Reductions in the brain's deep gray matter volumes help explain fetal alcohol spectrum disorders

- Individuals with fetal alcohol spectrum disorders (FASD) have numerous motor, behavioral, and cognitive difficulties.
- Deep gray matter, the brain's "relay" stations, may be key to understanding alcohol-related brain injuries.
- Recent findings show significant volume reductions in deep gray matter structures of those with FASD.

Individuals with fetal alcohol spectrum disorders (FASD) have numerous motor, behavioral, and cognitive difficulties. Investigation of deep gray matter structures, the brain's "relay" stations, may play a key role in understanding alcohol-related brain injuries. A recent analysis of differences in deep gray matter volumes of children and adolescents with FASD compared to children without FASD has found significant volume reductions throughout the deep gray matter structures of those with FASD.

Results will be published in the August 2011 issue of *Alcoholism: Clinical & Experimental Research* and are currently available at Early View.

"Deep gray matter are the brain's relay stations that receive and send many inputs between cortical brain regions," explained Christian Beaulieu, professor in biomedical engineering in the faculty of medicine and dentistry at the University of Alberta and corresponding author for the study. "Efficient communication between brain regions is essential for proper cognitive function. The major structures we looked at – the basal ganglia, hippocampus, thalamus and amygdala – are well known to be involved in memory, cognition, motor function, and emotional networks."

"These structures integrate incoming sensory and motor information before it passes to the cortex," added Elizabeth R. Sowell, professor of pediatrics at the University of Southern California and Children's Hospital Los Angeles. "They are critical for functions such as learning, memory, and emotion and are often disproportionally affected in various conditions. Although we already knew that some of these structures were affected by alcohol exposure, it was unclear what the extent of damage was or whether it was the same in children and teens."

"Several earlier studies showed major volume reductions with a focus on specific substructures in small groups of subjects," said Beaulieu. "Only two previous studies had looked at a decent number of subjects and measured a number of brain regions. We took advantage of advances in MRI image quality and more sophisticated quantitative image analyses to look at all six deep gray matter structures in a largish group of 28 FASD subjects. We also looked at volume differences over an age span of six to 17 years whereas other studies collapse all the ages and lose developmental profiles."

The researchers examined two groups matched on age (6 to 17 years) and gender with high resolution structural magnetic resonance imaging: 28 (16 males, 12 females) diagnosed with FASD, and 56 (32 males, 24 females) without FASD (2 controls per each FASD subject). Volumes of the hippocampus, amygdala, thalamus, caudate, putamen, and globus pallidus were compared between the two groups, and any changes with age were tracked.

"The deep gray matter volume was reduced in all six structures examined in the children and adolescents with FASD," said Beaulieu, "and volume reductions were observed over a wide age range. Less volume could be readily thought of as having less horsepower under the hood. Smaller structures would have less capacity to facilitate communication between different brain regions."
"The differences were substantial at seven to 18 percent," added Sowell, "when compared to controls, suggesting that these structures are considerably affected by alcohol during fetal development. This may indicate an underlying basis for some of the behavior, learning, and memory problems observed in children and adolescents with FASD. Also, the authors showed that some abnormalities are consistent with age while others are more apparent in one age group, suggesting that some of these brain abnormalities change with age."

Beaulieu noted that these volume differences would not have been uncovered by visual inspection of the images, thus pointing out the need for quantitative measurements. "It is necessary to incorporate modern brain imaging and analysis to better identify the brain regions that are deleteriously affected in individuals affected by alcohol and other adverse events," he said. "Furthermore, there was not a straightforward relationship between individual brain volumes and specific cognitive problems, suggesting a more complex inter-play between affected brain regions."

Both Beaulieu and Sowell emphasized a fundamental "brain basis" for the behavior and learning difficulties commonly experienced by children and adolescents with FASD. "It is important for readers to realize that children with a diagnosis of an FASD – and the associated cognitive, medical, and behavioral issues – have a widespread injured brain which is clearly not their fault," said Beaulieu.

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