Sex, Brains, and Learning Disabilities

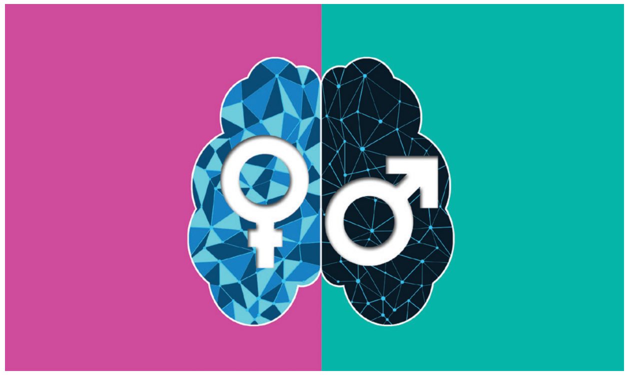
By Nina Kraus, PhD, and Travis White-Schwoch

Are boys at a higher risk of learning disabilities than girls? This simple question has roiled science and medicine for decades. Boys are diagnosed with learning disabilities at a higher rate than girls. But studies that have randomly sampled boys and girls and evaluated them with comprehensive neuropsychological testing suggest the prevalence of learning disabilities is similar between boys and girls. That is, equal numbers of boys and girls perform on these tests in a way consistent with a learning disability diagnosis. Some authors have suggested that boys who are struggling in the classroom are more likely to act out behaviorally, and therefore be referred for testing by teachers or caregivers, whereas girls are more likely to internalize their difficulties in class (*JAMA.* 1990;264,998-1002). This could explain the discrepancy between diagnoses and true prevalence.

That said, there are biological differences in the nervous system between boys and girls, including in the auditory system. These differences might help address some of the controversies about sex, brains, and learning disabilities. First, however, we want to make an important point about terminology. Because we are focused on neurobiology, we use the term "sex" to refer to biological sex assigned at birth. We do not intend to conflate this with an individual's gender identity. Rather, we are focusing on how sex chromosomes forge anatomical and physiological differences in the brain.

The auditory system provides an important springboard for language and learning development. Children who can quickly and accurately process the subtleties of speech can better develop a robust linguistic inventory to bring to bear when they start learning to read. In contrast, children with a blurry mental picture of speech sounds will struggle to associate those sounds with letters. Therefore, sex differences in the auditory system might help shed light on whether boys and girls are at different risk levels for learning disabilities.

Indeed, males and females process sound differently. Women have an auditory processing profile similar to expert listeners such as musicians and bilinguals. Their neural responses to sound are slightly, but reliably, faster, sharper, and larger (*Hear Res.* 2019;380:166-174). In contrast, males' responses are more similar to populations with listening difficulties, including children with learning disabilities. To be sure, the differences between males' and females' responses to sound are much



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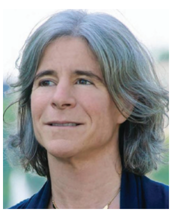
more subtle than those between, say, musicians, and dyslexics. Still, it's noteworthy that the patterns seem to overlap.

Krizman, Bonacina, and Kraus directly addressed this overlap in a study of over 500 males and females between the ages of 3-26 years (*Hear Res.* 2020; 398:108075). They found that the consistency of the response to sound—another hallmark disruption in language disorders—did not differ between males and females. No sex difference was found in neural noise, suggesting that neither internal brain "static" nor myogenic activity accounts for the auditory processing profiles seen in boys and girls.

Together, this work shows that males and females only differ on a subset of the aspects of auditory processing that distinguish children with learning disabilities from controls. This observation is evocative of work from animal models, which also suggests males and females differ on only certain aspects of neurologic function implicated in language development.

So are boys more likely to develop learning disabilities than girls? We think of the Y chromosome as a biological liability for sound processing. It does not mean males hear worse than girls or are bound to have problems with language development. Yet, it may set up a slightly weaker system for processing sound that, in interaction with other factors, could lead to a learning problem. It's important to note that only a subset of children with learning problems exhibit auditory processing difficulties. Many factors, from genes to the home environment, influence language outcomes. Boys' auditory system might interact with these factors in certain cases to cause difficulty with language and reading development.

Clinically, these results indicate that as more sophisticated measures of auditory processing are developed (see our previous *HJ* columns: http://bit.ly/HJHearingMatters), it will be important to have separate benchmarks and norms for boys and girls. Auditory processing might also be an important factor to consider when evaluating children for learning problems and crafting treatments and interventions. Similarly, with increasing research in developing drugs to treat hearing disorders, it will be critical to consider sex as a biological factor for evaluating safety and efficacy.



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