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Thinking about others is not child's play: brain study

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New MIT research shows what happens inside the brains of young children as they learn to think about the thoughts and emotions of other people.

When you try to read other people's thoughts, or guess why they are behaving a certain way, you employ a skill known as theory of mind. This skill, as measured by false-belief tests, takes time to develop: In children, it doesn't start appearing until the age of 4 or 5.

Several years ago, MIT neuroscientist Rebecca Saxe showed that in adults, theory of mind is seated in a specific brain region known as the right temporo-parietal junction (TPJ). Saxe and colleagues at MIT have now shown how brain activity in the TPJ changes as children learn to reason about others' thoughts and feelings.

The findings suggest that the right TPJ becomes more specific to theory

of mind as children age, taking on adult patterns of activity over time. The researchers also showed that the more selectively the right TPJ is activated when children listen to stories about other people's thoughts, the better those children perform in tasks that require theory of mind.

The paper, published in the July 31 online edition of the journal *Child Development*, lays the groundwork for exploring theory-of-mind impairments in autistic children, says Hyowon Gweon, a graduate student in Saxe's lab and lead author of the paper.

"Given that we know this is what typically developing kids show, the next question to ask is how it compares to autistic children who exhibit marked impairments in their ability to think about other people's minds," Gweon says. "Do they show differences from typically developing kids in their neural activity?"

Saxe, an associate professor of brain and cognitive sciences and associate member of MIT's McGovern Institute for Brain Research, is senior author of the *Child Development* paper. Other authors are Marina Bedny, a postdoc in Saxe's lab, and David Dodell-Feder, a graduate student at Harvard University.

Tracking theory of mind

The classic test for theory of mind is the false-belief test, sometimes called the Sally-Anne test. Experimenters often use dolls or puppets to perform a short skit: Sally takes a marble and hides it in her basket, then leaves the room. Anne then removes the marble and puts it in her own box. When Sally returns, the child watching the skit is asked: Where will Sally look for her marble?

Children with well-developed theory of mind realize that Sally will look where she thinks the marble is: her own basket. However, before

children develop this skill, they don't realize that Sally's beliefs may not correspond to reality. Therefore, they believe she will look for the marble where it actually is, in Anne's box.

Previous studies have shown that children start making accurate predictions in the false belief test around age 4 — but this happens much later, if ever, in autistic children.

In this study, the researchers used functional magnetic resonance imaging (fMRI) to look for a link between the development of theory of mind and changes in neural activity in the TPJ. They studied 20 children, ranging from 5 to 11 years old.

Each child participated in two sets of experiments. First, the child was scanned in the MRI machine as he or she listened to different types of stories. One type focused on people's mental states, another also focused on people but only on their physical appearances or actions, and a third type of story focused on physical objects.

The researchers measured activity across the brain as the children listened to different stories. By subtracting neural activity as they listen to stories about physical states from activity as they listen to stories about people's mental states, the researchers can determine which brain regions are exclusive to interpreting people's mental states.

In younger children, both the left and right TPJ were active in response to stories about people's mental states, but they were also active when the children listened to stories about people's appearances or actions. However, in older children, both regions became more specifically tuned to interpreting people's thoughts and emotions, and were no longer responsive to people's appearances or actions.

For the second task, done outside of the scanner, the researchers gave

children tests similar to the classic Sally-Anne test, as well as harder questions that required making moral judgments, to measure their theory-of-mind abilities. They found that the degree to which activity in the right TPJ was specific to others' mental states correlated with the children's performance in theory-of-mind tasks.

Kristin Lagattuta, an associate professor of psychology at the University of California at Davis, says the paper makes an important contribution to understanding how theory of mind develops in older children. "Getting more insight into the neural basis of the behavioral development we're seeing at these ages is exciting," says Lagattuta, who was not involved in the research.

In an ongoing study of autistic children undergoing the same type of tests, the researchers hope to learn more about the neural basis of the theory-of-mind impairments seen in autistic children.

"So little is known about differences in neural mechanisms that contribute to these kinds of impairments," Gweon says. "Understanding the developmental changes in brain regions related to theory of mind is going to be critical to think of measures that can help them in the real world."

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