Training Older Adults to Hear Better

By Nina Kraus, PhD, and Travis White-Schwoch

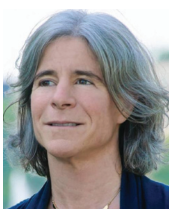
There is a strong interest in audiology to develop means to improve hearing, especially for people with daily difficulties with speech understanding. Auditory training is one potential approach. It is relatively affordable and can be completed by patients on their home computers or tablets. A growing body of evidence suggests that training is effective. In particular, training regimens that emphasize auditory processing in high-cognitive-load situations appear to improve speech-in-noise perception. Trainings that force listeners to make sound-to-meaning connections engage brain plasticity mechanisms, which can fine-tune the nervous system's auditory processing machinery.

EFFICACY OF SOUND-TO-MEANING TRAINING

Auditory training is of special interest in older adults. Even older adults with normal hearing tend to struggle to understand speech in noisy environments, and hearing aids only go so far to boost speech understanding. Anderson and colleagues conducted a randomized controlled study to determine the efficacy of sound-to-meaning training in older adults (*PNAS*. 2013. 110(11):4357). They found that eight weeks of computerized training that directed attention and memory to the fine details of sound improved speech-in-noise perception and short-term memory. Additionally, training sped up older adults' neural responses to the sound "da," partially reversing a hallmark of auditory aging. Does this training generalize to other aspects of sound processing? After all, there are many features of speech sounds that the brain has to encode reliably and accurately.

PROOF-OF-CONCEPT STUDY

We conducted a follow-up study to determine if sound-to-meaning training improves the brain's ability to distinguish between multiple speech sounds. We recruited 17 older adults between the ages of 55 to 70 years old who met the same study inclusion criteria as in the study of Anderson, et al. (*PNAS*. 2013). Eight were randomly assigned to undergo eight weeks of sound-to-meaning training and the other nine were the control group who received no intervention. We measured neural responses to the sounds "ba" and "ga" before and after training.



Dr. Kraus, left, is a professor of auditory neuroscience at Northwestern University, investigating the neurobiology underlying speech and music perception and learning-associated brain plasticity. **Mr. White-Schwoch** is a data analyst in the Auditory Neuroscience Laboratory (www.brainvolts.northwestern.edu), where he focuses on translational questions in speech, language, and hearing.

We measured the frequency following responses (FFRs) to determine how robustly the subjects' brain responses distinguished between the "ba" and "ga" sounds. We expected that the brain responses to the "b" and "g" portions of the sounds would be out of phase—that is, the response would differ in timing in response to the spectrotemporal features that distinguish "b" from "g." In contrast, we expected that responses to the "a" region of the speech sound would have the same timing. This can be visualized with a "cross-phaseogram" picture where red areas show that responses to "b" and "g" differ, and green areas show they are similar (*J Neuro Methods*. 2011; 196:308).

Prior to training, the older adults' brain responses to "b" and "g" were largely identical (left green panels on Fig. 1). However, sound-to-meaning training improved neural function such that the older adults' brains more accurately distinguished between the "b" and "g" sounds, shown as the red splotch on the upper-right panel in Figure 1 ($p = .03$). There were no changes among the older adults who didn't undertake any training.

Notably, populations with superior speech-in-noise abilities more accurately distinguish contrastive speech sounds such as "b" and "g" (*Cereb Cortex*. 2014; 24(9):2512). This

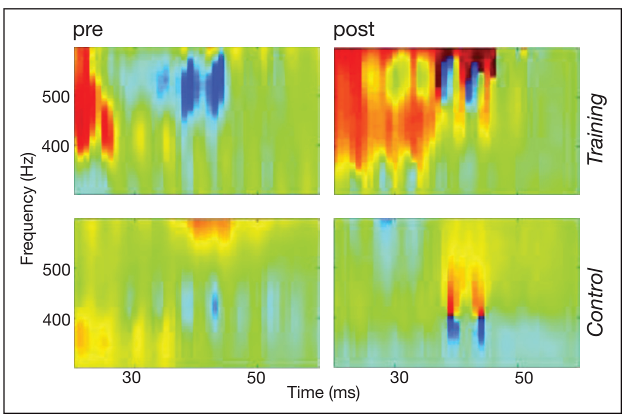


Figure 1. Brain Responses

suggests that one of the ways auditory training may boost speech-in-noise perception in older adults is by retuning the brain to encode the differences between sounds more robustly. This neural enhancement would be in addition to the faster brain response reported by Anderson and colleagues.

This small, proof-of-concept study demonstrated the potential of auditory training benefits to generalize to multiple speech sounds. Future work can validate these results in a larger and more diverse cohort of older adults who can be tested on direct behavioral benefits of superior speech sound differentiation.

These results add to the growing biological evidence indicating that sound-to-meaning training is a viable strategy to improve auditory function in older adults. Carefully designed interventions, such as computerized training protocols, are becoming more available and supported by stronger clinical evidence (*PNAS*. 2013; *Curr Biol*. 2017; 27(21):3237). Music training, including choir activities and instrument practice, may be an additional and more natural approach to mitigate the detrimental effects of aging on auditory functions.