Sex Differences in Sound Processing

By Nina Kraus, PhD

Sex differences in sound communication pervade the animal kingdom. For example, male songbirds sing to attract female ones, who choose a mate with their favorite song. Similarly, male humpback whales sing to attract mates. Sex differences in hearing have also been extensively documented, but until now, relatively little was known about how these differences emerge developmentally.

My lab, Brainvolts, undertook a comprehensive study of biological sex differences in auditory function in 600 preschoolers, adolescents, and adults (*Hear Res.* 2019. 380:166-174). This research is the culmination of many years' and many lab members' work with these populations to yield a rigorous, highly powered study. We discovered biological differences in specific aspects of auditory processing that emerge between pre-school and college. (A brief aside on terminology. I use the term sex differences to refer to biological differences in anatomy and physiology. I use this term explicitly instead of gender, which refers to an individual's personal identity.)

We measured frequency-following responses (FFRs) to look at multiple aspects of sound processing within a single biological response to a speech syllable. Males and females differ in the timing of their responses to sound onsets. Beyond these well-known differences, however, other aspects of biological function only differ between older males and females. Sex differences in response timing to transitions between phonemes, overall response size, and responses to speech harmonics emerge in adolescence. Thus, preschool males' and females' responses are similar, but adolescents' responses are not, suggesting that these differences are driven by factors such as hormonal changes associated with puberty. Finally, pre-school and adolescent males and females have similar responses to the fundamental frequency of speech, which conveys pitch, but adults differ in their responses. Throughout the lifespan, though, males and females have similar levels of neural noise in their biological responses to speech.

Many dimensions of this work intrigue me. For one, this work illustrates how a single brain response reveals many aspects of biological sound processing. Studying sex differences provides an ironclad lens to look at these fundamental aspects of sound processing, and shows that they do not all overlap. A single neural response to speech provides a wealth of independent pieces of information (*Hear Res.* 2019. Published online. doi:10.1016/j.heares.2019.107779).

This work shows that sex differences are not fixed from birth. Had we thought that all sex differences were inherited from some basic anatomical difference between boys and girls, such as the length of the cochlea, we would have predicted that all aspects of sound processing differ from birth. My view is that some of these sex differences, such as those in onset processing, are probably grounded in differences in cochlear anatomy, but others that emerge developmentally are probably driven by other yet unknown factors, including age-related changes in hormone expression and experience in the central nervous system.

These discoveries also have important clinical implications. For one, these may contribute to our understanding of why males seem more vulnerable to language disorders than females. The specific aspects of sound processing important to language development—transition timing and speech harmonics—emerge in the brain later in development. These intrinsic sex and developmental differences may create a biological liability for language.

Additionally, the fact that there are sex differences that emerge developmentally reinforces the need to interpret test results in light of carefully constructed sex- and age-specific norms. Finally, these differences in auditory processing suggest that males and females may respond differently to interventions. As behavioral and pharmacological therapies continue to be developed to improve auditory function and help the brain recover from injury, sex is a crucial biological variable to consider in evaluating treatment outcomes.

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