Brains with autism adapt differently during implicit learning

19 November 2015

Quinn, an autistic boy, and the line of toys he made before falling asleep. Repeatedly stacking or lining up objects is a behavior commonly associated with autism. Credit: Wikipedia.

Carnegie Mellon University scientists have discovered a crucial difference in the way learning occurs in the brains of adults with autism spectrum disorder (ASD).

Published in *NeuroImage*, Sarah Schipul and Marcel Just examined how the brains of typical and ASD individuals gradually became adapted to visual patterns they were learning, without awareness of the pattern, or implicit learning.

Using functional magnetic resonance (fMRI) imaging, Schipul and Just found that the brain activation of ASD individuals was slower to become familiar with the pattern they repeatedly saw, - meaning their brains failed to register the "oldness" of the patterns to the same degree that the control participants did. The brains of the control participants kept decreasing their level of activation with repeated exposures to the patterns being learned - showing adaptation - whereas the decreases in the brain of participants with ASD were significantly smaller.

They also found that the severity of an individual's autism symptoms correlated with the brain's degree of adaptation to the patterns. The findings provide insight into why many real-world implicit learning situations, such as learning to interpret facial expressions, pose challenges for those with ASD.

"This finding provides a tentative explanation for why people with ASD might have difficulty with everyday social interactions, if their learning of implicit social cues has been altered," said Just, the D.O. Hebb University Professor of Psychology in the Dietrich College of Humanities and Social Sciences.

While having their brains scanned, 16 high-functioning adults with ASD and 16 typical adults were trained to perform an implicit dot pattern-learning task. The target pattern was a random array of dots, which can gradually become familiar over multiple exposures despite minor changes in the pattern. Prior to the brain scan, both groups were familiarized with the type of task that would be used in the scanner. The ASD participants took longer than the control group to learn the task, demonstrating altered implicit learning in ASD. After equalizing the task structure learning and using the fMRI scanner, the two groups' brain activation differed while they were learning a new dot pattern.

The imaging showed that at the beginning of the learning session, both groups' brain activation levels were similar. By the end of the task, the typical participants showed decreased activation in the posterior regions. The ASD participants' brain activation did not decrease later in learning. In fact, it increased in frontal and parietal regions.

"Behaviorally, the two groups looked very similar throughout the task—both the ASD and typical participants were able to learn how to correctly categorize the dot patterns with reasonable accuracy," Just said. "But, because their activation levels differed, it tells us that there may be something qualitatively different in the way individuals with ASD learn and perform these kinds of task and reveals insights into the disorder that are not discernable from behavior alone."

A second finding involved brain synchronization—a measure of how well coordinated the brain activation was across different regions of the brain. The implicit learning exercise was specifically designed to engage both the frontal and posterior regions of the brain, and the results showed that brain synchronization between these regions was lower in ASD. This supports Just's 2004 influential "Frontal-Posterior Underconnectivity Theory of Autism," which first discovered this lower synchronization. In later studies, Just showed how this theory accounted for many brain imaging and behavioral findings in tasks that required a substantial role for the frontal cortex.

"This lack of synchronization with frontal regions in ASD—an impairment in brain connectivity—may lead to symptoms of the disorder that involve processes that require brain coordination between frontal and other areas, such as language processing and social interaction," Just explained.

The researchers also found that adaptation and synchronization were directly related to the severity of the participants' ASD symptoms.

"Seeing that individuals with more atypical neural responses also had more severe ASD symptoms suggests that these neural characteristics underlie or contribute to the core symptoms of ASD," Just said. "It is possible that reduced neural adaptability during learning in ASD may lead to the behavioral symptoms of the disorder. For example, the ability to learn implicit social clues may be affected in ASD, leading to impaired social processing."

Schipul, who received her bachelor's degree in cognitive science and Ph.D. in psychology from CMU and is now a postdoctoral fellow at the University of North Carolina at Chapel Hill, and Just believe that therapeutic approaches for ASD might benefit from making the learning of various everyday skills that people without ASD learn implicitly very clear.

This is among several brain research breakthroughs at Carnegie Mellon. CMU is the birthplace of artificial intelligence and cognitive psychology and has been a leader in the study of brain and behavior for more than 50 years. The university has created some of the first cognitive tutors, helped to develop the Jeopardy-winning Watson, founded a groundbreaking doctoral program in neural computation, and completed cutting-edge work in understanding the genetics of autism. Building on its strengths in biology, computer science, psychology, statistics and engineering, CMU launched BrainHub, an initiative that focuses on how the structure and activity of the brain give rise to complex behaviors.

Provided by Carnegie Mellon University