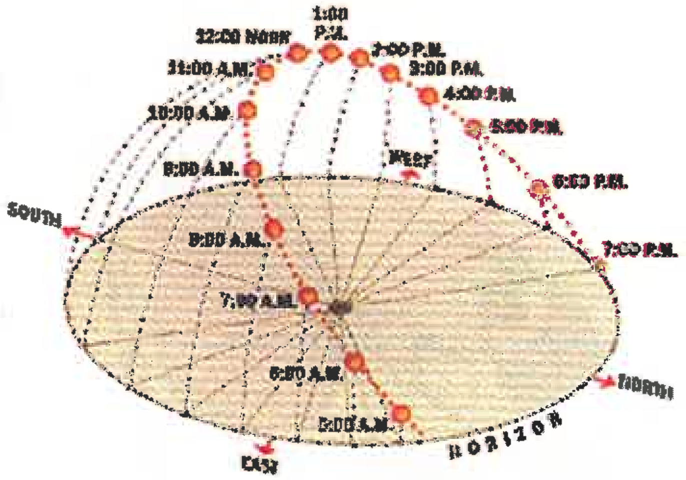


KIRK MOLDOFF

Animals that use the sun in navigation must compensate for the movement of its azimuth—its compass bearing observed from the earth's surface—relative to a fixed geographical heading. The diagram shows how the azimuth changes on a midsummer day at a northern temperate latitude. Note how the change is faster at midday than near sunrise or sunset. The pattern would be different at other latitudes and also changes seasonally. Honeybees and other animals learn the current local pattern of solar movement early in their lives.

to the pattern of stars that defines geographic north, although they must first have an opportunity to see the rotation of the heavens so they can learn which stars are important to watch; perhaps the complex and varying arrangement of the stars at different latitudes makes it impossible to preprogam birds with a universal stellar compass.

The magnetic and geographic poles are not perfectly aligned, however, and sometimes migrating songbirds are confronted with a discrepancy between magnetic north and celestial north. When this happens, as shown by Ken and Mary Able, of SUNY Albany, with savanna sparrows, learning again takes over as the birds "reset" their magnetic compass to correspond to celestial north. Fine-tuning the magnetic compass this way makes sense: once it is established, the stellar compass is utterly reliable, whereas the magnetic compass is subject to error because of local distortions in the geomagnetic field.

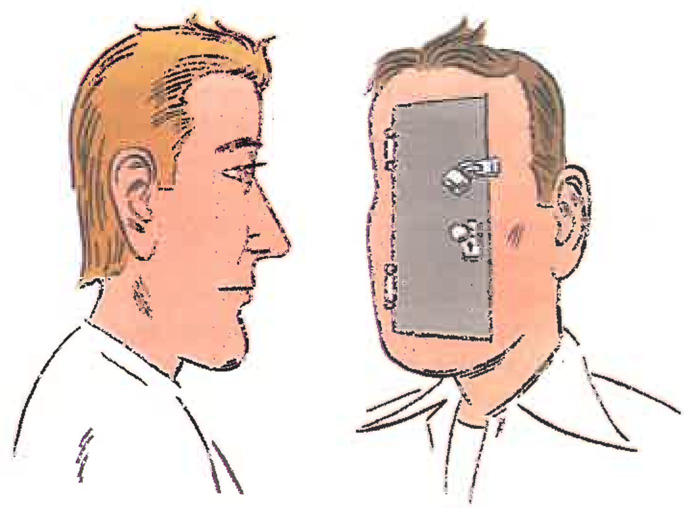
An interplay between innate and learned information has also been documented in the movements of sand hoppers seeking a favorable place on the beach, of hatchling sea turtles in their headlong rush to the sea, and of desert ants scavenging for dead insects in northern Africa. All these creatures rely on innate responses to aspects of their environment that don't change. But to deal with unpredictable events and unique aspects of their local conditions, the birds and the bees, as well as turtles, ants, and sand hoppers, find that the best way to adhere to the straight and narrow is to be a good learner.

Mindblind

By Simon Baron-Cohen

Imagine a movie that begins with the following scene: a woman enters a bedroom, walks around in it, and then leaves. Most people could not witness such a scene without thinking about the woman's behavior. Maybe she was looking for something she thought was in the bedroom. Or maybe she heard something in the bedroom and wanted to find out what made the noise. Or maybe, we might even imagine, she had intended to go into the kitchen and forgot where she was going.

All these explanations are based on our inferences about the woman's mental state. What we are attempting to do, in essence, is read her mind. Most of us engage in such mind reading all the time. Without it, we would be "mindblind," unaware of other people's mental existence, of the existence of thoughts, emotions, intentions, knowledge, memories. We would be unable to make sense of the actions of others, a terrible dilemma for a member of a social species such as ours.



Tragically, mindblindness is not the product of an idle thought xperiment or a piece of science fiction. For children and adults vith autism—a severe neurological disorder that often interferes vith, among other things, the ability to develop normal human elationships—mindblindness is all too real. Scientists study conlitions like autism for several reasons. The most obvious is to disover their causes and, if possible, effective treatments. But these lisorders of the brain, like some of the neurological problems that ollow strokes or traumatic head injury, can also help explain how he healthy mind works.

Autism starts early in childhood. Sufferers find it difficult to ommunicate or connect socially with others (hence the name autism," which comes from the Greek word for "self"). Their magination appears impoverished; their play, for example, lacks he element of make-believe. They tend to be very upset by hanges in their environment and seek to mainain strict order in all aspects of their lives, often y withdrawing into a world of repetition and ameness—performing rituals and routines and ccupying themselves with lists, timetables, or alendars.

In pretend play, children must keep track of two realities: that of the "real" world and that of make-believe. Above, a tea party; below, pretending to be beetles.

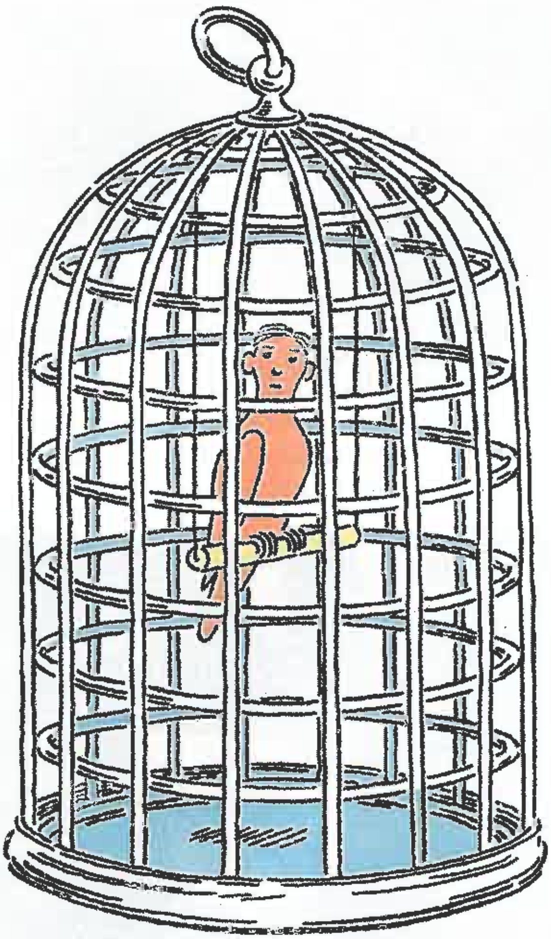
Most children with autism show little interest n people. They do form attachments to familiar dults and will approach a parent, for example, vhen they need something, but otherwise they nostly appear to be satisfied with a nonhuman vorld of objects, machines, and routines. Vhereas most children take pleasure in an exhange of humor, a shared game, or a conversaion, children with autism are indifferent to such ocial interactions. Lacking a concept of the ther person as an interested listener with a mind f his or her own, they often talk too loudly, too oftly, or with little inflection. They may tell you things you aleady know (such as your name and address) or things you have hown no interest in knowing (such as exactly how many song racks are on an album).

A quick look at certain milestones in the early development f "normal" children provides insight into why children with utism are so isolated. In their first year, most infants monitor vhere someone else is looking and turn to gaze in the same diection. By the time they are fourteen months old, these infants re pointing out interesting things in their environment and turnng to look at what someone else is pointing at. Toddlers also ring things to their parents or other caregivers, simply to show hem. All these actions bring child and adult together in what Jniversity of Sussex psychologist George Butterworth calls "a neeting of minds."

Also by fourteen months of age, most children show interest n another person's attitude or intentions toward them. They vatch facial expressions carefully to assess whether the other peron is being serious or playful, threatening or affectionately teasing. Pretend play, alone and with others, begins at about the same time. A child may pretend that a coat is a blanket and put it over a doll. Or the child may put a spoonful of imaginary food to his mother's lips, laughing with delight when she says, "Mmm, good!" Pretend play is particularly fascinating because it requires a child to recognize two realities: that of the physical world and that construed in the mind.

In children with autism, all these early milestones of development are missing or greatly delayed for months, sometimes years, depending on the severity of the disorder (and of the other conditions often associated with autism, such as epilepsy, mental retardation, and a variety of brain pathologies). And as children grow older, further signs of mindblindness typically show up. When they start to speak, children with autism tend to talk about only one level of existence: the physical. Unlike most three-year-old children—who say things like "Mommy thinks I'm sleeping, but I'm just pretending"—they use few, if any, words that refer to the contents of their own or other people's minds.

By four years of age, normal children are becoming even



into it, the other touching it but unable to see inside. When asked, "Which of the two people knows what is in the box?", two-thirds of the children with autism didn't know. Again unlike normal children, they didn't understand that seeing leads to knowing.

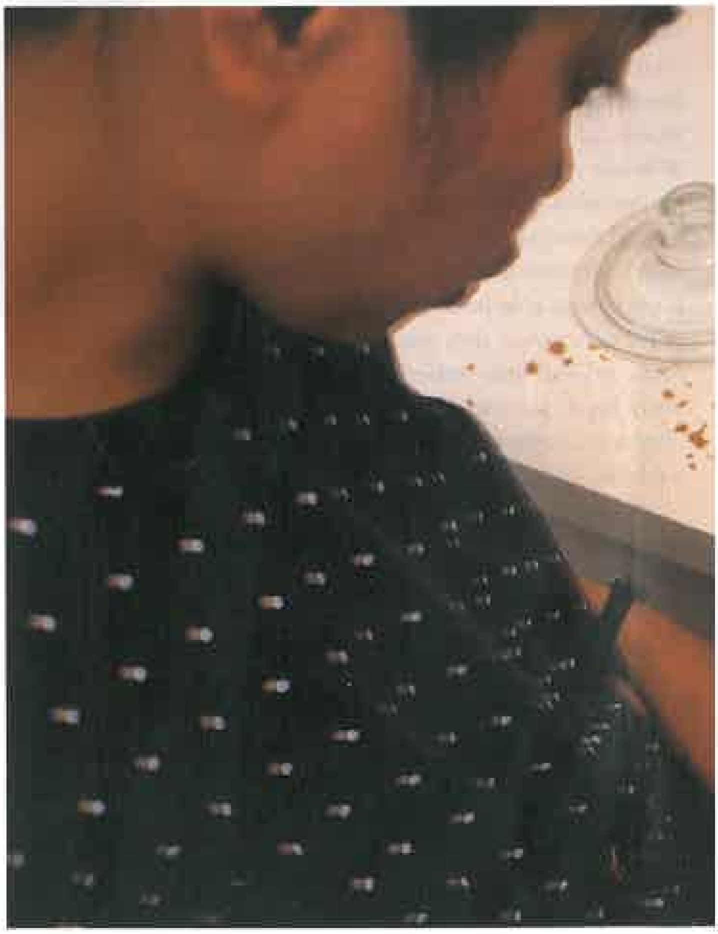
These sorts of studies suggest the existence of some system for mind reading, which is missing, damaged, or delayed in the development of people with autism. Currently, new imaging techniques are being used to hunt down parts of the brain that may be involved. The search is in its early stages, but the existing evidence points to parts of the prefrontal cortex (known to control planning and social judgment), part of the temporal lobe (involved in perceiving faces and the direction in which someone is looking), and the amygdala (involved in emotions).

Whatever the structure or mechanism for mind reading turns out to be, and wherever it is housed in the brain, I am convinced that this impressively efficient way of making sense of such a complex system as a human being is as much a product of evolution as our hands and eyes. Autism appears to be a genetic condition (a child's risk of developing autism is substantially increased if his or her identical twin or biological sibling has it), and genes are the raw material with which natural selection works. Another

more sophisticated: they begin to deceive. This might be in play (as in a game of hide-and-seek) or an attempt to get away with something (a little girl saying she has no idea what happened to the last cookie, for instance, while the crumbs on her face tell the true tale). While we may frown on the actions of the cookie thief, they are further evidence of the very human interest in reading, and manipulating, minds. Children with autism have real difficulty understanding deception, and they rarely, if ever, lie.

A number of experiments with young children have helped clarify just how much of a handicap mindblindness can be. In one experiment, children were shown—one at a time—a container of a familiar kind of candy and asked, "What do you think is in here?" The children naturally replied, "Candy." Each child was then shown that the container actually held pencils. Next the experimenter closed the container and asked each child two questions: "When I first showed you the container, what did you think was inside? And when another child comes into the room, what will he think is inside?" Most children with autism replied "pencils" to both questions. Unlike normal children tested in the same way, they appeared unable to understand that beliefs can be false or that two people can have different beliefs.

Another experiment involved a box with an open top and something inside it. Two people stood near the box, one looking



"No, really, I didn't take the last cookie." Along with an interest in rea[...] comes an awareness of the possibilities of deceiving them.

lue that mind reading might be innate, encoded in the genes, is hat normal infants and preschoolers are not explicitly taught to nind read; they just do it. No other species appears capable of nything close to the sophisticated mind reading humans engage 1: chimps, for example, may monitor another's gaze, but there is o hard evidence that they can understand beliefs or make-be-eve. This all suggests to me that mind reading, like many other nental abilities, has evolved further in humans.

What's more, mind reading is clearly adaptive. Without it, uman society as we know it simply would not exist. It would ei-her be rigid (like that of ants or bees) or limited to physical in-eractions and observable signs of social status and alliances (as in nany species of monkeys and apes). And although we may find it ifficult to think of something as intangible as mind reading being ubject to evolution, consider the alternative. Understanding the nillions of different physiological states that give rise to different ehaviors, for example, is out of the question; you would need vhat University of California psychologist Alison Gopnik has alled a brainoscope. Instead, long before most children acquire heir first periscope to spy around corners or a telescope to gaze p at the heavens, they have become proficient at peering into he minds of other people with their very own "mindoscope."

ıds of other people

Recommended Reading

"The Brain's Versatile Toolbox" (page 42)

How Humans Evolved, by Robert Boyd and Joan Silk (W. W. Norton, 1997)

Self-Made Man: Human Evolution from Eden to Extinction?, by Jonathan Kingdon (John Wiley and Sons, 1993)

"Human See, Human Do" (page 45)

Chimpanzee Cultures, edited by Richard W. Wrangham (Harvard University Press, 1994)

Primate Cognition, by Michael Tomasello and Josep Call (Oxford University Press, 1997)

"Learning Under the Influence" (page 47)

The Evolution of Culture in Animals, by John T. Bonner (Princeton University Press, 1980)

Social Learning in Animals: The Roots of Culture, edited by Cecilia M. Heyes and Bennett G. Galef, Jr. (Academic Press, 1996)

Chimpanzee Material Culture: Implications for Humans, by W. C. McGrew (Cambridge University Press, 1992)

"Inattention Must Be Paid" (page 49)

The Brain Pack: An Interactive, Three-Dimensional Exploration of the Mysteries of the Mind, by Ron Van der Meer and Ad Dudink (Running Press, 1996); a pop-up book with audio cassette

"Small Systems of Neurons," by Eric R. Kandel, in *Biology of the Brain: From Neurons to Network,* edited by Rodolfo R. Llinas (W. H. Freeman, 1989)

"Math Without Words" (page 52)

The Evolution of Communication, by Marc D. Hauser (MIT Press, 1996)

"Addition and Subtraction by Human Infants," by Karen Wynn (*Nature,* August 27, 1992)

"Memories Are Made of This" (page 56)

Searching for Memory, by Daniel L. Schacter (Basic Books, 1996)

Food Hoarding in Animals, by Stephen B. Vander Wall (University of Chicago Press, 1990)

"The Seat of Insect Learning?" (page 58)

"Birds Do It, Bees Do It, Even Turtles in the Sea Do It" (page 60)

Animal Navigation, by Talbot H. Waterman (Scientific American Library, W. H. Freeman, 1989)

The Organization of Learning, by C. R. Gallistel (MIT Press, 1993)

Web site: http://flybrain.neurobio.arizona.edu

"Mindblind" (page 62)

Autism: The Facts, by Simon Baron-Cohen and Patrick Bolton (Oxford University Press, 1993)

Mindblindness: An Essay on Autism and Theory of Mind, by Simon Baron-Cohen (MIT Press, 1995)

Thinking in Pictures: And Other Reports from My Life with Autism, by Temple Grandin (Vintage Books, 1995)

General Reading on the Nature of Learning

How Brains Think: Evolving Intelligence, Then and Now, by William H. Calvin (Basic Books, 1996)

The Animal Mind, by James L. Gould and Carol Grant Gould (W. H. Freeman, 1994)

Animal Minds, by Donald R. Griffin (University of Chicago Press, 1994)

Kinds of Minds, by Daniel C. Dennett (Basic Books, 1996)