MEETING: COGNITIVE NEUROSCIENCE SOCIETY

Probing the Social Brain

By scanning activity within the skull, researchers are trying to understand how our brains manage interactions with other people

SAN FRANCISCO, CALIFORNIA—Whether or not we admit it, we are all armchair psychologists. Every day we analyze the behavior of friends and colleagues, trying to infer their motivations, intentions, and emotions. We even analyze ourselves. Neuroscientists are no different, except that they have access to expensive brain-scanning machines, which give them an advantage in figuring out what’s going on inside someone’s head.

For the first time, this year’s meeting of the Cognitive Neuroscience Society (held here 9 to 12 April) included two symposia devoted to social and affective neuroscience, related fields that investigate how the human brain handles everyday situations such as figuring out what’s on someone else’s mind or controlling one’s own emotions in dealings with other people. The presentations highlighted the excitement as well as some of the growing pains of this active area of research.

Thinking of you

Christian Keysers of the University of Groningen in the Netherlands reported new work on the neural basis of empathy. In recent years, Keysers and others have described how the brain engages in “mirror” activity that reflects the actions and experiences we see in those around us. For example, if someone sees another person grab a piece of fruit lying on a table, the region of her brain that would prepare her own arm to reach for the fruit becomes active. This happens not only when we observe actions; brain imaging studies have revealed that the brain engages in analogous mirror activity when we observe sensations and emotions as well, leading to the hypothesis that mirror activity is part of the neural mechanism that creates empathy (Science, 13 May 2005, p. 945).

“It’s one of the more exciting areas ... for understanding individual differences and psychopathology.”
—Cameron Carter, UC Davis

In their new study, Keysers and his grad student Valeria Gazzola investigated whether hearing rather than seeing a human action elicits mirror activity. Inside a functional magnetic resonance imaging (fMRI) scanner, 16 volunteers listened to various sounds—some associated with mouth movements, such as gargling or spitting; some associated with hand movements, such as pouring a fizzy soda into a glass; and others not caused by human activity, such as a dripping faucet. Sounds made by the mouth or hand activated brain regions involved in planning movements, including the premotor cortex, whereas environmental sounds such as the dripping faucet did not, Keysers reported. Moreover, mouth sounds activated a different region of the premotor cortex than did hand sounds. The response is very specific, Keysers says: Hearing an action activates the same brain areas that would be involved in planning that action.

The auditory-evoked mirror activity was most pronounced on the left side of the brain, where language circuitry is concentrated. This fits nicely with theories linking mirror activity to the evolution of human language, Keysers says. Other researchers have proposed that mirror activity enabled early humans to communicate by imitating each other’s gestures (Science, 27 February 2004, p. 1316). In this view, gestures preceded vocal communication. But the new work suggests to Keysers that speech could have evolved directly from vocal imitation, aided by mirror activity in the left side of the brain.

Keysers and Gazzola also found that people who scored higher on a questionnaire that assessed their empathetic tendencies had more mirror activity. “The people who reported in everyday life that they consider the perspective of other people were the ones whose mirror systems were most active when hearing sounds made by other people,” Keysers says.

“The mirror data are fantastic,” says Jason Mitchell, a cognitive neuroscientist at Harvard University. But Mitchell doesn’t think this is the only mechanism at the brain’s disposal for reading other people’s minds. “It’s almost certainly part of it, but there are things we can do that the mirror system can’t handle.” For instance, Mitchell says, “we’re really good at inferring the mental state of a character in a novel, but it’s a real stretch to imagine how the mirror system could do that because it doesn’t have any [firsthand] information about the person.”

Other studies have shown that this sort of inference—in which no human activity has been observed—involves the medial prefrontal cortex (mPFC), Mitchell notes. In a talk at the conference, he presented new findings from his lab that suggest an intriguing refinement: People seem to use one region of mPFC to consider the mental state of someone they perceive as similar to themselves and another region of mPFC to consider someone perceived as dissimilar.

Mitchell and colleagues introduced 15 volunteers—all undergraduate or graduate students from the Boston area—to two hypothetical students by showing them photographs and short descriptions supposedly representing the students’ profiles on an Internet dating site. One hypothetical student described his politics as “left of center” and said he “still can’t believe Bush got reelected.” The other described himself as a fundamentalist Christian and “strong supporter of the Republican Party.”

The researchers then used a reaction-time test to assess which of the two hypothetical students the volunteers deemed more similar.
to themselves. The reaction-time test, which required students to match the faces of the two students with pronouns—such as “I” or “they”—by pressing computer keys, is more reliable than simply asking people about their preferences because it’s harder to fake, Mitchell says. (In liberal Cambridge, for example, a conservative might find it socially expedient to apply a leftward adjustment to his answers.)

Their true allegiances revealed, the volunteers then slid into an fMRI scanner and answered yes-or-no questions about themselves and the hypothetical students. The questions required the volunteers to consider the mental state of the person in question, asking, for example, “Would Student #1 worry about getting a summer job?” or “Would Student #2 get upset waiting in traffic?” When volunteers thought about their own mental states in these situations, a region of ventral mPFC became active. The same area revved up when volunteers put themselves in the shoes of the student they viewed as similar to themselves. However, when volunteers considered the mental state of the dissimilar student, a nearby region, dorsal mPFC, lit up in the scans. The study will appear in the 18 May issue of Neuron.

Keysers says Mitchell’s findings may provide a bridge between two traditionally opposed hypotheses about how we infer the mental states of others: simulation theory and theory of mind. Simulation theory holds that we use our own experience to infer the experience of others. Mirror activity in the brain is often held up as an example of simulation theory in action. In contrast, theory of mind holds that we use abstract rules about how people behave to infer the mental states of others. The activity in dorsal mPFC seems to represent this second kind of cognition, Keysers says, but the activity in ventral mPFC seems to represent aspects of both simulation theory and theory of mind: It’s abstract thought because the person under consideration isn’t actually present, yet it taps into the same brain circuitry used for self-reflection. Rather than being mutually exclusive, simulation theory and theory of mind may turn out to be “two processes we can mix together,” Keysers says.

**Getting a grip on emotions**

Reading the minds of invisible strangers isn’t the only talent neuroscientists have attributed to the prefrontal cortex, a sizable swath of tissue just behind the forehead that has expanded greatly in the course of mammalian evolution. In humans, the area also appears to have much to do with personality, planning for the future, and keeping a lid on inappropriate thoughts, behaviors, and emotions—another common focus of research presented at the meeting.

Several recent studies have investigated the role of the prefrontal cortex in keeping emotions in check in social situations. In 2003, for example, Naomi Eisenberger and Matthew Lieberman of the University of California (UC), Los Angeles, and Kipling Williams of Macquarie University in Sydney, Australia, described findings suggesting that the right ventrolateral prefrontal cortex (RVPFC) dampens the feeling of social rejection people experience when their character is shunned by other characters in a video game (Science, 10 October 2003, p. 290). Subjects who reported feeling less rejection showed more RVPFC activity and less activity in the amygdala, a part of the brain whose activity reflects emotional arousal.

At the conference, Lieberman presented new work that suggests the RVPFC region helps keep emotions in check during another type of social interaction. Lieberman and colleagues adapted a version of the “ultimatum game” used in behavioral economics. In each round, two players are told that they will split a sum of money; Player 1 decides what share to give Player 2, whose only options are to take it or leave it. The researchers scanned the brains of volunteers playing the part of Player 2 as they played one round each against what they were told were 70 different Player 1s (all of whom were actually a computer programmed to share between 5% and 50% of the total stake).

The most interesting situations, Lieberman says, are those in which the volunteer is offered a decent sum of cash that’s a low percentage of the total stake. The rational thing to do is to take the money, but many people will reject an offer they deem to be insulting low. From the brain scans, the best way to predict whether a volunteer would take an unfair offer was the amount of activation of RVPFC. “The more they activate this area, the more likely they are to say ‘Forget the insult, I’ll take the money,’” Lieberman says.

Lieberman has found that the amount of RVPFC activity in people playing the game is inversely proportional to activity in the insula, a brain region that has been linked to the perception of disgust. Although he concedes that such correlations don’t prove that RVPFC directly suppresses activity in the insula or amygdala, he says that’s his working hypothesis: “What RVPFC does well is it disengages us from our immediate responses … [and] allows higher cognitive abilities to guide thought and behavior without interference from emotional processes.” Lieberman is now investigating whether RVPFC activity is abnormal in people with anxiety disorders and whether activity in this brain region changes in people undergoing therapy.

The work is an interesting attempt to examine how people respond in a situation similar to what they might face in everyday life, says Jennifer Beer of UC Davis. Yet Beer says she’s not convinced the RVPFC activity in Lieberman’s experiment represents emotional regulation per se. “In the ultimatum task, there’s probably a lot of things going on when you’re dealing with fair and unfair offers, not just [regulating] emotion,” she says. RVPFC activity could represent some more general cognitive process related to decision-making or response selection, Beer says.

Determining whether particular brain regions and patterns of activity are uniquely dedicated to social or emotional cognition is a major challenge for the field, says Cameron Carter of UC Davis. “This new area doesn’t quite have the theoretical or methodological rigor of more traditional cognitive neuroscience” research on memory and attention, which scientists have probed with fMRI since the early 1990s, Carter says. But the field will improve as it matures, he adds: “It’s one of the more exciting areas, and it’s important for understanding individual differences and psychopathology.”

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**GREG MILLER**