Newborn Hearing Screening 2.0

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Universal newborn hearing screening is arguably audiology's greatest public health achievement. Identifying children with hearing loss and providing interventions is critical because auditory experience jumpstarts language and cognitive development.

We think that audiologists have even more to offer to newborns. As we have discussed in many *Hearing Journal* columns, the speech-evoked frequency-following response (FFR) is a noninvasive snapshot of sound processing in the brain. The same equipment that collects auditory brainstem responses (ABRs) can also collect FFRs–just swap out a click or chirp for a complex sound such as speech.

These neural responses to speech paint a rich picture about how well sound is processed by the brain, and distinct neural fingerprints have been identified in children with dyslexia, autism, and auditory processing disorder (*Trends Cogn Sci.* 2015;19[11]:642). In addition to revealing the biological imprint of developmental disorders, the FFR can forecast language development. For example, FFRs to consonants in noise predict how 3-year-olds will perform on tests of skills important for language and literacy after one year–tests that can indicate risk for reading impairment but children were too young to take when they were three (*PLoS Biol.* 2015;14;13[7]:e1002196).

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Imagine a scenario where after an ABR, a newborn gets an FFR. The FFR can be done quickly–often within 10 minutes–and could come after normal hearing thresholds are confirmed. Much like the ABR, the newborn FFR could be used as a screening test. Children who fail the FFR screening can be referred to developmental specialists such as speech-language pathologists for more careful screening. This is important because early interventions are critical in offsetting lifelong challenges, particularly in language development and learning. Just as it is important to provide auditory input to a child with hearing loss, it is important to provide cognitive and linguistic enrichment to a child at risk for a learning problem.

Of course, this scenario is contingent on the ability to reliably capture FFRs in infants. We investigated this question with our colleagues Samira Anderson, AuD, PhD, and Alexandra Parbery-Clark, AuD, PhD (*J Acoust Soc Am.* 2015;137[6]:3346). We measured FFRs to the sound "d" in 28 infants between the ages of 3 and 10 months.

First, we were pleased to learn that we could reliably capture FFRs in infants. Although it certainly was not as easy as in adults, we could collect unsedated ABRs and FFRs in our cohort. The children sat in their parents' labs and were entertained with toys or videos during collection. As in adults, each individual's FFR was identifiable and interpretable.

When we analyzed the children as a group, we identified a systematic developmental shift within the first year of life. Unlike the ABR, the FFR tells us much more about how sounds are processed in the brain and reveals multiple distinct processes. Although there was greater inter-subject variability than observed in older children, responses to high-frequency sound ingredients systematically increased

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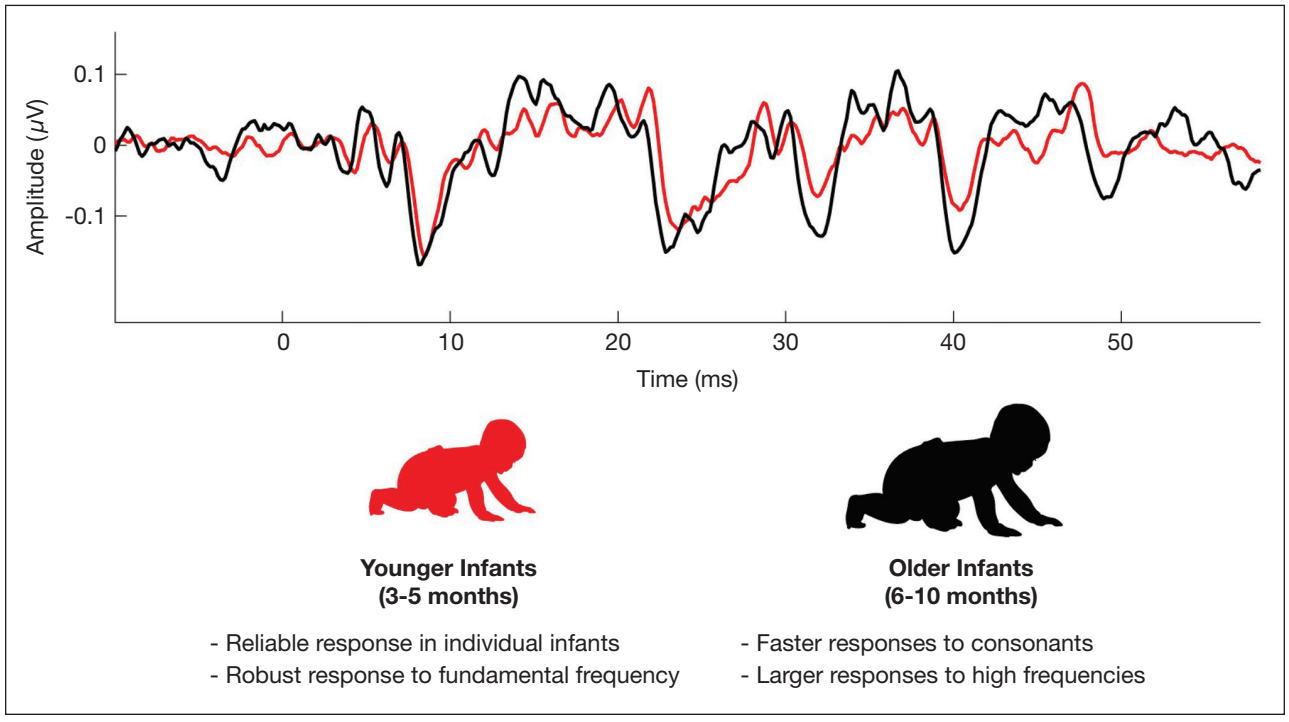

Figure 1. Frequency-following responses (FFRs) from younger and older infant groups.

in amplitude across different stages of infancy. In contrast, responses to lower-frequency cues, such as the fundamental frequency, were stable, consistent with the idea that the ability to process lower-frequency sounds emerges early in life (*Science.* 1983;219[4584]:512). Additionally, responses became faster across infancy, with peak timing decreasing up to three minutes across several months. This suggests a decrease in neural conduction that may be driven by an increase in myelination. Responses from younger and older infant groups are illustrated in Fig. 1.

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The next steps are to develop norms for the infant FFR, and track children for several years to identify FFR signatures of potential developmental problems. The fact that the FFR is viable in infancy is promising, but its rapid maturation across the first year of life has to be understood before it can be used more broadly. Importantly, early linguistic experience can shape FFR properties, suggesting it could be used both to identify candidates for early intervention and track outcomes (*Ear Hear* 2011;32[6]:699).

Early interventions are effective in bringing struggling children in line with their peers for key language and learning milestones. For example, a study by Bishop and Adams has shown that if a language-impaired child's language problems are resolved by 5.5 years old, literacy development will proceed smoothly (*J Child Psychol Psychiatry.* 1990;31[7]:1027). The challenge lies in identifying candidates for these interventions. The FFR could one day fill this gap, ushering in the next generation of newborn screening, focusing not just on whether or not sounds get in, but on how well they are processed by the brain.