Learning difficulties in children: the role of hearing

Up to twenty percent of children have difficulty listening to sounds and making sense of what people are saying to them, despite clinical tests showing that their ears are working well. Our understanding of this type of listening difficulty – often called Auditory Processing Disorder – has been revolutionised by the work of Professor David Moore at Cincinnati Children’s Hospital Medical Center. Moore’s current research aims to unravel the complex roles of the ear, auditory nervous system and the cognitive (‘thinking’) ability of the brain in these complex systems. For a long time APD was thought to be a result of listening problems attributed to impaired bottom-up processing of sounds by the CANS. It’s now become widely accepted that cognitive factors play a central role in listening. Seeking to inform future diagnostic and management strategies of children with listening difficulties, Moore’s research closely examines whether these difficulties are due to sensory, cognitive, or both sensory and cognitive impairments. In a 2010 study he showed that poor listening in children has an important cognitive component: putting forward the idea that APD could be a result of top-down cognitive difficulties causing impaired attention, working memory and executive functions, that are outside the traditional auditory system.

Many of us take it for granted, but auditory processing – the way in which we pick up sound and attach meaning to it – is exquisitely complicated. In a truly remarkable series of steps, sound waves in the air are changed into electrical signals which are carried to the central auditory nervous system (CANS); these signals are then recognised, processed and understood. Hearing and speech underpin language and communication, but for many people these processes cause difficulties. Commonly, the causes of these difficulties are poorly understood. Most children who present with listening difficulties appear to have normal hearing when measured using standard clinical tests (the audiogram). These children may or may not then be assessed for ‘auditory processing disorder’ (APD) using mostly speech-based tests.

RETHINKING AUDITORY PROCESSING DISORDER

Each year over 50,000 children in the US are diagnosed with APD. But APD has become an umbrella term for a much larger population who have a poorly understood and poorly defined condition. Current problems with the diagnosis and other uses of APD are largely due to a historical lack of scientific rigour and accepted clinical definition. Changing this is Professor David Moore, Director of the Communication Sciences Research Center at Cincinnati Children’s Hospital Medical Center, whose work has challenged the long-standing thinking behind APD. A 2013 white paper published in the International Journal of Audiology led by Moore and colleagues at the British Society of Audiology, was a catalyst for international discussions and research that are profoundly advancing our understanding, evaluation and treatment of children with listening difficulties. Forging the way ahead, Moore’s research aims to tease apart the nature and mechanisms of APD. He also explores the idea that rather than being a disorder in its own right, APD is a collection of auditory symptoms that are markers of more general learning difficulties. His work has implications for learning disorders that will help to provide a more rational diagnosis and improved treatment options for many currently underserved children.

SOUND SCIENCE

Language processing is a multifaceted, subtle balancing act between auditory sensory (‘bottom-up’) and cognitive, modulating (‘top-down’) processes. Only recently, with advances in neuroscience, are we beginning to understand the complex roles of the ear, auditory nervous system and the cognitive (‘thinking’) ability of the brain in these complex systems. For a long time APD was thought to be a result of listening problems attributed to impaired bottom-up processing of sounds by the CANS. It’s now become widely accepted that cognitive factors play a central role in listening. Seeking to inform future diagnostic and management strategies of children with listening difficulties, Moore’s research closely examines whether these difficulties are due to sensory, cognitive, or both sensory and cognitive impairments. In a 2010 study he showed that poor listening in children has an important cognitive component: putting forward the idea that APD could be a result of top-down cognitive difficulties causing impaired attention, working memory and executive functions, that are outside the traditional auditory system.

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Forging the way ahead, Professor Moore’s goal is to tease apart the nature and mechanisms of listening difficulties

Understanding speech within a noisy environment is a complex task involving sensory encoding and cognitive resources such as working memory and attention. To better understand the neural processes associated with the top-down cognitive processing in adverse listening environments, Moore and colleagues measured brain oscillations (alpha waves) during attentive listening, compared to passive listening. The team demonstrated that changes in brain alpha activity are specific to listening conditions. This is the first report to show that brain oscillatory changes occur during active tasks but not during passive tasks. The team also gave evidence that selective auditory attention can be indexed using brain oscillatory power changes during active, relative to passive, attention. This has important implications for detecting hidden hearing loss by distinguishing dysfunction arising at higher cognitive levels of the nervous system.

HEARING IS LINKED TO LEARNING DIFFICULTIES? LISTEN UP!

For over 100 years it has been recognised that there is a close relationship between even mild hearing loss and learning difficulties. Verifying this association, Moore and colleagues published data from a large paediatric audiology service at Cincinnati Children’s Hospital Medical Center showing that children with APD present a collection of symptoms that frequently occur alongside other neurodevelopmental disorders. Common signs and symptoms include inattention, impairments of well recognised cognitive processes associated with language (learning, attention and memory) and autistic spectrum disorder.

Exploring the close relationship between hearing loss and learning difficulties in children, Moore and colleagues suggest that hearing could be key in the search for an explanation of childhood learning difficulties. Their current research explores the idea that listening, language and learning problems in children are causally related and expressed by a common symptomatology of a wider ‘neurodevelopmental syndrome.’ The team argue that although these symptoms are often attributed to APD by audiologists, they are not of course exclusive to APD. They suggest that the symptoms may represent manifestations of APD for those trained to diagnose only hearing problems. Research has shown that the same symptoms may be diagnosed as language or attention problems by other professionals. The high occurrence of APD with other language-, attention- and memory-based learning disorders reflects what Professor Moore proposes could collectively be the more general neurodevelopmental syndrome. Within this framework, ‘APD’ can be viewed as a marker rather than a separate diagnostic label.

TRANSLATING SCIENCE TO PRACTICE

Ever-advancing developments in technologies such as electrophysiology, functional magnetic resonance imaging and magnetoencephalography are allowing us to further explore the neurobiological basis for hidden hearing loss. Professor Moore’s current research employs cutting-edge behavioural and physiological approaches to specifically test the two theories of APD: that children have either compromised bottom-up auditory function in the ear or the CANS, or impaired top-down auditory cognition, reflected in auditory attention, working memory and executive function (common to language-based learning difficulties described above), or indeed a variety of both bottom-up and top-down difficulties. Using sophisticated methods, he will localise the source of these disorders in six- to twelve-year-olds. Not only will Professor Moore’s study advance and develop our understanding of the mechanisms underlying listening difficulties, it will also have immediate impact on a broader diagnosis of hearing loss and implications for hearing disorders, helping to inform clinical practice for a currently undervalued problem.