How birds distinguish where a specific sound is coming from

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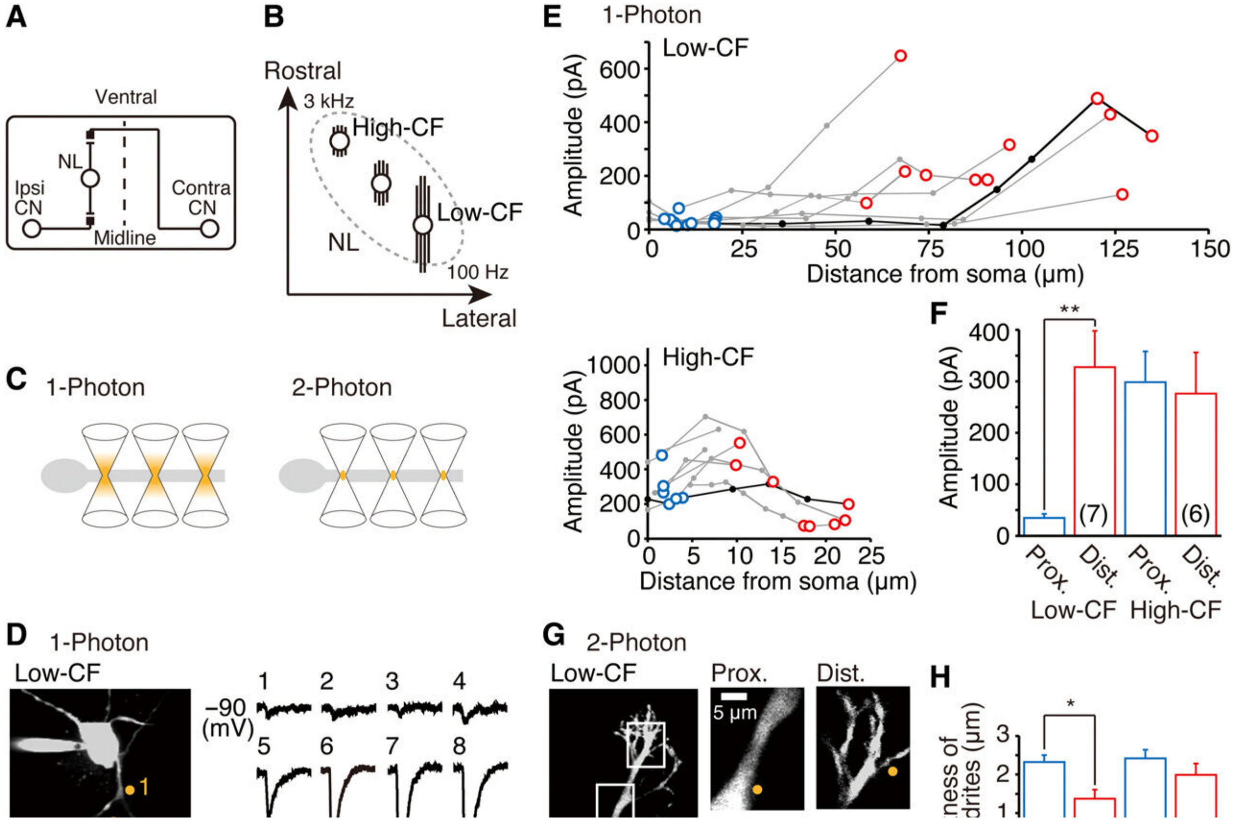

FIG. 1. Biased distribution of glutamate receptors at dendrites in low-cf neurons. (A) Brainstem auditory circuit of chickens. CN, cochlear nucleus. (B) Tonotopic organization of NL. (C) Schematic drawing of single- and two-photon stimulation. (D) Single-photon (405 nm) glutamate uncaging along dendrites in low-CF and high-CF neurons. Current responses at soma are shown for corresponding uncaged points (orange). (E) Current amplitude against distance from soma for seven dendrites of low-CF neurons and six dendrites of high-CF neurons. Data in (D) are connected with black lines. Blue and red circles indicate

responses from proximal (80%) locations, respectively. (F) Current amplitude by single-photon stimuli. (G) Two-photon (720 nm) glutamate uncaging in low-CF and high-CF neurons. Proximal and distal dendrites are magnified, and current responses from each location (orange) are shown. (H) Thickness of stimulated dendrites. (I) Current amplitude by two-photon stimuli. *P

Nagoya University physiologists have furthered understanding of the bird neural circuitry that allows them to distinguish where a specific sound is coming from. Their findings, published in the journal *Science Advances*, could help scientists understand the basics of how mammalianbrains compute the time difference between a single sound arriving at each individual ear, known as 'interaural time difference." This ability is an integral component of sound localization.

"Animals can perform accurate interaural time difference detection for sounds of a wide range of frequencies," explains Rei Yamada, who specializes in cell physiology at Nagoya University's Graduate School of Medicine. The nerve circuitry for this process is so specialized that the many branches extending from a single nerve cell, called dendrites, receive a specific sound frequency from one or the other ear. But it's not yet clear exactly how all of this works together to enable interaural time difference detection.

Yamada and his colleague Hiroshi Kuba wanted to understand more about this process. They conducted laser experiments on chicken brain slices by stimulating excitatory receptors on a part of the brain responsible for sound localization. This was followed by simulation experiments to clarify the meaning of their initial findings.

They discovered that nerve junctions, called synapses, were particularly clustered at the ends of specialized long dendrites dedicated to conducting signals from low-frequency sounds. Counterintuitively, this clustering reduced the strength of signal transmission along the length of the dendrite so that it was smaller by the time it reached the nerve cell. This process, however, enabled the nerve cell to tolerate intense inputs arriving through dendrites dedicated to each ear, thereby maintaining its ability to conduct the necessary time difference and location computing activities.

"Many animals, including humans, use the time difference of a sound reaching both ears as a clue for sound source localization," says Yamada. "We would like to examine whether the association we found between neural function and structure is universally common in other species. Expanding our research to mammalian brains will be important to understand the basic principle of interaural time difference detection that birds and animals have in common with humans."

The study, "Dendritic synapse geometry optimizes binaural computation in a sound localization circuit," was published in the journal *Science Advances* on November 24, 2021.

More information: Rei Yamada et al, Dendritic synapse geometry optimizes binaural computation in a sound localization circuit, *Science Advances* (2021). DOI: 10.1126/sciadv.abh0024

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