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REVIEW SUMMARY

SOCIAL COGNITION

The cultural evolution of mind reading

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BACKGROUND: We use "theory of mind" or "mind reading" to understand our own thoughts and feelings and those of other agents. Mind reading has been a focus of philosophical interest for centuries and of intensive scientific inquiry for 35 years. It plays a pivotal role in human social interaction and communication. Mind reading allows us to predict, explain, mold, and manipulate each other's behavior in ways that go well beyond the capabilities of other animals; therefore, mind reading is crucial to understanding what it means to be human. In many respects, the capacity to read minds is like the capacity to read print: It involves the derivation of meaning from signs, depends on dedicated brain mechanisms, is subject to specific developmental disorders, shows cultural variation as well as cultural commonality, and has both interpretive (reading) and regulative (writing) functions. However, recent studies of mind reading in young infants suggest that, unlike print reading, mind reading develops very early in human ontogeny.

ADVANCES: In nonverbal tests of mind reading, infants' eye movements have been taken as evidence that infants expect an agent to reach toward a location where he or she believes a desirable object to be hidden, even when the agent's belief is false. This "implicit" mind reading could indicate that humans genetically inherit the specialized neurocognitive mechanisms used for "explicit," verbally mediated mind reading in adulthood. However, recent research with adults shows that, unlike explicit mind reading, implicit mind reading does not make demands on executive function. This indicates that, although they may be genetically inherited, the mechanisms that mediate implicit mind reading, whether specialized or general-purpose, are distinct from those controlling explicit mind reading. Furthermore, studies of twins, people with hearing impairments, and children from non-Western cultures, as well as typically developing Western children, suggest that, like print reading, explicit mind reading is culturally inherited. Rather than being constructed by simulation or theory-testing, explicit mind reading is a skill that is passed from one generation to the next by verbal instruction.

Most, possibly all, human neurocognitive skills are shaped by culture and many are culturally inherited, but the parallels between mind reading and print reading are extraordinary. In contrast, whereas linguistic communities vary in the ways that they categorize colors, color perception is not culturally inherited in the same way as print reading. Unlike print reading, color perception is rooted in highly specialized, genetically inherited mechanisms that humans share with other species. Though cultural input adjusts these mechanisms, it does not make them into a whole new neurocognitive system.

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OUTLOOK: The cultural evolutionary account of mind reading does not imply that mental states are mere fictions, but it does suggest that any aspect of mind reading—even those relating to knowledge and primary emotions—could show substantial cultural variation. More cross-cultural studies using sensitively translated test procedures are needed to chart extant variation. Similarly, although the cultural evolutionary account suggests that humans do not genetically inherit mechanisms that are specialized for the representation of mental states, it assumes that, as in the case of print reading, many of the neurocognitive raw materials for explicit mind reading are inborn. Therefore, priorities for future research are to identify the genetic "start-up kits" for both implicit and explicit mind reading and to find out exactly how the products of the former contribute to the development of the latter. Our view suggests that, like print reading, mind reading is a culturally inherited skill that facilitates the cultural inheritance of other, more specific skills; mind reading is a cultural gift that keeps on giving.

Learning to read minds is like learning to read print. The acquisition of explicit mind reading is a slow, effortful process in which a novice develops an important, culture-specific skill through expert tuition. Experts facilitate development by directing the novice's attention to signs that the novice is on the edge of understanding, as well as by explaining in conversation how these signs relate to their meaning.

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REVIEW

SOCIAL COGNITION

The cultural evolution of mind reading

Cecilia M. Heyes[1]* and Chris D. Frith[2]

It is not just a manner of speaking: "Mind reading," or working out what others are thinking and feeling, is markedly similar to print reading. Both of these distinctly human skills recover meaning from signs, depend on dedicated cortical areas, are subject to genetically heritable disorders, show cultural variation around a universal core, and regulate how people behave. But when it comes to development, the evidence is conflicting. Some studies show that, like learning to read print, learning to read minds is a long, hard process that depends on tuition. Others indicate that even very young, nonliterate infants are already capable of mind reading. Here, we propose a resolution to this conflict. We suggest that infants are equipped with neurocognitive mechanisms that yield accurate expectations about behavior ("automatic" or "implicit" mind reading), whereas "explicit" mind reading, like literacy, is a culturally inherited skill; it is passed from one generation to the next by verbal instruction.

"Why did she do that?" Neuroscience tries to answer this kind of question by referring to neural processes, but in everyday life we invoke the actor's thoughts and feelings. We predict and explain behavior by ascribing beliefs, desires, and intentions to the actor; for example, "She destroyed the evidence because she thought it was incriminating," or "She nodded at the auctioneer because she wanted to bid for the Miró." Our ability to ascribe mental states to ourselves and others is known as "theory of mind," "mentalizing," "folk psychology," or "mind reading." It has been a major focus of philosophical investigation for centuries and of scientific enquiry for 35 years (*1*). Mind reading has been studied intensively because it is thought to play a pivotal role in human social interaction and communication. Mind reading allows us to predict, explain, mold, and manipulate each other's behavior in ways that go well beyond the capabilities of other animals. Understanding mind reading is therefore crucial to understanding what it means to be human.

Until now, the term "mind reading" has been used in a casual, eye-catching way to suggest kinship with telepathy or to highlight a superficial resemblance between the ascription of mental states and print reading; both involve the derivation of meaning from signs. In print reading, the signs are marks on paper and their meaning relates to objects and events in the world. In mind reading, the signs are facial expressions, body movements, and utterances, and their meaning relates to the actor's mental states. In this article, we argue that the resemblance goes much deeper (Table 1). We suggest that mind reading, like print reading or literacy, is culturally inherited.

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Literate people have neurocognitive mechanisms that are specialized for reading. If literacy were an ancient feature of human life, it would be natural to assume that these mechanisms evolved by genetic means. However, because literacy originated only 5 to 6 thousand years ago, these specialized neurocognitive mechanisms are thought to be products of cultural inheritance or cultural evolution. Cultural evolution has been modeled in a number of ways (*2*). The basic idea is that the reading and writing systems used across the world today have developed, diversified, and been honed by nongenetic evolutionary processes. These processes are evolutionary because they produce change through heritable variation in fitness. However, the inheritance occurs via social learning rather than genetic mechanisms, and fitness is defined by the number of individuals or groups who adopt the system through social learning, rather than by the number of biological offspring. On this kind of evolutionary analysis, when people are trained to read and write, they culturally inherit from their teachers a body of knowledge (for example, about rules governing character inscription and pronunciation) and a set of skills (for example, in distinguishing words from other objects) that are embodied in specialized neurocognitive mechanisms. These mechanisms are constructed or "recycled" (*3*) from genetically evolved mechanisms in the course of literacy training, but they have not been direct targets of gene-based natural selection.

We begin this Review by discussing features of mind reading—its neural bases, developmental disorders, cultural variation, and functions—that might be thought to show that mind reading depends on genetically evolved neurocognitive mechanisms. In each case, we point out that print reading has similar features. Because it is known that print reading is culturally rather than genetically inherited, these similarities between mind reading and print reading clear the way for us to consider the possibility that mind reading is also culturally inherited. In the second section, we discuss recent studies indicating that infants are capable of mind reading. These studies apparently support the view that mind reading depends on genetically evolved mechanisms because there is very little opportunity for cultural inheritance in the first few months of life. However, we will suggest that, when they seem to be mind reading, infants are not using the mechanisms that control "full-blown" or "explicit" mind reading in adults—mechanisms that allow us to deliberate and talk about mental states. In the third section, we turn to direct evidence that explicit mind reading is culturally inherited. This research indicates that, like learning to read print, learning to read minds in an explicit manner is a slow process that depends on instruction (Fig. 1).

Mind reading and print reading

Neural bases

Neuroimaging has shown that adults have cortical circuits specialized for mind reading. These circuits, which include the medial prefrontal cortex, temporo-parietal junction, and precuneus (Fig. 2), are more active when people are thinking about mental states than when they are performing similar tasks that do not involve thinking about mental states (*4*). It is tempting to assume that this sort of cortical specialization is due to genetic evolution. However, similar specialization has been found in the case of print reading. For example, in literate adults an area of the occipito-temporal cortex known as the "visual word form area" is more active during the presentation of words than comparable nonword stimuli (*5*).

Developmental disorders

Many people with autism spectrum conditions (ASCs) have a specific impairment in mind reading. Compared with IQ (intelligence quotient)– and language-matched controls, people with ASCs have difficulty working out what others are thinking and feeling (*6*). There is a substantial genetic contribution to the heritability of ASCs, which might suggest that neurocognitive mechanisms specialized for mind reading are usually genetically inherited and that people with ASCs genetically inherit atypical versions of these mechanisms. But dyslexia reminds us that this is only one of many candidate explanations for the mind-reading impairment associated with ASCs. Dyslexia is a genetically heritable developmental disorder that interferes with the acquisition of a culturally inherited skill: learning to read print (*7*).

Cultural variation

At first glance, it seems that print reading is characterized by cross-cultural diversity and mind reading by cross-cultural commonality. In the print domain, there is certainly a rich diversity of scripts, and the size of the speech units that are mapped onto printed units varies from whole words in Kanji, to syllables in Japanese Kana, to phonemes in alphabetic writing systems (*8*). Furthermore, in the mental domain, it is commonly assumed that

Table 1. Parallels between mind reading and print reading.

Feature	Mind reading	Print reading
Meaning from signs	Mental states from situations and behavior	Referents from inscriptions
Neural specialization	E.g., medial prefrontal cortex and temporo-parietal junction (4)	E.g., occipito-temporal "visual word form area" (5)
Developmental disorders	Autism spectrum conditions (6)	Dyslexias (7)
Cultural commonality	Thoughts and feelings can influence behavior (11)	Number of strokes per character and degree of redundancy (9)
Cultural variation	Importance, range, location, and causation of thoughts and feelings (10–13)	Importance, range, and medium of print; print-to-pronunciation rules (8)
Interpretation	Mental states from situations and behavior	Reading
Regulation	Promotes socially acceptable behavior (15, 16)	Writing and spelling
Implicit competence	Accurate expectations about behavior (17–19, 25–29)	Pictorial "reading"
Slow development	Specialization continues into late adolescence (32–34)	Specialization continues into late adolescence (31)
Cognitive effort	Uses executive processes (26)	Uses executive processes
Individual differences	Due to environmental rather than genetic factors (35)	Due to environmental rather than genetic factors (41)
Development depends on tuition: engineering	Desires and emotions before beliefs and knowledge (43–45)	Easy words before hard words
Development depends on tuition: instruction	Causal-explanatory relations among mental states, situations, and behavior (38–41, 43–48)	Rules relating print to referents and pronunciation

the members of all cultures ascribe thoughts and feelings and understand these states to be related to behavior.

However, recent research suggests that print reading is more (and mind reading is less) uniform across cultures than was previously supposed. For example, featural analysis of 115 writing systems, contemporary and historical, has shown that most characters are formed by three strokes (9). In a complementary way, psychological experiments are beginning to reveal substantial cross-cultural variation in the development of mind reading. For example, children in Australia and the United States understand that different people can have different opinions ("diverse beliefs") before they understand that a person can be knowledgeable or ignorant about a particular fact ("knowledge access"). In contrast, children in China and Iran, where individualism and self-expression are less important, understand knowledge access before they understand diverse beliefs (10). Research of this kind supports earlier ethnographic data suggesting that cultures vary widely in the importance they assign to mental states, rather than situations, as causes of behavior; whether they take mental states to reside inside or outside the body; and the extent to which they regard mental states as subject to natural rather than supernatural laws (11). This research also converges with literary historical studies indicating that, in Western cultures, ideas about the mind and mental disorders have changed radically since ancient times (12, 13).

Interpretation and regulation

Literacy has both interpretative (reading) and regulative (writing) aspects. As children are tutored in the writing conventions of their language, they learn not only to decode printed words (i.e., to relate them to spoken words and to meaning) but also to produce printed words that obey the conventions of their writing system and can therefore be decoded by others. Research on mind reading has emphasized its interpretive role: the way that the attribution of mental states allows us to explain and predict behavior. However, "mental literacy" also has an important regulative role (14). Novice mind readers learn that not only can behavior be produced by rational interactions among beliefs and desires, but also that it should be, and they are encouraged to make their own behavior obey these conventions. Recent research in social psychology and cognitive neuroscience has provided clear evidence in support of this regulative hypothesis. When adults are discouraged from believing in free will—for instance, when they are told that deterministic neurological processes, rather than mental states, control behavior—there is a weakening of neural signals

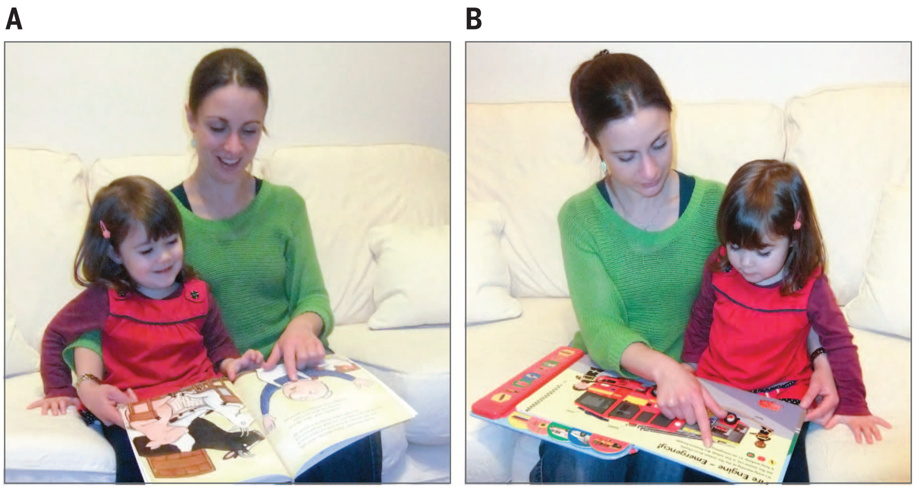

Fig. 1. Learning to read minds is like learning to read print. It is a slow, effortful process in which a novice develops an important, culture-specific skill through expert tuition. Experts facilitate the development of explicit mind reading by directing the novice's attention to signs [(**A**) behaviors, (**B**) words] that the novice is on the verge of understanding. Experts also explain in conversation how these signs relate to their meaning [(A) mental states, (B) objects and events].

associated with action planning (15), and they exhibit more antisocial cheating and aggressive behavior (16).

Implicit mind reading in infants and adults

In contrast, studies of infants suggest that the development of mind reading is very different from that of print reading. Western children do not typically acquire the skill of print reading until they are 5 or 6 years old, but infants as young as 7 months old seem to be capable of mind reading (17). The most notable results suggest that infants ascribe false beliefs to agents; they understand that an agent can believe something that does not match the physical reality of the situation. For example, in a typical experiment (18), infants first watch an adult placing a toy in one of two boxes, green rather than yellow, and subsequently reaching repeatedly for that box. Then they see the toy moved from the green box to the yellow box when the adult is present (true-belief condition) or absent (false-belief condition). In the final phase, infants in the true-belief condition show more surprise, measured by looking time, when the adult reaches for the green box rather than the yellow box, whereas infants in the false-belief condition are more surprised when she reaches for the yellow box. In both cases, the infant "expects" a reach toward the box where the adult believes the toy to be located.

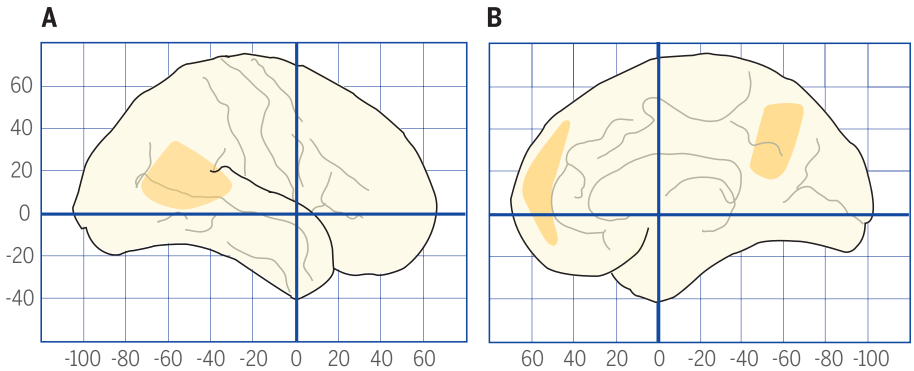

Fig. 2. Brain regions activated by tasks involving mind reading (4). (**A**) A region located on the border of the posterior temporal sulcus and temporo-parietal junction is shown on a diagram of the lateral surface of the right hemisphere embedded in Talairach coordinates. (**B**) Two regions, the medial prefrontal cortex (left) and the precuneus (right), are shown on a diagram of the medial surface of the right hemisphere embedded in Talairach coordinates.

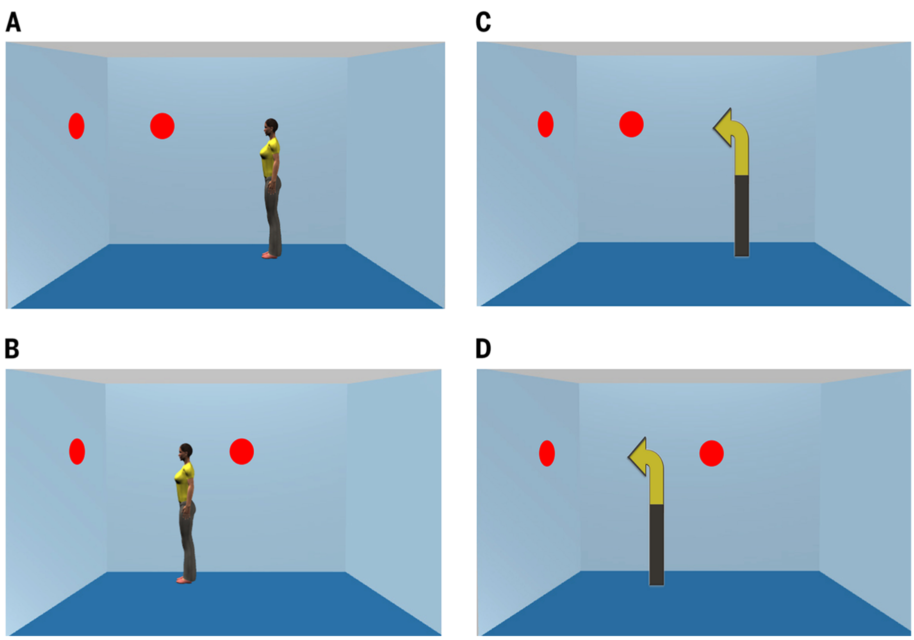

Fig. 3. Stimuli used in the dot perspective task. Adults are asked to report the number of dots they can see. Providing evidence of implicit mind reading, the adults make a faster judgment when all dots are in front of the avatar (**A**) than when some dots are behind the avatar (**B**). This difference also occurs when the central object is an arrow [(**C**) versus (**D**)], suggesting that it may be due to domain-general neurocognitive mechanisms that mediate automatic attentional orienting (29).

Research of this kind, which infers the occurrence of mind reading from nonverbal behavior such as looking time, is said to provide evidence of "implicit" mind reading. Implicit mind reading can be interpreted in three ways. The continuity interpretation suggests that it is controlled by the same neurocognitive mechanisms that mediate explicit mind reading in adults (19). The two-systems interpretation, favored by Frith, suggests that implicit and explicit mind reading arise from different neurocognitive mechanisms, but both systems are specialized for thinking about mental states (20, 21). This is supported by the case of autism, in which there is evidence of specific failures in mind reading, whereas other domains remain intact (22). The implicit system develops early and tracks mental states in a fast and efficient way, whereas the explicit system develops later, operates more slowly, and makes heavier demands on executive functions such as working memory and inhibitory control. In common with the two-systems model, the submentalizing interpretation, favored by Heyes, assumes that explicit mind reading depends on specialized mechanisms that are late developing, slow, and effortful. However, the submentalizing view suggests that implicit mind reading depends on domain-general neurocognitive mechanisms, rather than mechanisms that are specialized for thinking about mental states (23, 24).

The case of autism suggests that implicit and explicit mind reading depend on different mechanisms because explicit mind reading can be achieved in spite of continuing problems with implicit mind reading (25). Further evidence for this dissociation is found in studies of neurotypical adults. In tasks in which adults make verbal judgments about other people's thoughts and feelings (explicit mind reading), judgment accuracy is impaired by concurrent performance of an executive function task (26). In contrast, concurrent demands on executive function do not interfere with implicit mind reading (27). This dissociation is hard to reconcile with the continuity hypothesis but is compatible with the two-systems and submentalizing interpretations of implicit mind reading.

Evidence that implicit mind reading is automatic—that it does not make demands on executive function—comes from a "dot perspective task" in which participants see pictures of a room (Fig. 3). There is a human figure (an "avatar") in the middle of the room, facing to the right or left, and dots on the walls. The participant is required to report the total number of dots in each picture. Implicit mind reading is inferred from the fact that responses are slower and less accurate when some of the dots are behind the avatar than when they are all in front (28). On the two-systems account, this "self-other consistency" effect is due to automatic calculation by a specialized system of the number of dots that the avatar can see (i.e., of the content of the avatar's mental state). This automatic calculation gives a different result from the calculation of the number of dots the participant can see and thus causes interference. On the submentalizing account, the effect is due to automatic attentional orienting to the gaze direction of the avatar (29); the same domain-general process that allows inanimate stimuli, such as arrows, to direct attention (30).

According to both accounts, however, explicit mind reading—the kind that allows us to deliberate about mental states and to express our thoughts about mental states in words—is like print reading: it develops slowly and is cognitively demanding. The slow development of print reading is reflected in the fact that event-related potentials indicative of reading fluency are not quite as fast in 16 year olds as in mature adults (31). Similarly, it is now known that in Western cultures, the neural systems implicated in explicit mind reading (Fig. 2) are among the last to reach maturity (32), and performance on explicit tests of mind reading (including perspective-taking, emotion recognition, and detection of pretense and irony) continues to improve between adolescence and adulthood (33, 34).

Learning to read minds

Further evidence that the development of explicit mind reading depends on a slow process of learning, rather than the maturation of genetically inherited neurocognitive mechanisms, comes from a major twin study (35). When more than one thousand twin pairs were given a comprehensive battery of explicit mind-reading tests at 5 years old, the correlation in performance within pairs was the same (0.53) for nonidentical twins, with an average of 50% of genes in common, and for identical twins, who have all of their genes common. This indicates a "substantial shared environmental influence but negligible genetic influence on individual differences in theory of mind" (35).

However, by itself, this twin study does not tell us about the nature of the environmental influence or the kind of learning involved in the development of explicit mind reading. There are two well-established accounts of mind reading: simulation theory and theory-theory. Although they were previously treated as competing approaches to the explanation of mind reading, it is now widely accepted that these are complementary accounts with theory-theory having a role in explicit high-level mind reading, whereas simulation theory is more relevant to implicit low-level mind reading (36). Theory-theory proposes that children learn like scientists, developing explicit theories of how mental states cause behavior through observation and hypothesis testing (37). In this case, the ideas are not only honed and tested, but also generated by the novice mind reader herself. In contrast, our cultural evolutionary view suggests that the novice's ideas about the mind are derived primarily not from observation but from instruction, from what the novice is told about the mind by the expert mind readers in her social world.

A "natural experiment" has provided compelling evidence that language-based tuition is crucial in the development of mind reading. This natural experiment was the emergence in the 1970s of a new sign language (NSL) among deaf people in Nicaragua. Pyers and Senghas compared false-belief understanding in two adult cohorts of NSL users. They found that the first cohort, who learned NSL when it was still a rudimentary language, was less able to understand false beliefs than the second cohort, who learned NSL ~10 years later when it included many more signs for mental states. This suggests that although adults in the first cohort were 10 years older—and therefore had 10 years more opportunity to reflect on their own mental states and to watch the behavior of social partners—their understanding of false belief lagged behind that of adults in the second cohort because, lacking mental-state vocabulary, they had not been able to receive instruction about the mind (38). These results are supported by a recent study showing that children in Samoa, where it is considered improper to talk about mental states, develop an understanding of false belief at ~8 years of age, 4 or 5 years later than children in Europe and North America (39).

In combination with other research involving typically and atypically developing children (40, 41), the NSL and Samoan studies indicate that we learn about the mind through conversation about the mind. In principle, the appropriate conversational experience could come from eavesdropping; that is, by listening to what expert mind readers say when they have no intention of teaching a novice. However, many studies suggest that experts, especially mothers, tailor or "epistemically engineer" (42) their conversation about the mind so that it helps children to learn (43–45). For example, in conversation with their 15 month old children, mothers make proportionally more references to desires and emotions than to thoughts and knowledge, and the frequency of desire/emotion talk selectively predicts the children's explicit mind-reading performance at 24 months. In contrast, at 24 months, mothers talk proportionally more about thoughts/knowledge than desires/emotions, and it is the frequency of references to thoughts/knowledge that predicts explicit mind reading at 33 months (43). Desires/emotions are easier to understand because infants and children are constantly attempting to fulfil their desires, and emotions are often reflected in distinctive facial expressions. Therefore, these findings suggest that, just as novice print readers are introduced to easy words before hard words, novice mind readers are introduced to easy states before hard states, and this epistemic engineering of the child's learning environment promotes the development of mind reading.

The development of explicit mind reading is not only predicted by the frequency with which mothers use mental state terms—such as "think," "want," and "happy"—in conversation with their children; it is also predicted by the frequency of mothers' "causal-explanatory" statements about the mind, specifying relations between situations, mental states, and observable behavior. For example, "She is smiling because she is happy," and "She thinks the toy is in the green box because she didn't see it moved to the yellow box" (41). In addition, Lohmann and Tomasello (46) found that training sessions in which 3 and 4 year olds conversed with an adult about deceptive objects (e.g., a pen that looks like a flower) were especially effective at improving false-belief understanding when the adult used sentential complement syntax: sentences such as "What do you think it is?" and "You say it is a flower," which take a full clause as their object complement. Research on causal-explanatory statements and sentential complements (47) suggests that conversation about the mind does not merely teach children labels for mental states. It also teaches them mental state concepts—what it is to "think" or to "feel" something, to be "happy" or "doubtful"—and gives them a format in which to represent these concepts. In other words, children culturally inherit from their parents, and other mind-reading experts (48), mechanisms that are specialized for the representation of mental states.

In emphasizing the importance of conversation and the possibility of marked cross-cultural variation, our view is similar to social constructivist accounts of mind reading (49). However, unlike many social constructivists, and in common with theory-theory, we assume that the processes involved in the development of explicit mind reading are broadly rational and yield conceptual knowledge about the mind. It is likely that some elements of mind reading, such as those relating to knowing or to primary emotions, will be found to show less cross-cultural variation than others, but our framework allows substantial variation, even in the "heartland" of mind reading. For example, given the structure of the human nervous system, it is likely that, in all cultures, looking is predictive of behaviors that, in many cultures, are understood to indicate knowing. But there could still be substantial variation in beliefs about the relation between seeing and knowing (50). Distinctive assumptions about the origin, location, and functioning of mental states will lead the members of different cultures to attend to different aspects of observable behavior, and because mind reading has regulative as well as interpretive functions, distinctive beliefs about the mind will lead to different patterns of observable behavior.

Start-up kit

In contrast with nativist theories of mind reading, our cultural evolution hypothesis suggests that humans do not genetically inherit neurocognitive mechanisms that are specialized for the development of explicit mind reading. Nonetheless, we naturally assume that genetically evolved mechanisms provide much of the raw material for the construction of explicit mind reading: the mechanisms that become specialized for representation of mental states and the processes that make cultural inheritance possible. Our perspective implies that a priority for future research is to identify the genetic "start-up kit" (22) for the cultural inheritance of mind reading. No one has made a concerted attempt to train chimpanzees to read minds, but few, if any, researchers would expect this enterprise to be a success. Why? What are the genetically inherited neurocognitive resources that enable humans, but not chimpanzees, to culturally inherit mind reading?

Implicit mind reading

The healthy human infant comes into the world armed with a number of brain mechanisms that have a critical role in learning about the behavior of others. Some of these mechanisms are primitive and held in common with many other species. However, their presence in humans, in conjunction with dramatically enhanced learning processes, creates the potential for acquiring powerful social abilities. From birth, human infants attend to face-like stimuli and, by the end of their first year, can use faces to recognize identity, race, emotion, and gaze direction (*51*). Human infants also show a preference for observing moving limbs (*52*) and, by the age of 12 months, show predictive eye movements when observing the actions of others (*53*). In other words, they can predict where a movement will end, given how it starts. Infants are also attending to their own movements, thereby creating the link between action observation and action production that generates the motor resonance fundamental to accounts of low-level mind reading associated with simulation theory (*54*).

Much further work is needed to discover how and to what extent these low-level observational mechanisms contribute to the development of explicit mind reading. Again, the analogy with print reading may be helpful. Through listening to speech, the infant discovers statistical regularities that define components such as words and syllables (*55*). The implicit knowledge of such components is a vital precursor for learning how to map sounds onto strings of letters. Likewise, there are detectable statistical regularities associated with body movements derived, in part, from the physical constraints created by gravity and the construction of mammalian bodies (*56*), which define a vocabulary of action components. At the same time, infants, through the experience of their own instrumental actions, are learning to categorize actions in terms of features such as success and efficiency (*57*). This implicit knowledge not only provides a basis for expectations about the outcomes of observed actions (*58*), but also provides predetermined targets for instructions about how mental states are related to actions.

Explicit mind reading

Implicit mind reading emerges from observing the behavior of others. This is a one-way process. The learner observes the actor, who need not be aware that he or she is being observed. In contrast, explicit mind reading emerges from the deliberately instructive behavior of others. This is essentially a two-way process. The behavior of the actor is designed to help the observer learn, and both actor and observer are actively engaged in a communicative process. Components of a start-up kit for such processes might include the preference of newborn infants for faces making eye contact and the preference of very young infants for objects that respond to their own actions with high contingency. By 4 months, gaze following is much more likely to occur if it is preceded by direct eye contact (*59*). Between 12 and 18 months, infants can use eye contact and pointing behavior as signals that distinguish between communicative and noncommunicative interactions (*60*, *61*). This phenomenon of joint attention, in which both parties are aware that they are jointly attending, seems to be distinctly human (*62*).

Conclusions and future directions

We have argued that explicit mind reading is culturally inherited in the same way as print reading. The neurocognitive mechanisms that allow us to deliberate and talk about mental states are constructed, or recycled (*3*), from mechanisms that evolved genetically to fulfill more general functions (to parse and predict dynamic sequences of events and to get information from others), and the construction process depends on tuition. Expert mind readers communicate mental-state concepts, and ways of representing these concepts, to novices. As the present generation of novices becomes expert, it passes on the knowledge and skill of mind reading to the next cultural generation.

Most, possibly all, human neurocognitive skills are shaped by culture, and many are culturally inherited, but the parallels between mind reading and print reading are extraordinary. For example, linguistic communities vary in the ways that they categorize colors, but color perception is not culturally inherited in the same way as print reading. Unlike print reading, color perception is rooted in highly specialized, genetically inherited mechanisms that humans share with other species. Although cultural input adjusts these mechanisms, it does not make them into a whole new neurocognitive system.

The analogy between print reading and mind reading is not perfect. "Sound symbolism" shows that the relations between inscriptions and their corresponding speech sounds and referents often depend on structural features of the nervous system (*63*), but it is likely that these relations are more arbitrary than the relations between observable behavior and mental states. In this respect, numeracy may be a better analog than literacy. However, explicit mind reading is comparable to print reading, not only in terms of its weak dependence on specialized genetically inherited mechanisms and strong dependence on tuition, but also in the shape and size of the cultural legacy. Like print reading, explicit mind-reading mechanisms represent representational relations—between mental states, behavior, and events in the world—and allow the mind reader to regulate and interpret a virtually limitless range of mental contents. Consequently, the print reading and mind reading legacies are also alike in promoting the cultural inheritance of other, more specific skills. Reading and writing enable us to teach others almost anything we know through the written word, and mind reading improves the efficiency of all teaching by allowing the expert to represent what the novice does and does not already understand. Like print reading, mind reading is a cultural gift that goes on giving, a culturally inherited skill that facilitates the cultural inheritance of an enormous range of other, more specific skills (*64*).

We have suggested that in infancy, when the enculturation process is only beginning, implicit mind-reading mechanisms produce, under some circumstances, accurate expectations about the behavior of agents. A priority for future research is to find out whether these implicit mechanisms are specialized for mind reading, or whether implicit mind reading is mediated by domain-general mechanisms. In either case, it is clear that implicit mind-reading mechanisms continue to operate throughout the life cycle, enabling swift social coordination of behavior when time is short and other demands on the neurocognitive system are heavy. It is possible that the outputs of these implicit mechanisms also contribute to the development of explicit mind reading by, for example, segmenting the stream of observable behavior into units that can subsequently be aligned with mental categories. However, in our view, implicit mind reading is radically insufficient for the development of explicit mind reading. Our view suggests that no amount of individual learning—implicit mind reading, introspection, and watching the behavior of others—would be enough for the development of explicit mind reading. If a group of human infants managed to survive on a desert island, in a cruel *Lord of the Flies*–like experiment, they would be no more likely to develop a theory of mind and become explicit mind readers than to develop a writing system and become literate print readers.

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