Silencers refine sound localization

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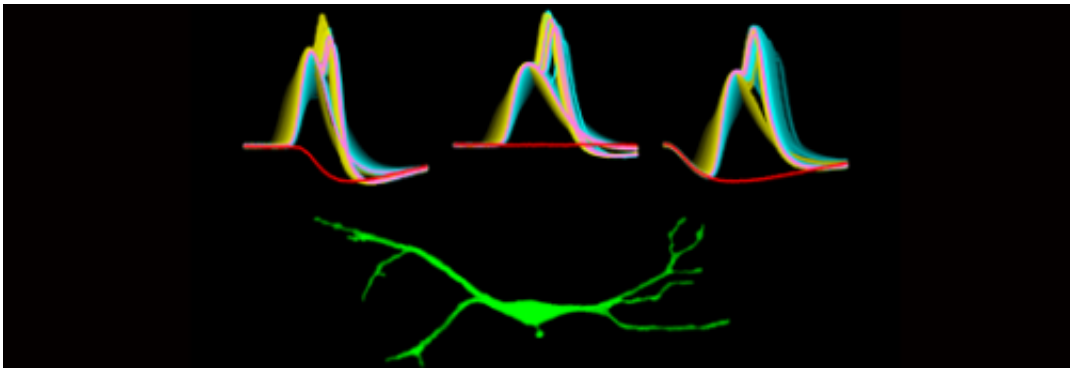

A new study by LMU researchers shows that sound localization involves a complex interplay between excitatory and inhibitory signals. Pinpointing of sound sources in space would be impossible without the tuning effect of the latter.

Did that lion's growl come from the left or the right? Or are there two of them out there? In the wild, the ability to perceive sound is of little use unless one can also pinpoint, and discriminate between, different sound sources in space. The capacity for sound localization is equally important for spatial orientation and vocal communication in humans. The underlying mechanism is known to depend on the processing of binaural signals in bilateral nerve-centers in the brainstem, where neural computations extract spatial information is extracted from them. "Each nerve-cell in the processing center receives not only excitatory but also

inhibitory signals," says LMU neurobiologist Professor Benedikt Grothe. "We have now shown how the intrinsic silencing mechanism works at the cellular level, and why it plays such a crucial role in the localization of sounds."

Sound localization depends on the fact that the "ipsilateral" ear (the one closer to the sound source) perceives the incoming sound slightly earlier than the "contralateral" ear. Since the difference in reception time may be as brief as a fraction of a millisecond, the neural integration process in the time domain must be extremely precise. It was long thought that the direction of the source was determined solely by measuring the difference in the arrival times of excitatory signals from ipsilateral and contralateral ears. But, as Grothe explains: "Comparison of the excitatory signals alone is not sufficient to permit precise discrimination between impulses that arrive only microseconds apart."

Inhibition reduces background distortion

Using a highly sophisticated experimental design, Grothe and his team were able to demonstrate that spatial information is distilled from four different inputs, namely pairs of inhibitory and excitatory signals arriving from each ear. Moreover, the researchers were able to elucidate the nature of the processing mechanism with the help of a technique known as dynamic patch clamping. With this method, one can measure electrical signals intracellularly, compute their combined effect in real time, and inject the resulting signal back into the cell. "This permits us to measure and manipulate electric currents within cells. By employing this highly complex approach, we were able to characterize the effects of both inhibitory and excitatory signals at the cellular level, and investigate the impact of their integration on the ability to localize sounds," Grothe explains.

It turns out that neural inhibition controls and dynamically adjusts the

time-point at which a given cell becomes maximally active. Thanks to this fine-tuning mechanism, the difference in arrival times between the right and left signals can be determined more precisely than would otherwise be possible. "This is a very dynamic process, which is utilized great precision. Above all, it allows for very rapid resetting of the relationship between the magnitudes of excitatory and inhibitory signals, which would not be feasible on the basis of only two signals," Grothe adds. How the optimal timing offset is chosen remains unclear, but Grothe hopes that future studies will shed light on this phenomenon.

More information: "Glycinergic inhibition tunes coincidence detection in the auditory brainstem." Michael H. Myoga, et al. *Nature Communications* 5, Article number: 3790 DOI: 10.1038/ncomms4790. Received 10 October 2013 Accepted 02 April 2014 Published 07 May 2014

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