Hormones, harmonics help explain sex differences in sound processing

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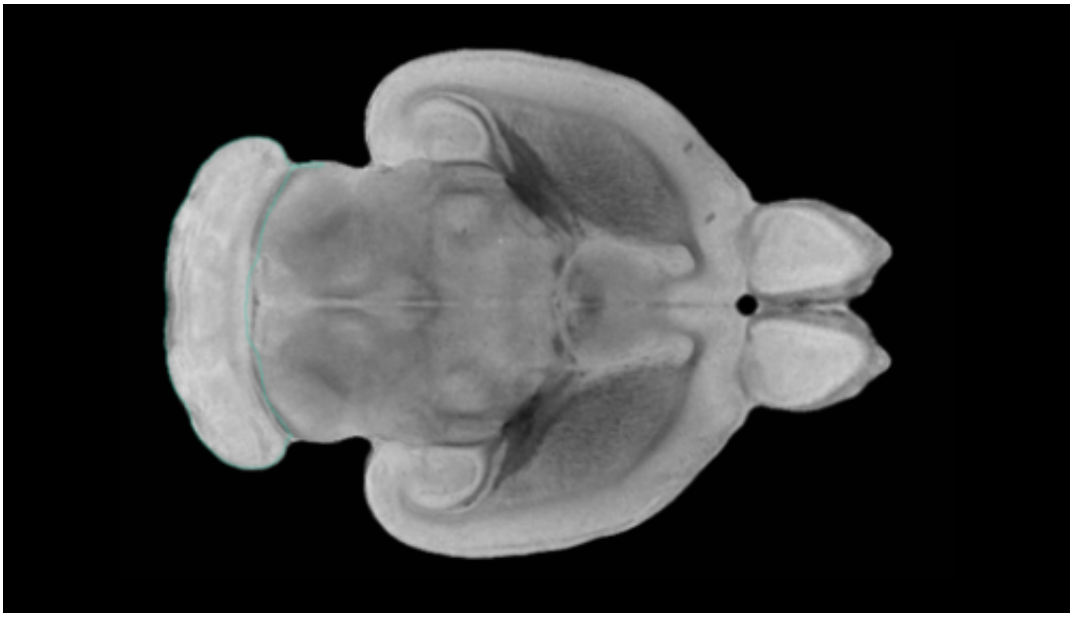

Cerebellum of CIVM postnatal rat brain atlas. Credit: Neurolex

A new Northwestern University study suggests sex hormones differentiate hearing in male versus female brains.

Neuroscientists from the Brainvolts Lab in Northwestern's School of Communication, collaborated with neuroscientists at Rutgers University to help explain why males and females process sound differently. They found that sex hormones are responsible for finely tuning the auditory systems in female rats through stronger harmonic encoding.

It is well known that males and females throughout the animal kingdom process sound differently, and that human females hear better than human males. But the mechanisms underlying these sex differences in sound processing, and whether they are the same mechanisms in humans and animals, are not well understood.

"The general belief is that any difference in sound processing between males and females is due to males, on average, being larger than females or being exposed to greater noise throughout life, leading to poorer responses in males. However, we found that sex hormones are likely to account, in part, for why males and females hear the world differently," said Jennifer Krizman, study co-author and research assistant professor at Northwestern.

The study, "Sex differences in auditory processing vary across estrous cycle," published today in the journal *Scientific Reports*.

"That cycling sex hormones influence a very basic sensory process is striking," said lead author Kasia Bieszczad, assistant professor in the department of psychology at Rutgers University. "It is another remarkable example of how much more we have to learn about the mechanisms that shape how we perceive the world around us."

In previously published research, Krizman and co-author Nina Kraus, the Hugh Knowles Professor in the School of Communication and author of "Of Sound Mind," reported sex differences in how the brain process specific "ingredients" of sound, including frequency, harmonics, phase, loudness and timing. Studying the developmental course of these ingredients in males and females, they identified harmonics as the ingredient that diverges between the sexes in adolescence, a time when hormone differences between males and females begins to emerge.

Harmonics determine what is known as timbre—why the same note

sounds differently played on a piano and a clarinet. Harmonics are important for distinguishing one speech sound from another—for example, "dad" verses "bad."

"Difficulty distinguishing these differences is a hallmark of language disorders, such as dyslexia, which are more prevalent in males. So, it may be that estrogen provides some protection for females for these disorders," said Kraus.

The goal of this study was to determine whether the differences in harmonic encoding seen in humans is also evident in rodents, and whether the magnitude of these harmonic differences varies with changes in hormone levels across the female rat's estrous cycle.

Researchers exposed rats to auditory stimuli and then observed their brain activity with a measurement called the frequency following response (FFR), which charts the brain's automatic electric reaction to sound via sensors on the rodents' heads—the same system used to measure the brain activity in the human studies.

Female FFRs were collected during both low and high levels of circulating estrogen during the estrous cycle and compared with FFRs from male rats.

To determine whether harmonic encoding fluctuates with the estrous cycle, researchers then compared each female's FFR collected during periods of high and low hormonal levels. They found females had greater encoding of harmonic frequencies when estrogen concentrations were high, compared to when the concentrations were low.

The researchers concluded that greater harmonic encoding in females is conserved across species and that the magnitude of this enhancement ebbs and flows with the changes in hormone level across the estrous

cycle. The ethological function of harmonic encoding across the estrous cycle is unknown but may be important for mate selection and sexual reproduction, they said. These findings underscore that sex can impact virtually any aspect of brain function and suggest that sex hormones underlie some of these effects.

More information: Jennifer Krizman et al, Sex differences in auditory processing vary across estrous cycle, *Scientific Reports* (2021). DOI: 10.1038/s41598-021-02272-5

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