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Current Biology

Audiomotor Perceptual Training Enhances Speech Intelligibility in Background Noise

Highlights

- Elderly subjects trained for 8 weeks on a computerized audiomotor interface
- Speech-in-noise intelligibility in challenging listening conditions improved by 25%
- Generalized training benefits were compared to and exceeded placebo effects
- Inhibitory control ability and game strategy predicted individual training benefits

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In Brief

Whitton et al. put the "real-world" usefulness of computerized perceptual training to the test in a randomized, double-blind, placebo-controlled study. They report that hearing-impaired older adults can triple the speech intelligibility benefits of their hearing aids in challenging listening environments after training on a custom audiomotor game.

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Audiomotor Perceptual Training Enhances Speech Intelligibility in Background Noise

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SUMMARY

Sensory and motor skills can be improved with training, but learning is often restricted to practice stimuli. As an exception, training on closed-loop (CL) sensorimotor interfaces, such as action video games and musical instruments, can impart a broad spectrum of perceptual benefits. Here we ask whether computerized CL auditory training can enhance speech understanding in levels of background noise that approximate a crowded restaurant. Elderly hearing-impaired subjects trained for 8 weeks on a CL game that, like a musical instrument, challenged them to monitor subtle deviations between predicted and actual auditory feedback as they moved their fingertip through a virtual soundscape. We performed our study as a randomized, double-blind, placebo-controlled trial by training other subjects in an auditory working-memory (WM) task. Subjects in both groups improved at their respective auditory tasks and reported comparable expectations for improved speech processing, thereby controlling for placebo effects. Whereas speech intelligibility was unchanged after WM training, subjects in the CL training group could correctly identify 25% more words in spoken sentences or digit sequences presented in high levels of background noise. Numerically, CL audiomotor training provided more than three times the benefit of our subjects' hearing aids for speech processing in noisy listening conditions. Gains in speech intelligibility could be predicted from gameplay accuracy and baseline inhibitory control. However, benefits did not persist in the absence of continuing practice. These studies employ stringent clinical standards to demonstrate that perceptual learning on a computerized audio game can transfer to "real-world" communication challenges.

INTRODUCTION

Sensorimotor skills can be acquired and refined throughout adulthood. This form of implicit learning is thought to depend, at least in part, on structural, neurochemical, and functional changes in sensory and motor regions of the adult cortex that emerge with practice on reinforced sensory or motor tasks [1]. Whether and how these plasticity mechanisms can be engaged by simple, computerized "brain-training" games to drive enhanced cognitive and perceptual abilities is a subject of intense debate [1, 2]. Perceptual training paradigms are typically psychophysical tests with behavioral feedback added at the end of each trial. These paradigms drive threshold improvements, though these gains generally do not transfer far beyond the training stimuli [3, 4]. For many perceptual training studies, the specificity of learning is a feature, not a bug, that can be used to infer the relative involvement of different brain regions as well as underlying plasticity mechanisms that enable and constrain performance [4–10]. But for more clinically oriented studies that set out with the goal of imparting a broad spectrum of enhanced perceptual abilities as a means to forestall the deleterious effects of aging or sensory impairment, the specificity of learning is a curse [11]. As an example, in the auditory modality, there is a strong motivation to improve communication abilities in older adults by boosting the intelligibility of target speech occurring in high levels of background noise. For the most part, this has been attempted by training hearing-impaired subjects to discriminate variations in low-level speech features using adaptations of psychophysical testing procedures. As with most any conventional perceptual training protocol, substantial improvements are noted on practice stimuli (~40%), but speech discrimination benefits are highly specific and show minimal transfer to untrained words [12–17], or even trained words presented in the context of untrained sentences [18].

Generalized gains in perceptual processing are routinely reported when training stimuli are instead packaged as games that require subjects to shift their focus of attention between multiple targets and devise fluid motor strategies for continuous, dynamic sensory challenges. A growing literature reports that relatively short periods of training with action video games drives enhanced visual processing across psychophysical tasks ranging from low-level feature detection to spatial attention