

Autism Linked To Mirror Neuron Dysfunction

ScienceDaily (Apr. 18, 2005) — Seeing is doing -- at least it is when mirror neurons are working normally. But in autistic individuals, say researchers from the University of California, San Diego, the brain circuits that enable people to perceive and understand the actions of others do not behave in the usual way.

According to the new study, currently in press at the journal *Cognitive Brain Research*, electroencephalograph (EEG) recordings of 10 individuals with autism show a dysfunctional mirror neuron system: Their mirror neurons respond only to what they do and not to the doings of others.

Mirror neurons are brain cells in the premotor cortex. First identified in macaque monkeys in the early 1990s, the neurons -- also known as "monkey-see, monkey-do cells"

-- fire both when a monkey performs an action itself and when it observes another living creature perform that same action. Though it has been impossible to directly study the analogue of these neurons in people (since human subjects cannot be implanted with electrodes), several indirect brain-imaging measures, including EEG, have confirmed the presence of a mirror neuron system in humans.

The human mirror neuron system is now thought to be involved not only in the execution and observation of movement, but also in higher cognitive processes -- language, for instance, or being able to imitate and learn from others' actions, or decode their intentions and empathize with their pain.

Because autism is characterized, in part, by deficits in exactly these sorts of social interaction and communication skills, previous research has suggested that a dysfunctional mirror neuron system may explain the observed pathology. The current findings, the researchers say, lend substantial support to the hypothesis.

The UC San Diego team collected EEG data in 10 males with autism spectrum disorders who were considered "high-functioning" (defined as having age-appropriate verbal comprehension and production and IQs above 80) and 10 age- and gender-matched control subjects.

The EEG data was analyzed for mu rhythm suppression. Mu rhythm, a human brain-wave pattern, is suppressed or blocked when the brain is engaged in doing, seeing or imagining action, and correlates with the activity of the mirror neuron system. In most people, the mu wave is suppressed both in response to their own movement and to observing the movement of others.



A child with autism, wearing an EEG cap to measure brain-waves, watches video of a moving hand. (Credit: Lindsay Oberman)

Subjects were tested while they moved their own hands and while they watched videos of visual white noise (baseline), of bouncing balls (non-biologic motion) and of a moving hand.

As expected, mu wave suppression was recorded in the control subjects both when they moved and when they watched another human move. In other words, their mirror neuron systems acted normally. The mirror neurons of the subjects with autism spectrum disorders, however, responded anomalously -- only to their own movement.

"The findings provide evidence that individuals with autism have a dysfunctional mirror neuron system, which may contribute to many of their impairments -- especially those that involve comprehending and responding appropriately to others' behavior," said Lindsay Oberman, first author of the paper and UCSD doctoral student working in the labs of senior authors V.S. Ramachandran, director of the Center for Brain and Cognition, and Jaime Pineda, director of the Cognitive Neuroscience Laboratory.

The current study, the researchers say, adds to understanding the neural basis of autism and may point the way to early diagnosis and to potential therapies.

A first step, Ramachandran said, might be to test those individuals who seem to have a greater genetic likelihood of autism: the younger siblings of those already diagnosed.

Though EEG is not at present designed to measure the brain rhythms of low-functioning autistics -- whose many repetitive movements confound EEG signals and where mental retardation also plays a significant role in behavioral deficits -- it can be used as a tool for earlier diagnosis of high-functioning autistics, whose disorder today is typically not recognized until age 3 or 4 and often later.

Earlier diagnosis in turn could lead to earlier interventions. One therapeutic possibility suggested by the study's findings is biofeedback.

Pineda, who also works on a number of brain-computer interface projects, says that the mu rhythm is one that we most readily learn to control.

"We can learn to increase or decrease the strength of the mu signal at will. By imagining action, subjects are able to move a paddle in a computer game of 'Pong' after just four to six hours of practice," he said. "Because this rhythm is one that we have access to volitionally, it may prove useful in therapy."

Another possible therapy would involve ordinary mirrors. Ramachandran has successfully treated amputees who experience pain or paralysis in their missing, or "phantom," limbs by using a mirror reflection of their healthy limb to "trick" their brains into believing that the missing limb has been restored to pain-free motion. Since autistics' mirror neurons respond to their own motion, the researchers say, perhaps their brains can be induced to perceive their own reflected movements as the movements of another human being.

"We have a long way to go before these therapeutic possibilities are a reality, but we're that much closer now that we've linked autism to a specific region of the brain," said Ramachandran. "More than just documenting a brain anomaly in autism, we've been able to relate symptoms that are unique to the disorder -- loss of empathy and imitative skills -- to the function of a particular circuit, the mirror neuron system."

Other authors on the study are: Eric Altschuler, former UCSD postdoctoral researcher now at the Mt. Sinai School of Medicine in New York, who with Ramachandran and Pineda originally presented preliminary findings on mirror neuron dysfunction in one autistic child in 2000; Edward Hubbard, recent UCSD graduate now at the

French National Institute of Health (INSERM) in Paris; and UCSD graduate student Joseph McCleery.

The team is now pursuing another, related line of research: Are mirror neurons involved in the ability to understand metaphors? Autistic individuals typically have difficulties with metaphors, often interpreting them literally, and the researchers believe this too may be connected to a dysfunctional mirror neuron system.

"Even as the clinical study of mirror neurons is giving us insights into autism and other disorders," Ramachandran said, "it is also giving us glimpses of a host of uniquely human -- and elusive -- mental capacities: making metaphors and passing on proverbs, to name just two."

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