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Researchers identify pattern of cognitive risks in some children with cochlear implants

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Children with profound deafness who receive a cochlear implant had as much as five times the risk of having delays in areas of working memory, controlled attention, planning and conceptual learning as children with normal hearing, according to Indiana University research published May 22 in the *Journal of the American Medical Association Otolaryngology—Head and Neck Surgery*.

The authors evaluated 73 children implanted before age 7 and 78 children with normal hearing to determine the risk of deficits in executive functioning behaviors in everyday life.

Executive functioning, a set of mental processes involved in regulating and directing thinking and behavior, is important for focusing and attaining goals in daily life. All children in the study had average to above-average IQ scores. The results, reported in "Neurocognitive Risk in Children With Cochlear Implants," are the first from a large-scale study to compare real-world executive functioning behavior in children with cochlear implants and those with normal hearing.

A cochlear implant device consists of an external component that processes sound into electrical signals that are sent to an internal receiver and electrodes that stimulate the auditory nerve. Although the device restores the ability to perceive many sounds to children who are born deaf, some details and nuances of hearing are lost in the process.

First author William Kronenberger, Ph.D., professor of clinical

psychology in psychiatry at the IU School of Medicine and a specialist in neurocognitive and executive function testing, said that delays in executive functioning have been commonly reported by parents and others who work with children with cochlear implants. Based on these observations, his group sought to evaluate whether elevated risks of delays in executive functioning in children with cochlear implants exist, and what components of executive functioning were affected.

"In this study, about one-third to one-half of children with cochlear implants were found to be at-risk for delays in areas of parent-rated executive functioning such as concept formation, memory, controlled attention and planning. This rate was 2 to 5 times greater than that seen in normal-hearing children," reported Dr. Kronenberger, who also is co-chief of the ADHD-Disruptive Behavior Disorders Clinic and directs the psychology testing clinic at Riley Hospital for Children at IU Health.

"This is really innovative work," said co-author David B. Pisoni, Ph.D., director of the Speech Research Laboratory in the IU Department of Psychological and Brain Sciences. "Almost no one has looked at these issues in these children. Most audiologists, neuro-otologists, surgeons and speech-language pathologists—the people who work in this field—focus on the hearing deficit as a medical condition and have been less focused on the important discoveries in developmental science and cognitive neuroscience." Dr. Pisoni also is a Chancellors' Professor of Psychological and Brain Sciences at IU Bloomington.

Richard Miyamoto, M.D., chair of the IU School of Medicine Department of Otolaryngology-Head and Neck Surgery and a pioneer in the field of cochlear implantation in children and adults, said this finding augments other research on interventions to help children with cochlear implants perform at a level similar to children without hearing deficits.

"The ultimate goal of our department's research with cochlear implants

has always been to influence higher-level neurocognitive functioning," Dr. Miyamoto said. "Much of the success we have seen to date clearly relates to the brain's ability to process an incomplete signal. The current research will further assist in identifying gaps in our knowledge."

One possible answer may lie in earlier implantation, Dr. Miyamoto said. The age at which children are implanted has been steadily decreasing, which has produced significant improvement in spoken language outcomes. Research shows the early implantation is related to better outcomes in speech and understanding, and it is reasonable to believe that there may be less of a deficit in executive functioning with earlier implantation, said Dr. Miyamoto, who is the Arilla Spence DeVault Professor of Otolaryngology-Head and Neck Surgery and medical director of audiology and speech language pathology at the IU School of Medicine.

Preschoolers in the IU study were implanted at an average age of 18 months, and they had fewer executive function delays than school-age children who were implanted 10 months later, at an average age of 28 months.

Children in the study were divided into two age groups: preschool (3 to 5 years) and school-age (7 to17 years). Using an established rating scale, parents rated executive function in everyday life for children with cochlear implants and for the control group with normal hearing.

"We compared parent ratings and looked at the percentage of children in each group who scored above a cut-off value that indicates at least a mild delay in executive functioning," Dr. Kronenberger said. "In the critical areas of controlled attention, working memory, planning and solving new problems, about 30 to 45 percent of the children with cochlear implants scored above the cut-off value, compared to about 15 percent or less of the children in the normal-hearing sample."

Dr. Kronenberger said the research also shows that many children develop average or better executive functioning skills after cochlear implantation.

"These results show that half or more of our group with cochlear implants did not have significant delays in executive functioning," Dr. Kronenberger said. "Cochlear implants produce remarkable gains in spoken language and other neurocognitive skills, but there is a certain amount of learning and catch-up that needs to take place with children who have experienced a hearing loss prior to cochlear implantation. So far, most of the interventions to help with this learning have focused on speech and language. Our findings show a need to identify and help some children in certain domains of executive functioning as well."

"We are now looking for early markers in children who are at risk before they get implants," Dr. Pisoni said. "It will be beneficial to identify as early as possible which children might be at risk for poor outcomes, and we need to understand the variability in the outcome and what can be done about it."

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