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A maturational frequency discrimination deficit may help explain developmental language disorder

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Abstract

Auditory perceptual deficits are widely observed among children with developmental language disorder (DLD). Yet the nature of these deficits and the extent to which they explain speech and language problems remain controversial. In this study, we hypothesise that disruption to the maturation of the basilar membrane may impede the optimisation of the auditory pathway from brainstem to cortex, curtailing high-resolution frequency sensitivity and the efficient spectral decomposition and encoding of natural speech. A series of computational simulations involving deep convolutional neural networks that were trained to encode, recognise, and retrieve naturalistic speech are presented to demonstrate the strength of this account. These neural networks were built on top of biologically truthful inner ear models developed to model human cochlea function, which – in the key innovation of the current study – were scheduled to mature at different rates over time. Delaying cochlea maturation qualitatively replicated the linguistic behaviour and neurophysiology of individuals with language learning difficulties in a number of ways, resulting in: (i) delayed language acquisition profiles; (ii) lower spoken word recognition accuracy; (iii) word finding and retrieval difficulties; (iv) 'fuzzy' and intersecting speech encodings and signatures of immature neural optimisation; and (v) emergent working memory and attentional deficits. These simulations illustrate the many negative cascading effects that a primary maturational frequency discrimination deficit may have on early language development, and generate precise and testable hypotheses for future research into the nature and cost of auditory processing deficits in children with language learning difficulties.