Interactions between attention-grabbing brain networks weak in ADHD, study says

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Children with ADHD find it more difficult to focus and to complete their schoolwork. Credit: public domain image

Interactions between three brain networks that help people pay attention are weaker than normal in children with attention-deficit hyperactivity disorder, according to a new study from the Stanford University School of Medicine.

The degree of weakness was correlated to the severity of the children's inattention symptoms, the researchers found.

The study will be published online Dec. 15 in *Biological Psychiatry*.

The researchers focused on the salience network, which is a set of brain regions that work together through well-synchronized neural activity to help decide where one's attention should be directed. In most children, this network can assess the importance of internal and external events, and then regulate other thoughts to focus attention in the right place.

"A lot of things may be happening in one's environment, but only some grab our attention," said Vinod Menon, PhD, a professor of psychiatry and behavioral sciences and the study's senior author. "The salience network helps us stop daydreaming or thinking about something that happened yesterday so we can focus on the task at hand. We found that this network's ability to regulate interactions with other brain systems is weaker in kids with ADHD."

More than 6 million children in the United States, or 11 percent of children aged 4 to 17, have received ADHD diagnoses. The disorder is characterized by impulsiveness, hyperactivity and difficulty paying attention. Kids with ADHD tend to struggle in school, have trouble with friendships and be more prone to injury than other children their age.

Subjectivity of diagnoses

At present, diagnosing ADHD is quite subjective, with different thresholds of behavior used to make the diagnosis in different places. For instance, according to the U.S. Centers for Disease Control and Prevention, in 2011, 7.3 percent of California children had at some point been diagnosed with ADHD, making the state one of five nationwide with diagnosis rates below 8 percent among children. At the other end of

the spectrum, six states had rates above 15 percent.

"It would be very beneficial to have a diagnostic measure that uses more objective and reliable measures, not just clinical and parental assessments of behavior," said Weidong Cai, PhD, an instructor in psychiatry and behavioral sciences and the study's lead author. "This study also demonstrates that we can develop a very robust biomarker based on functional neuroimaging to reliably differentiate children with ADHD from other kids."

Menon's team studied functional magnetic resonance imaging brain scans from 180 children, half with ADHD and half without. The scans were taken when the children were awake but resting quietly. The children were also assessed for ADHD symptoms using traditional diagnostic methods. All study data were obtained from the ADHD-200 Consortium, an open-source database of fMRI scans and other clinical characteristics of hundreds of children with or without ADHD. The new results are noteworthy in part because they were replicated in independent data sets from three different sites in New York, Portland and Beijing that contributed to the consortium.

The team scored each brain scan according to the synchronization between the salience network and two other related brain networks: the default mode network, a set of brain regions that directs self-referential activities such as daydreaming; and the central executive network, which manipulates information in working memory. To focus one's attention, the salience network must turn down the activity of the default mode network while turning up the activity of the central executive network.

Scans discern ADHD from non-ADHD

Menon and colleagues have previously proposed that poor coordination between these three brain networks could underlie a variety of

psychiatric and neurologic problems, including depression, schizophrenia, brain injury, autism and drug addiction.

The children with ADHD had weaker interactions between these networks than children without the condition. The difference was large enough that brain scans could distinguish kids who had ADHD from those who did not. Among children with ADHD, worse scores on clinical tests of inattentiveness were linked with weaker interactions between the three brain networks.

"These three brain networks come up over and over in pretty much every cognitive task we ask subjects to do," said Menon, who holds the Rachael L. and Walter F. Nichols, MD, Professorship. "They are critical for information processing and attending to stimuli in the environment."

Future research is needed to explore whether fMRI can also differentiate between the brains of children with ADHD and those with other psychiatric or neurodevelopmental conditions, the researchers said. Answering that question is an important aspect of determining whether brain scans could become a practical component of ADHD diagnosis.

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