it follows that eye direction ides information not only about what a person is attending ut also about the target (or goal) of the person's next ac- It may be, then, that one reason for making eye contact is acilitate goal detection. And because goals are mental states, face-processing again appears to interact with theory of mind.

At what age might such goal detection via face-processing begin? Phillips, Baron-Cohen, and Rutter (1992) investigated this with normal infants ranging from 9 to 18 months. The child was presented with either an ambiguous or an unambiguous action. One ambiguous action comprised blocking the child's hands during manual activity; an adult's hands were cupped over the child's. A second ambiguous action comprised offering an object to the child, but then, at the last minute, teasingly withdrawing it, just as the child began to reach for it. The unambiguous action simply comprised giving or presenting an object to the child. This study found that, on at least half of the trials, 100% of the infants responded to the ambiguous actions by instantly looking at the adult's eyes (within the first 5 seconds after the tease or the block); only 39% did so following the unambiguous action. This suggests that, under conditions in which the goal of an act is uncertain, the first place young children (and indeed, adults) look for information to disambiguate the goal is the eyes. In a further study, we demonstrated that children indeed use eye direction in the goal-detection function of face-processing (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, in press). Thus, when 3-year-olds are asked, "Which chocolate will Charlie take?", after being shown a display of 4 chocolates and Charlie's

gure 12.3 Test of "Which one is looking at you?" From "Reading the Eyes: Evidence for the Role of Perception in the Development a Theory of Mind" by S. Baron-Cohen and P. Cross, 1992, *Mind and Language, 6,* pp. 172–186. Reproduced from Fairburn System of eral References (1978).

face (a cartoon representation) looking at one of these, they tend to pick the one he is *looking at* as the goal of his next action.

Evidence from Thought Detection

Joint attention and goal detection are two face-processing phenomena that suggest a mentalistic function might drive them. A further phenomenon we have tested (Baron-Cohen, Campbell et al., in press; Baron-Cohen & Cross, 1992) is in *thought detection*—the ability to judge when another person is thinking. We do not mean being able to recognize the *content* of someone's thoughts, only that someone is thinking. In this experiment, normal 3- and 4-year-olds were shown a series of photographs of pairs of children's faces, in which one child was looking straight ahead and one was looking upward and sideways, with neutral emotional expression in the mouth (see Figure 12.4). The subject was asked, "Which one is thinking?". The vast majority of children chose the person in the photo who was looking upward and sideways as the one who was thinking. The only difference in the pictures was eye direction, so this again suggests that aspects of face-processing continue to have mentalistic functions, at 3 to 4 years of age and from then on.

Does Eye Direction Cue Recognition of Other Mental States?

In a further study, we considered whether face-processing might be used by normal children (and adults) in drawing inferences about *other* mental states too. When Baron-Cohen, Campbell et al. (in press) presented normal 3- and 4-year-olds with a display of 4 chocolates, and placed the cartoon face of Charlie in the center of the display, Charlie's eyes were depicted as pointing toward one of the 4 chocolates, randomly selected. In one condition, the subjects were asked, "Which one does Charlie *want?*"; in another, "Which one does Charlie *say* is the (x)?". Children of this age had no difficulty at all in inferring Charlie's desire, or intended referent, from his eye direction. This was particularly striking because, in a retest of this experiment, the display included a distractor cue—a large black arrow pointing at another of the 4 chocolates. Normal 3- and 4-year-olds appeared to ignore this "unnatural" cue, and predominantly used the "natural" cue of eye direction to infer this range of mental states.

In summary, we have presented some evidence that, from early childhood onward, one function of face-processing is to recognize not only emotional states (Ekman & Friesen, 1971), but also other mental states such as attention, desire, goal, and thought. This

Figure 12.4 Test of "Which one is thinking?" From "Reading the Eyes: Evidence for the Role of Perception in the Development of a Theory of Mind" by S. Baron-Cohen and P. Cross, 1992, *Mind and Language, 6*, pp. 172–186. Reproduced from Fairburn System of Visual References (1978).

idea builds on Hobson's (1990) notion of "visual coorientation" being involved in the development of a theory of mind.

ABNORMALITIES IN THE USE OF FACE-PROCESSING FOR THEORY OF MIND

Autism

Face-processing appears to be impaired in children with autism. Although these children have no difficulties in recognizing a person's *identity* in faces (Campbell, Walker, & Baron-Cohen, 1993; Langdell, 1978; Volkmar, Sparrow, Rende, & Cohen, 1989) and can recognize age and gender in faces (Baron-Cohen, 1991d; Campbell et al., 1993), they nevertheless seem to use unusual face-processing strategies. For example, they do not appear to show the normal inversion effect in identity recognition (Hobson, Ouston, & Lee, 1988b; Langdell, 1978). From Diamond and Carey's (1986) study,[4] one might interpret this abnormality in terms of a relative lack of expertise with faces, because of the limited amount of social experience they have had; others have speculated that this abnormality might reflect featural rather than configural face-processing (Langdell, 1978).

Children with autism have been reported to show some difficulties in recognizing facial expressions of emotion (Hobson, 1986). However, such deficits are not found when control groups are matched for verbal mental age (Braverman, Fein, Lucci, & Waterhouse, 1989; Hobson, Ouston, & Lee, 1988a, 1988b, 1989; Ozonoff, Pennington, & Rogers, 1990; Prior, Dahlstrom, & Squires, 1990; Tantam, Monaghan, Nicholson, & Stirling, 1989).[5] There may, nevertheless, be autism-specific deficits in recognizing "complex" emotions such as surprise, rather than "simple" emotions such as happy and sad (Baron-Cohen, Spitz, & Cross, 1993). This deficit may relate to difficulties in developing a theory of mind; emotions such as surprise entail understanding that a person had held a false belief about what was going to happen.

Some evidence in support of the earlier argument that joint-attention behaviors entail the child's possessing the concept of attention can also be found in autism. Children with autism show little, if any, joint-attention behaviors (Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1993; Sigman, Mundy, Ungerer, & Sherman, 1986), yet they pass Level 1 visual perspective-taking tasks (Baron-Cohen, 1989d; Hobson, 1984; Tan & Harris, 1991), as reviewed earlier. One way of accounting for this dissociation is to assume that Level 1 visual perspective-taking tasks can be solved using geometric, "line of sight" algorithms (Lempers et al., 1977), which do not necessarily require any understanding of the mental state of attention. In contrast, joint-attention behaviors, on the analysis given above, do require understanding the mental state of attention. Abnormalities in joint attention in autism may therefore reflect an inability to recognize eye direction information as indicating a person's attentional state. Such joint-attention deficits may be developmentally and conceptually related to the later theory of mind deficits found in autism.

Phillips et al. (1992), using the ambiguous and unambiguous actions described earlier, tested very young children with autism for their ability to use face-processing to detect goals. These children did not seem to use eye contact to disambiguate the ambiguous actions; in each test, in both conditions, less than 11% used looking. This result suggests that they may have lacked the concept of people's actions being caused by mental states such as goals. Again, it is plausible to assume that these face-processing deficits may be developmentally related to the deficits in their theory of mind, reviewed earlier.

Baron-Cohen, Campbell et al. (in press) tested children with autism (a) on the tests originally developed by Baron-Cohen and Cross (1992), to see whether these children could use eye direction to deduce a person's mental state of thinking, and (b) on the 4 chocolates task, to see whether they were able to use eye direction to infer the mental states of want, goal, and refer. They found significant impairments in the children's use of eye direction in inferring all of these. In addition, the children were significantly more likely to use the "unnatural" cue of the large black arrow than the "natural" cue of gaze, when responding to questions like "Which one does Charlie want?". The researchers concluded that these children may be blind to the mentalistic significance of the eyes, a deficit that may contribute to the observation of unusual use of eye contact by children with autism (Mirenda, Donnellan, & Yoder, 1983).

Blindness

A second condition in which abnormalities have been suggested in the use of face-processing in developing a theory of mind is congenital blindness (Hobson, 1990). Hobson noted the converging reports that autisticlike symptoms are sometimes reported in children who are congenitally blind, or partially blind and partially deaf (e.g., Fay, 1973; Fraiberg & Adelson, 1977; Wing, 1969). These symptoms include delayed onset of pretend play and referential communication (such as pointing), problems in pronoun usage, deixis, flexible thought, and the

[4] Configural processing in normal subjects is severely disrupted when inverted faces are presented (Sergent, 1984). The temptation is to interpret this inversion data as evidence for a purpose-built face-processing mechanism. Diamond and Carey (1986) show, however, that this assumption is probably mistaken. Similar orientation effects can be achieved with other objects, as long as subjects possess "expert" experience of the stimulus. Thus, they demonstrated that identification of (specific breeds of) *individual* champion dogs by experts is also vulnerable to the inversion effect.

[5] Emotion recognition deficits are found in a range of other clinical disorders, such as schizophrenia (Cutting, 1981; Novic, Luchins, & Perline, 1984), mental handicap (Gray, Frazer, & Leuder, 1983), abused children (Camras, Grow, & Ribordy, 1983), deaf children (Odom, Blanton, & Laukhuf, 1973), and prosopagnosia (De Kosky, Heilman, Bowers, & Valenstein, 1980; Kurucz, Feldmar, & Werner, 1979), but *not* children with visual impairment (Ellis, Young, & Markham, 1987). Future research in this area needs to untangle how emotion perception deficits in different clinical groups relate to each other. At present, it is not clear whether these deficits are the same (i.e., caused by the same underlying neuropathology), or constitute only superficially similar patterns of impairment (i.e., caused by different underlying patterns of neuropathology).

presence of echolalia. Given that these symptoms are also characteristic of autism, Hobson proposed that "there may be a common psychological deficit underlying the specific constellation of impairments common to autistic and congenitally blind children" (1990, pp. 118–119). He went on to outline what this common psychological deficit might be.

In essence, he argued that, in the normal case, "vision greatly facilitates the child's grasp of shared reference" (p. 119), as is clear in both joint attention and social referencing. Shared reference, he argued, is an important stage in the development of an understanding of other minds.

Prosopagnosia

Prosopagnosia is a neurological condition in which patients, following brain injury, no longer recognize famous faces, friends, relatives, or even their own face in a mirror (Benton, 1980). Prosopagnosic patients can say when they are looking at *a* face, but not whose it is, simply from the facial information alone. When they do recognize the person, it is on the basis of other information (voice, clothing, context, etc.).

Early cases of this disorder were discussed by Charcot (1883) and Wilbrand (1892), in the context of widespread cognitive impairment. Bodamer (1947) coined the term *prosopagnosia* to describe the specific deficit of face recognition. The term literally means "loss of knowledge of faces." Whether such cases are indeed cases of "pure" face recognition deficits (De Renzi, 1986) or always occur in the context of wider deficits in object recognition, remains controversial (see Morton & Johnson, 1991). Prosopagnosia can occur in both childhood and adulthood, although the differential effects of age of onset of the condition are not well understood (De Haan & Campbell, 1991).

It has long been recognized that there are different forms of prosopagnosia. The handicap does not always extend to all aspects of face perception, and the particular patterns of impairment have added important evidence to neuropsychological models of face-processing. For example, some patients with prosopagnosia can recognize facial expressions of emotion but still not recognize identity from faces (Shuttleworth, Syring, & Allen, 1982). Others have the exact opposite pattern of deficit: they can identify faces but have difficulty interpreting their facial expressions (Kurucz & Felmar, 1979; Kurucz et al., 1979). The latter pattern remains to be replicated, but such *double dissociations* are held to be strong evidence of the independence between the neurocognitive systems responsible for these two abilities.

Other dissociations in prosopagnosia have also been reported. For example, Campbell, Landis, and Regard (1986) reported a prosopagnosic woman who could neither recognize (nor even identify the sex of) faces nor interpret their expressions, but who could judge what phonemes were mouthed in photographs of faces and was susceptible to the McGurk illusion (McGurk & MacDonald, 1976). A second patient, they reported, had the exact opposite set of impairments. She could identify faces and categorize their expressions, but was not susceptible to the McGurk illusion. De Haan and Campbell (1991) reported a case (AB) who was unable to detect eye direction. Given the role of eye direction in computing the mental states of attention, goal, desire, and reference, suggested earlier, we might predict that cases with this subtype of prosopagnosia would, like the blind, show delay in the development of a theory of mind. At the time of writing, there is no evidence of what the development of a theory of mind is like in such patients' childhood.[6]

CONCLUSIONS AND FUTURE DIRECTIONS

Theory of mind and face-processing represent well-studied domains within developmental psychology. Both appear vulnerable to impairment, the clearest expression of such deficits being found in autism and prosopagnosia, respectively. Both disorders have shaped the development of models of normal functioning in these areas (Baron-Cohen, 1994, 1995). The development of face-processing and theory of mind may interact in important ways, from about the 8th month of infancy onward. Evidence for such interaction comes from the toddler's ability to judge a person's mental states of *attention, goal, desire, refer,* and *think* from the direction of the person's eyes. Perceiving eye direction may also give the child a first lesson in (at least some aspects of) intentionality, or aboutness, because gaze direction always points to (or is about) something.

In a volume of this nature, it is useful to speculate about future directions for research. What might we expect for theory of mind research? There has been enormous interest in this field over the past 10 years. Will this (like many other "fashions" in science) be shortlived?

On one view, a single topic cannot continue to sustain such a high level of interest. The alternative view (the one that I am drawn to support) is that theory of mind will continue as a major research area in the future. My reasons for this prediction are based on the kind of topic that theory of mind is. It is not a narrow topic, with limited implications. On the contrary, as a psychological process or capacity, it appears to be as basic as several other important processes, such as language or memory. Just as language or memory research will continue to be fundamental areas of cognitive science, so (in this view) will theory of mind.

Future lines of investigation that are opening up (I shall mention just a few) include the development of nonverbal theory of mind tests for potential use with nonhuman primates (Povinelli, Parks, & Novak, 1991), neonates (Premack, 1990), and language-impaired clinical populations (Whiten, 1993); the investigation of cross-cultural aspects of theory of mind (Avis & Harris, 1991); and the brain basis of theory of mind (Baron-Cohen, Ring et al., 1994; Brothers, 1992).

Similarly, the interface between theory of mind and face-processing, on which this chapter has focused, is likely to continue to raise many new questions. Although this interface (albeit under a different guise) was an important topic in the initial pioneering studies by Ekman and Friesen (1971) and by Scaife and Bruner (1975), face-processing and theory of mind subsequ-

[6] The only relevant study is a single case study by Young et al. (1989). The subject (KD) passed a false belief test at 8 years. This is too late an age to investigate subtle delays.

became rather divorced from one another. The work in autism may serve to refocus research on this interface.

Examples of just a few of the important questions that will, it is hoped, be part of future investigations in this area include: the possible neural connections between face-processing and theory of mind "modules" in the brain (Brothers, 1992; Frith, 1992; Baron-Cohen & Ring, 1994); the differential pathology underlying emotion-recognition impairments in a large range of clinical populations (Cutting, 1981; De Kosky et al., 1980; see also note 5); and the relationship between inferences about one's own mental states and inferences (from facial expressions) about another person's mental states (Gopnik, 1993). I hope that this chapter will encourage further empirical work on the interface between face-processing and theory of mind, from the perspective of both the normal and the abnormal.

REFERENCES

Astington, J., Harris, P., & Olson, D. (1988). *Developing theories of mind.* New York: Cambridge University Press.

Astington, J., & Lee, E. (1991, April). *What do children know about intentional causation?* Paper presented at the Society for Research in Child Development Conference, Seattle, WA.

Avis, J., & Harris, P. (1991). Belief-desire reasoning among Baka children: Evidence for a universal conception of mind. *Child Development, 62,* 460–467.

Baron-Cohen, S. (1987). Autism and symbolic play. *British Journal of Developmental Psychology, 5,* 139–148.

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

Baron-Cohen, S. (1989a). Are autistic children behaviourists? An examination of their mental-physical and appearance-reality distinctions. *Journal of Autism and Developmental Disorders, 19,* 579–600.

Baron-Cohen, S. (1989b). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30,* 285–298.

Baron-Cohen, S. (1989c). Joint attention deficits in autism: Towards a cognitive analysis. *Development and Psychopathology, 1,* 185–189.

Baron-Cohen, S. (1989d). Perceptual role-taking and protodeclarative pointing in autism. *British Journal of Developmental Psychology, 7,* 113–127.

Baron-Cohen, S. (1989e). Thinking about thinking: How does it develop? Critical notice. *Journal of Child Psychology and Psychiatry, 30,* 931–933.

Baron-Cohen, S. (1990). Autism: A specific cognitive disorder of "mind-blindness." *International Review of Psychiatry, 2,* 79–88.

Baron-Cohen, S. (1991a). The development of a theory of mind in autism: Deviance and delay? *Psychiatric Clinics of North America, 14,* 33–51.

Baron-Cohen, S. (1991b). Do people with autism understand what causes emotion? *Child Development, 62,* 385–395.

Baron-Cohen, S. (1991c). Precursors to a theory of mind: Understanding attention in others. In A. Whiten (Ed.), *Natural theories of mind* (pp. 223–254). Oxford, England: Basil Blackwell.

Baron-Cohen, S. (1991d). The theory of mind deficit in autism: How specific is it? *British Journal of Developmental Psychology, 9,* 301–314.

Baron-Cohen, S. (1992a). On modularity and development in autism: A reply to Burack. *Journal of Child Psychology and Psychiatry, 33,* 623–629.

Baron-Cohen, S. (1992b). Out of sight or out of mind? Another look at deception in autism. *Journal of Child Psychology and Psychiatry, 33,* 1141–1155.

Baron-Cohen, S. (1993). From attention-goal psychology to belief desire psychology: The development of a theory of mind, and its dysfunction. In S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen (Eds.), *Understanding other minds: Perspectives from autism.* Oxford, England: Oxford University Press.

Baron-Cohen, S. (1994). How to build a baby that can read minds: Cognitive mechanisms in mind reading. *Cahiers de Psychologie Cognitive, 13*(5), 513–552.

Baron-Cohen, S. (1995). *Mindblindness.* Cambridge, MA: MIT Press/ Bradford Books.

Baron-Cohen, S., Campbell, R., Karmiloff-Smith, A., Grant, J., & Walker, J. (in press). Are children with autism blind to the mentalistic significance of the eyes? *British Journal of Developmental Psychology.*

Baron-Cohen, S., & Cross, P. (1992). Reading the eyes: Evidence for the role of perception in the development of a theory of mind. *Mind and Language, 6,* 172–186.

Baron-Cohen, S., & Goodhart, F. (1994). The "seeing leads to knowing" principle: Deficit in autism. The Pratt and Bryant probe. *British Journal of Developmental Psychology, 12,* 397–402.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21,* 37–46.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1986). Mechanical, behavioural and intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology, 4,* 113–125.

Baron-Cohen, S., & Ring, H. (1994). A model of the mindreading system: Neuropsychological and neurobiological perspectives. In P. Mitchell, & C. Lewis (Eds.), *Orgins of an understanding of mind.* Hove: Erlbann.

Baron-Cohen, S., Ring, H., Moriarty, J., Schmitz, P., Costa, D., & Ell, P. (1994). Recognition of mental state terms: A clinical study of autism, and a functional neuroimaging study of normal adults. *British Journal of Psychiatry, 165,* 640–649.

Baron-Cohen, S., Spitz, A., & Cross, P. (1993). Do children with autism recognize surprise? A research note. *Cognition and Emotion, 7,* 507–516.

Baron-Cohen, S., Tager-Flusberg, H., & Cohen, D. J. (Eds.). (1993). *Understanding other minds: Perspectives from autism.* Oxford, England: Oxford University Press.

Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy.* New York: Academic Press.

Benton, A. (1980). The neuropsychology of facial recognition. *American Psychologist, 35,* 176–186.

Berger, J., & Cunningham, C. (1981). The development of eye-contact between mothers and normal versus Down's syndrome infants. *Developmental Psychology, 17,* 678–689.

Berndt, T., & Berndt, E. (1975). Children's use of motives and intentionality in person perception and moral judgement. *Child Development, 46,* 904–912.

Bishop, D. (1989). Autism, Asperger's syndrome, and Semantic-Pragmatic Disorder: Where are the boundaries? *British Journal of Disorders of Communication, 24,* 107–122.

Bodamer, J. (1947). Die Prosopagnosie. *Archiv für Psychiatrie und Zeitschrift für Neurologie, 179,* 6–54.

Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 19,* 301–316.

Bretherton, I., McNew, S., & Beeghly-Smith, M. (1981). Early person knowledge as expressed in gestural and verbal communication: When do infants acquire a "theory of mind"? In M. Lamb & L. Sharrod (Eds.), *Infant social cognition* (pp. 333–374). Hillsdale, NJ: Erlbaum.

Brothers, L. (1992). Perception of social acts in primates: Cognition and neurobiology. *Seminars in the Neurosciences, 4.*

Bruce, V. (1988). *Recognizing faces.* E. Sussex, England: Erlbaum.

Bruner, J. (1983). *Child's talk: Learning to use language.* Oxford, England: Oxford University Press.

Butterworth, G. (1991). The ontogeny and phylogeny of joint visual attention. In A. Whiten (Ed.), *Natural theories of mind* (pp. 223–231). Oxford, England: Basil Blackwell.

Campbell, R., Landis, T., & Regard, M. (1986). Face recognition and lip-reading: A neurological dissociation. *Brain, 109,* 509–521.

Campbell, R., Walker, J., & Baron-Cohen, S. (1993). Face-processing in autism: An experimental investigation. Unpublished manuscript, Department of Psychology, Goldsmiths College, University of London.

Camras, L. A., Grow, G., & Ribordy, S. C. (1983). Recognition of emotional expression by abused children. *Journal of Child Psychology and Psychiatry, 12,* 325–328.

Caron, A., Caron, R., Caldwell, R., & Weiss, S. (1973). Infant perception of structural properties of the face. *Developmental Psychology, 9,* 385–399.

Carpenter, G. (1974). Mother's face and the newborn. *New Scientist, 61,* 742–744.

Charcot, J. (1883). Un cas de suppression brusque et isolée de la vision mentale des signes et des objets (formes et couleurs). *Le Progres Medicale, 88,* 568–571.

Cheney, D., & Seyfarth, R. (1990). *How monkeys see the world.* Chicago: University of Chicago Press.

Cicchetti, D. (1984). The emergence of developmental psychopathology. *Child Development, 55,* 1–7.

Cutting, J. (1981). Judgement of emotional expression in schizophrenics. *British Journal of Psychiatry, 139,* 1–6.

De Haan, E., & Campbell, R. (1991). A 15-year follow-up of a case of developmental prosopagnosia. *Cortex, 27,* 1–21.

De Kosky, S., Heilman, K., Bowers, M., & Valenstein, E. (1980). Recognition and discrimination of emotional faces and pictures. *Brain and Language, 9,* 206–214.

Dennett, D. (1978a). Beliefs about beliefs. *Behaviour and Brain Sciences, 4,* 568–570.

Dennett, D. (1978b). *Brainstorms: Philosophical essays on mind and psychology.* Brighton, England: Harvester Press.

De Renzi, E. (1986). Current issues on prosopagnosia. In H. Ellis, M. Jeeves, F. Newcombe, & A. Young. (Eds.) *Aspects of face processing.* Dordrecht, The Netherlands: Nijhoff.

Diamond, R., & Carey, S. (1986). Why faces are not special: An effect of expertise. *Journal of Experimental Psychology: General, 115,* 107–117.

Dodge, K. (1980). Social cognition and children's aggressive behaviour. *Child Development, 51,* 162–170.

Ekman, P., & Friesen, W. (1971). Constants across cultures in face and emotion. *Journal of Personality and Social Psychol* *17,* 124–129.

Ellis, A., & Young, A. (1989). *Human cognitive neuropsychol* Hillsdale, NJ: Erlbaum.

Ellis, H., Young, A., & Markham, R. (1987). The ability of visually i paired children to read expressions and recognize surprise. *Jour of Visual Impairment and Blindness, December,* 485–486.

Fantz, R. (1961). The origin of form perception. *Scientific Americ* *204,* 66–72.

Fantz, R. (1963). Pattern vision in newborn infants. *Science, 1* 296–297.

Fay, W. (1973). On the echolalia of the blind and of the autistic chil *Journal of Speech and Hearing Disorders, 38,* 478–489.

Field, T. (1979). Visual and cardiac responses to animate and inanima faces by term and preterm infants. *Child Development, 50,* 188–19

Flavell, J., Everett, B., Croft, K., & Flavell, E. (1981). Young children knowledge about visual perception: Further evidence for the lev 1–level 2 distinction. *Developmental Psychology, 17,* 99–103.

Flavell, J., Shipstead, S., & Croft, K. (1978). Young children's knowl edge about visual perception: Hiding objects from others. *Child De velopment, 49,* 1208–1211.

Fodor, J. A. (1987). *Psychosemantics: The problem of meaning in th philosophy of mind.* Cambridge, MA: MIT Press.

Fonagy, P. (1989). On tolerating mental states: Theory of mind in bor derline personality. *Bulletin of the Anna Freud Centre, 12,* 91–115.

Fraiberg, S., & Adelson, E. (1977). Self-representation in language and play. In S. Fraiberg (Ed.), *Insights from the blind* (pp. 248–270). London: Souvenir Press.

Freeman, N., Lewis, C., & Doherty, M. (1991). Preschoolers' grasp of desire for knowledge in false-belief prediction: Practical intelligence and verbal report. *British Journal of Developmental Psychology, 9,* 139–158.

Frith, C. (1992). *The neuropsychology of schizophrenia.* Hillsdale, NJ: Erlbaum.

Frith, C., & Frith, U. (1991). Elective affinities in schizophrenia and childhood autism. In P. Bebbington (Ed.), *Social psychiatry: Theory, method, and practice.* New Brunswick, NJ: Rutgers University Press.

Frith, U. (1989). *Autism: Explaining the enigma.* Oxford, England: Basil Blackwell.

Frith, U., Happé, F., & Siddons, F. (1994). Autism and theory of mind in everyday life. *Social Development, 3,* 108–124.

Gelman, R., & Spelke, E. (1981). The development of thoughts about animate and inanimate objects: Implications for research on social cognition. In J. Flavell & L. Ross (Eds.), *Social cognitive development* (pp. 43–66). Cambridge, England: Cambridge University Press.

Gomez, J. C. (1991). Visual behaviour as a window for reading the mind of others in primates. In A. Whiten (Ed.), *Natural theories of mind* Oxford, England: Basil Blackwell.

Gopnik, A. (1993). How we know our own minds: The illusion of first person knowledge of intentionality. *Behavioural and Brain Sciences, 16,* 1–14.

Gopnik, A., & Slaughter, V. (1991). Young children's understanding of changes in their mental states. *Child Development, 62,* 98–110.

Goren, C., Sarty, M., & Wu, R. (1975). Visual following and pattern discrimination of facelike stimuli by newborn infants. *Pediatrics, 56,* 544–549.

Gratch, G. (1964). Response alternation in children: A developmental study of orientations to uncertainty. *Vita Humana, 7,* 49–60.

Gray, J. M., Frazer, W. L., & Leudar, I. (1983). Recognition of emotion from facial expression in mental handicap. *British Journal of Psychiatry, 142,* 566–571.

Happé, F. (1993). Communicative competence and theory of mind in autism: A test of relevance theory. *Cognition, 48,* 101–119.

Hobson, R. P. (1984). Early childhood autism and the question of egocentrism. *Journal of Autism and Developmental Disorders, 14,* 85–104.

Hobson, R. P. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry, 27,* 321–342.

Hobson, R. P. (1990). On acquiring knowledge about people and the capacity to pretend: Response to Leslie (1987). *Psychological Review, 97,* 114–121.

Hobson, R. P., Ouston, J., & Lee, A. (1988a). Emotion recognition in autism: Coordinating faces and voices. *Psychological Medicine, 18,* 911–923.

Hobson, R. P., Ouston, J., & Lee, A. (1988b). What's in a face? The case of autism. *British Journal of Developmental Psychology, 79,* 441–453.

Hooson, R. P., Ouston, J., & Lee, T. (1989). Naming emotion in faces and voices: Abilities and disabilities in autism and mental retardation. *British Journal of Developmental Psychology, 7,* 237–250.

Johnson, M., Dziurwiec, S., Bartrip, J., & Morton, J. (1991). Infants' preference for facelike stimuli: Effects of the movement of internal features. *Infant Behaviour and Development.*

Johnson, M., & Morton, J. (1991). *Biology and cognitive development.* Oxford, England: Basil Blackwell.

Kanner, L. (1943). Autistic disturbance of affective contact. *Nervous Child, 2,* 217–250. (Reprinted in Kanner, L. (1973). *Childhood psychosis: Initial studies and new insights.* New York: Wiley.

Karmiloff-Smith, A. (1992). *Beyond modelarity.* Cambridge, MA: MIT Press/Bradford Books.

Kaug, M. (1971). The development of some intention concepts in children. *Child Development, 42,* 1145–1152.

Kaurcz, J., & Feldmar, G. (1979). Prosopo-affective agnosia as a symptom of cerebral organic disease. *Journal of the American Geriatrics Society, 27,* 225–230.

Kaurcz, J., Feldmar, G., & Werner, W. (1979). Prosopo-affective agnosia associated with chronic organic brain syndrome. *Journal of the American Geriatrics Society, 27,* 91–95.

Langdell, T. (1978). Recognition of faces: An approach to the study of autism. *Journal of Child Psychology and Psychiatry, 19,* 225–238.

Lackam, S. (1991). Jokes and lies: Children's understanding of intentional falsehood. In A. Whiten (Ed.), *Natural theories of mind* (pp. 159–174). Oxford, England: Basil Blackwell.

Lackam, S., Baron-Cohen, S., Perrett, D., Milders, M., & Brown, S. (1993). *Gaze-monitoring and perceptual role-taking: A dissociation in autism.* Unpublished manuscript, Department of Social and Applied Psychology, University of Kent, Canterbury.

Lackam, S., & Perner, J. (1991). Does the autistic child have a metarepresentational deficit? *Cognition, 40,* 203–218.

Lampers, J., Flavell, E., & Flavell, J. (1977). The development in very young children of tacit knowledge concerning visual perception. *Genetic Psychology Monographs, 95,* 3–53.

Leslie, A. M. (1987). Pretence and representation: The origins of "theory of mind." *Psychological Review, 94,* 412–426.

Leslie, A. (1991). The theory of mind impairment in autism: Evidence for a modular mechanism of development? In A. Whiten (Ed.), *Natural theories of mind* (pp. 63–78). Oxford, England: Basil Blackwell.

Leslie, A., & Roth, D. (1993). What can autism teach us about metarepresentation? In S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen (Eds.), *Understanding other minds: Perspectives from autism.* Oxford, England: Oxford University Press.

Leslie, A. M., & Frith, U. (1988). Autistic children's understanding of seeing, knowing, and believing. *British Journal of Developmental Psychology, 6,* 315–324.

Lewis, M. (1969). Infants' responses to facial stimuli during the first year of life. *Developmental Psychology, 1,* 75–80.

Light, P., & Nix, C. (1983). Own view versus good view in a perspective-taking task. *Child Development, 54,* 480–483.

Lister-Brook, S., & Bowler, D. (1992). Autism by another name? Semantic and pragmatic impairments in children. *Journal of Autism and Developmental Disorders, 22,* 61–82.

McCune-Nicholich, L. (1981). Towards symbolic functioning: Structure of early use of pretend games and potential parallels with language. *Child Development, 52,* 785–797.

McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature, 264,* 746–748.

Maurer, D. (1985). Infants' perception of facedness. In T. Field & N. Fox (Eds.), *Social perception in infants* (pp. 73–100). Norwood, NJ: Ablex.

Maurer, D., & Barrera, M. (1981). Infants' perception of natural and distorted arrangements of a schematic face. *Child Development, 52,* 196–202.

Maurer, D., & Young, R. (1983). Newborns' following of natural and distorted arrangements of facial features. *Infant Behavior and Development, 6,* 127–131.

Meltzoff, A. (1990). Towards a developmental cognitive science: The implications of cross-modal matching and imitation for the development of representation and memory in infancy. *Annals of the New York Academy of Sciences, 608,* 1–37.

Mirenda, P., Donnellan, A., & Yoder, D. (1983). Gaze behavior: A new look at an old problem. *Journal of Autism and Developmental Disorders, 13,* 397–409.

Morton, J., & Johnson, M. (1991). Conspec and Conlern: A two-process theory of infant face-recognition. *Psychological Review, 98,* 164–181.

Novic, J., Luchins, D. J., & Perline, R. (1984). Facial affect recognition in schizophrenia: Is there a differential deficit? *British Journal of Psychiatry, 144,* 533–537.

Odom, P. B., Blanton, R. L., & Laukhuf, C. (1973). Facial expressions and interpretations of emotion-arousing situations in deaf and hearing children. *Journal of Abnormal Child Psychology, 1,* 139–151.

Oswald, D. P., & Ollendick, T. (1989). Role taking and social competence in autism and mental retardation. *Journal of Autism and Developmental Disorders, 19,* 119–128.

Ozonoff, S., Pennington, B., & Rogers, S. (1990). Are there emotion perception deficits in young autistic children? *Journal of Child Psychology and Psychiatry, 31,* 343–363.

Ozonoff, S., Pennington, B., & Rogers, S. (1991). Executive function deficits in high-functioning autistic children: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry, 32,* 1081–1106.

Perner, J. (1988). Developing semantics for theories of mind: From propositional attitudes to mental representations. In J. Astington,

P. Harris, & D. Olson (Eds.), *Developing theories of mind* (pp. 141–172). Cambridge, England: Cambridge University Press.

Perner, J. (1991). *Understanding the representational mind.* Cambridge, MA: MIT Press.

Perner, J. (1993). The theory of mind deficit in autism: Rethinking the metarepresentation theory. In S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen (Eds.), *Understanding other minds: Perspectives from autism* (pp. 112–137). Oxford, England: Oxford University Press.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief, and communication. *Child Development, 60,* 689–700.

Perner, J., & Wilde-Astington, J. (1991, May). The child's understanding of mental representation. *Proceedings of the 20th Anniversary Symposium of the Jean Piaget Society,* Philadelphia.

Perner, J., & Wimmer, H. (1985). "John *thinks* that Mary *thinks* that . . .": Attribution of second-order beliefs by 5-10-year-old children. *Journal of Experimental Child Psychology, 39,* 437–471.

Perrett, D., Smith, P., Potter, D., Mistlin, A., Head, A., Milner, A., & Jeeves, M. (1985). Visual cells in the temporal cortex sensitive to face view and gaze direction. *Proceedings of the Royal Society of London, B223,* 293–317.

Phillips, W. (1993). *Comprehension of intention and desire by children with autism.* Unpublished doctoral dissertation, Institute of Psychiatry, University of London.

Phillips, W., Baron-Cohen, S., & Rutter, M. (1992). The role of eye-contact in goal detection: Evidence from normal infants, and children with mental handicap or autism. *Development and Psychopathology, 4,* 375–383.

Piaget, J. (1929). *The child's conception of the world.* New York: Harcourt Brace.

Piaget, J. (1962). *Dreams, play and imitation in childhood.* London: Routledge & Kegan Paul.

Piaget, J., & Inhelder, B. (1956). *The child's conception of space.* London: Routledge & Kegan Paul.

Povinelli, D., Parks, K., & Novak, M. (1991). Do rhesus monkeys (Macaca mulatta) attribute knowledge and ignorance to others? *Journal of Comparative Psychology, 105,* 318–325.

Premack, D. (1990). The infant's theory of self-propelled objects. *Cognition, 36,* 1–16.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a "theory of mind"? *Behaviour and Brain Sciences, 4,* 515–526.

Prior, M., Dahlstrom, B., & Squires, T. (1990). Autistic children's knowledge of thinking and feeling states in other people. *Journal of Child Psychology and Psychiatry, 31,* 587–602.

Reed, T., & Petersen, C. (1990). A comparative study of autistic subjects' performance at two levels of visual and cognitive perspective-taking. *Journal of Autism and Developmental Disorders, 20,* 555–568.

Riviere, A. (1993). Second-order belief attribution in 5- and 6-year-old normal children. Unpublished manuscript, Universidad Autonoma de Madrid.

Rutter, M. (1983). Cognitive deficits in the pathogenesis of autism. *Journal of Child Psychology and Psychiatry, 24,* 513–531.

Scaife, M., & Bruner, J. (1975). The capacity for joint visual attention in the human infant. *Nature, 253,* 265.

Sellars, L., & Leslie, A. (1990). *The deaf child's theory of mind.* Unpublished manuscript, MRC Cognitive Development Unit, London.

Sergent, J. (1984). An investigation into component and configural processes underlying face recognition. *British Journal of Psychology, 75,* 221–242.

Shatz, M., Wellman, H., & Silber, S. (1983). The acquisition of mental verbs: A systematic investigation of the first reference to mental states. *Cognition, 14,* 301–321.

Sherrod, L. (1979). Social cognition in infants: Attention to the human face. *Infant Behaviour and Development, 2,* 279–294.

Shuttelworth, E., Syring, V., & Allen, N. (1982). Further observations on the nature of prosopagnosia. *Brain and Cognition, 1,* 307–322.

Sigman, M., Mundy, P., Ungerer, J., & Sherman, T. (1986). Social interactions of autistic, mentally retarded, and normal children and their caregivers. *Journal of Child Psychology and Psychiatry, 27,* 647–656.

Smith, M. (1978). Cognizing the behavioral stream: The recognition of intentional action. *Child Development, 49,* 736–748.

Sodian, B., & Frith, U. (1992). Deception and sabotage in autistic, retarded, and normal children. *Journal of Child Psychology and Psychiatry, 33,* 591–606.

Sorce, J., Emde, R., Campos, J., & Klinnert, M. (1985). Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21,* 195–200.

Tan, J., & Harris, P. (1991). Autistic children understand seeing and wanting. *Development and Psychopathology, 3,* 163–174.

Tantam, D., Monaghan, L., Nicholson, H., & Stirling, J. (1989). Autistic children's ability to interpret faces: A research note. *Journal of Child Psychology and Psychiatry, 30,* 623–630.

Temple, C., & Vilarroya, O. (1990). Perceptual and cognitive perspective-taking in two siblings with callosal agenesis. *British Journal of Developmental Psychology, 8,* 3–8.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry, 17,* 1–13.

Ungerer, J., & Sigman, M. (1981). Symbolic play and language comprehension in autistic children. *Journal of Abnormal Child Psychology, 9,* 149–165.

Volkmar, F. R., Sparrow, S., Rende, R. D., & Cohen, D. J. (1989). Facial perception in autism. *Journal of Child Psychology and Psychiatry, 30,* 591–598.

Wellman, H. (1990). *The child's theory of mind.* Cambridge, MA: MIT Press.

Whiten, A. (Ed.). (1991). *Natural theories of mind.* Oxford, England: Basil Blackwell.

Wilbrand, H. (1892). Ein Fall von Seelenblindheit und Hemianopsie mit Sectionsbefund. *Deutscher Zeitschrift für Nervenkrankheiten,* 361–387.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13,* 103–128.

Wing, L. (1969). The handicaps of autistic children: A comparative study. *Journal of Child Psychology and Psychiatry, 10,* 1–40.

Young, A., & Ellis, H. (1989). Childhood prosopagnosia. *Brain and Cognition, 9,* 16–47.