Auditory-Cognitive Training Alters the Neural Encoding of Speech for Older Adults with Normal Hearing

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Introduction

- Understanding speech in noise is challenging for older adults, even with normal hearing. This difficulty is due in part to changes in auditory and cognitive functions, such as speed of processing.[1]
- Magnetoencephalography (MEG) studies have shown that the temporal encoding of speech information in auditory cortex is attention-modulated: greater phase-locking to the envelope has been observed for an attended versus ignored speech signal.[2]
- Older adults exhibit greater cortical phase-locking compared to younger adults, likely reflective of an inefficient, over-representation of all auditory signals.[3]
- Training cognitive functions within auditory tasks is hypothesized to more comprehensively target and thus benefit the processes that support speech recognition in noise than auditory- or cognitive-only training.[4]
- This **preliminary** study investigated the extent to which auditory-cognitive training (vs. an active control) improves cortical encoding of speech for older adults.

Method

Participants

- Eleven older adults (8 female) with normal hearing:
  - Auditory-cognitive training group, N = 7
  - Cognitive-training control group, N = 4
- Age: M = 71.5, SD = 4.8 years old
- Thresholds: ≦25 dB HL through 4.0 kHz in both ears
- Younger adult data sampled from Presacco et al. (2016)[3]

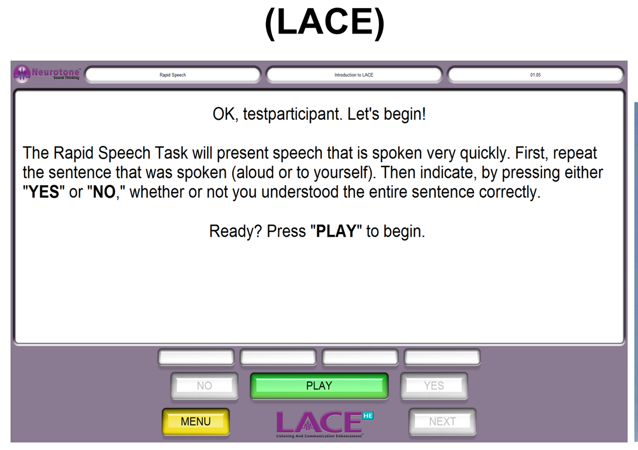
Materials

- NIH Toolbox Cognition Battery
- MEG task: One-minute stories in quiet and four signal-to-noise ratios (+3, 0, -3, -6 dB SNR, speech at 70 dB SPL) with a relatively meaningful (English) or meaningless (Dutch) competing speaker[3]
- Aligned training programs
  - Auditory-cognitive training: LACE[5]
  - Active cognitive-training control: BrainHQ (Posit Science)
  - Designed to train: attention (50% of tasks), processing speed (20%), working memory (15%), identifying missing info (15%)

Procedure

- MEG and cognitive tests pre- and post-training
- ~7 hrs of training completed across multiple lab sessions

Auditory-Cognitive Training (LACE) | **Cognitive-Training Control (BrainHQ)**



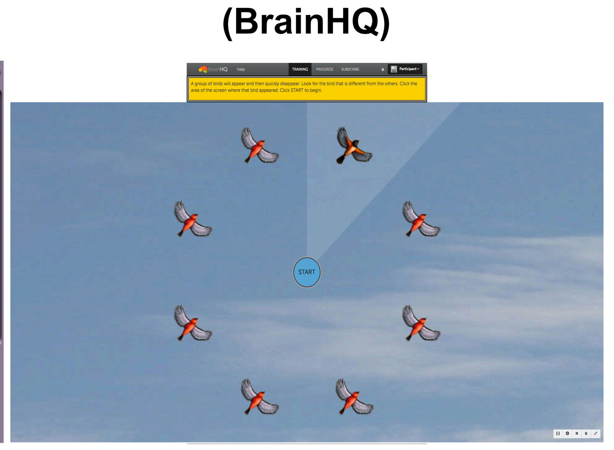


Fig. 1. Example of aligned tasks in the auditory-cognitive (*rapid speech identification*) and cognitive (*rapid visual identification*) training.

Results

Speech Recognition

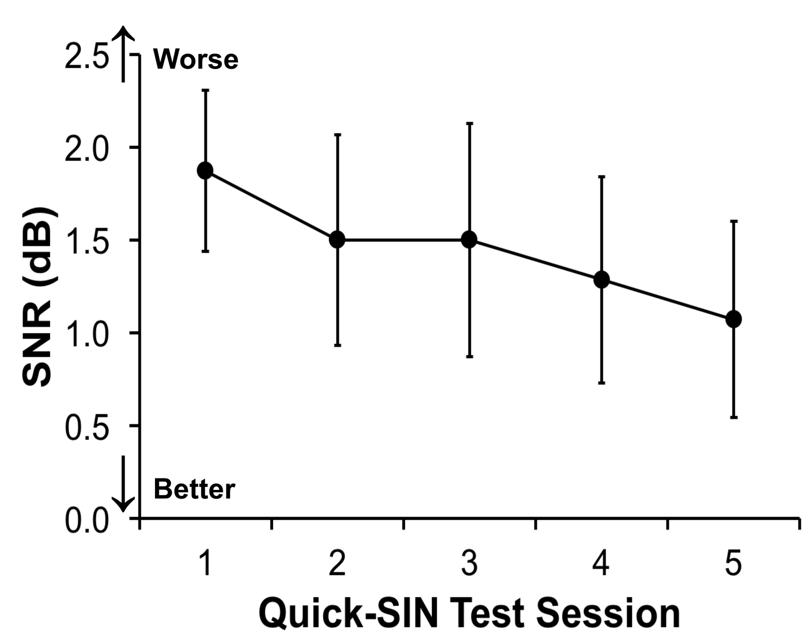


Fig 2. LACE trainees tended to improve on a measure of sentence recognition in background noise across sessions. Error bars represent SE.

Slope: M = -0.37, SD = 0.47
$t(6) = 2.09$, $p = 0.082$

Processing Speed

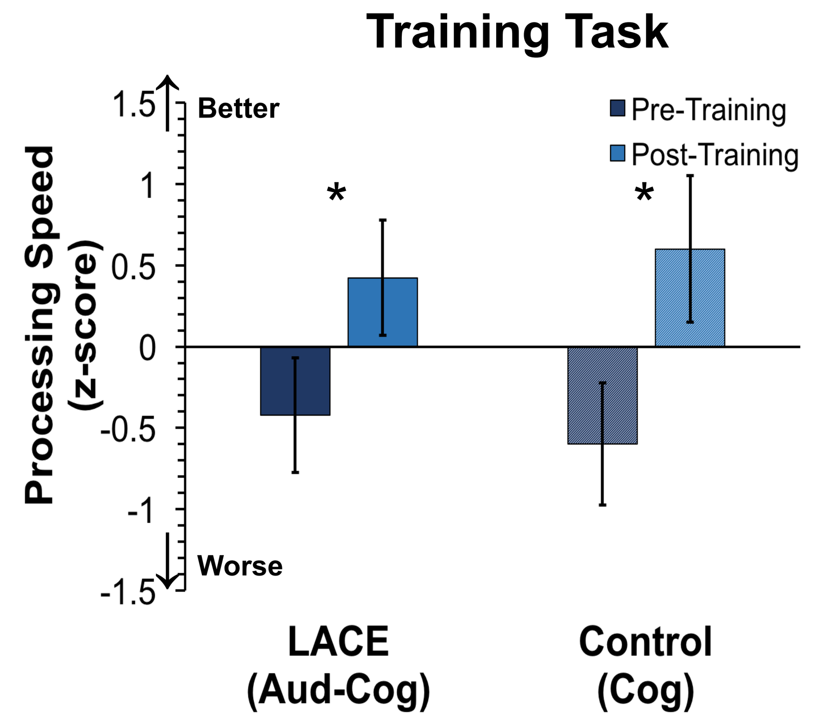


Fig 3. Participants improved on processing-speed tasks that they were trained on. The change was significant in both groups. Error bars represent SE.

LACE: $t(6) = 2.52$, $p = 0.045$
Control: $t(3) = 8.20$, $p = 0.004$

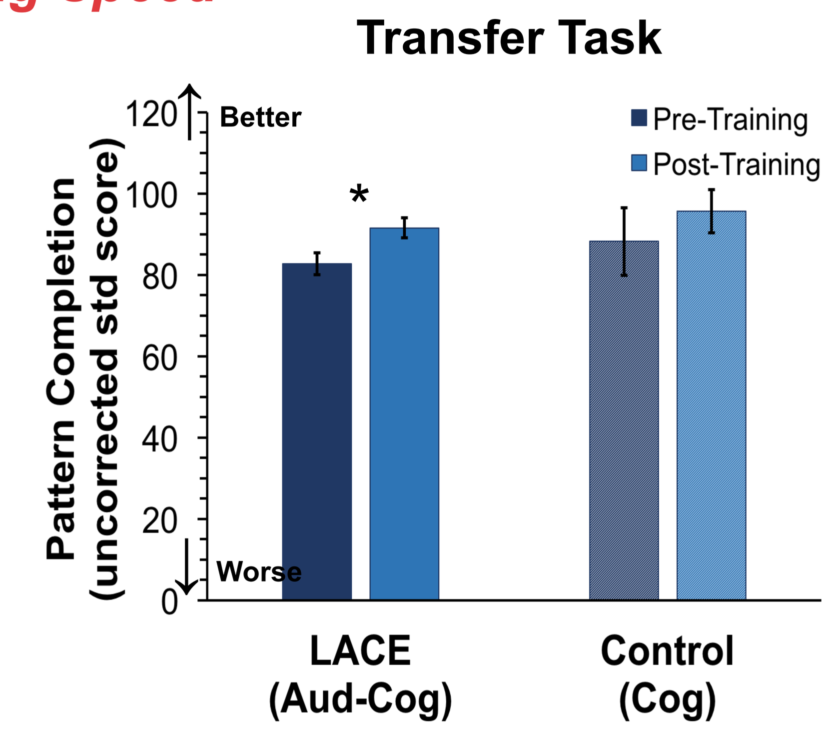


Fig 4. Participants generally improved on an untrained measure of processing speed following training. This change was significant for the auditory-cognitive training group. Error bars represent SE.

LACE: $t(6) = 2.87$, $p = 0.028$
Control: $t(3) = 1.72$, $p = 0.182$

*$p < .05$

Magnetoencephalograhy (MEG)

Analysis. Neural encoding was quantified as the correlation between the actual and the neurally reconstructed speech envelope across participants (500 ms integration window). The correlation for each individual was r-to-z transformed prior to analysis.

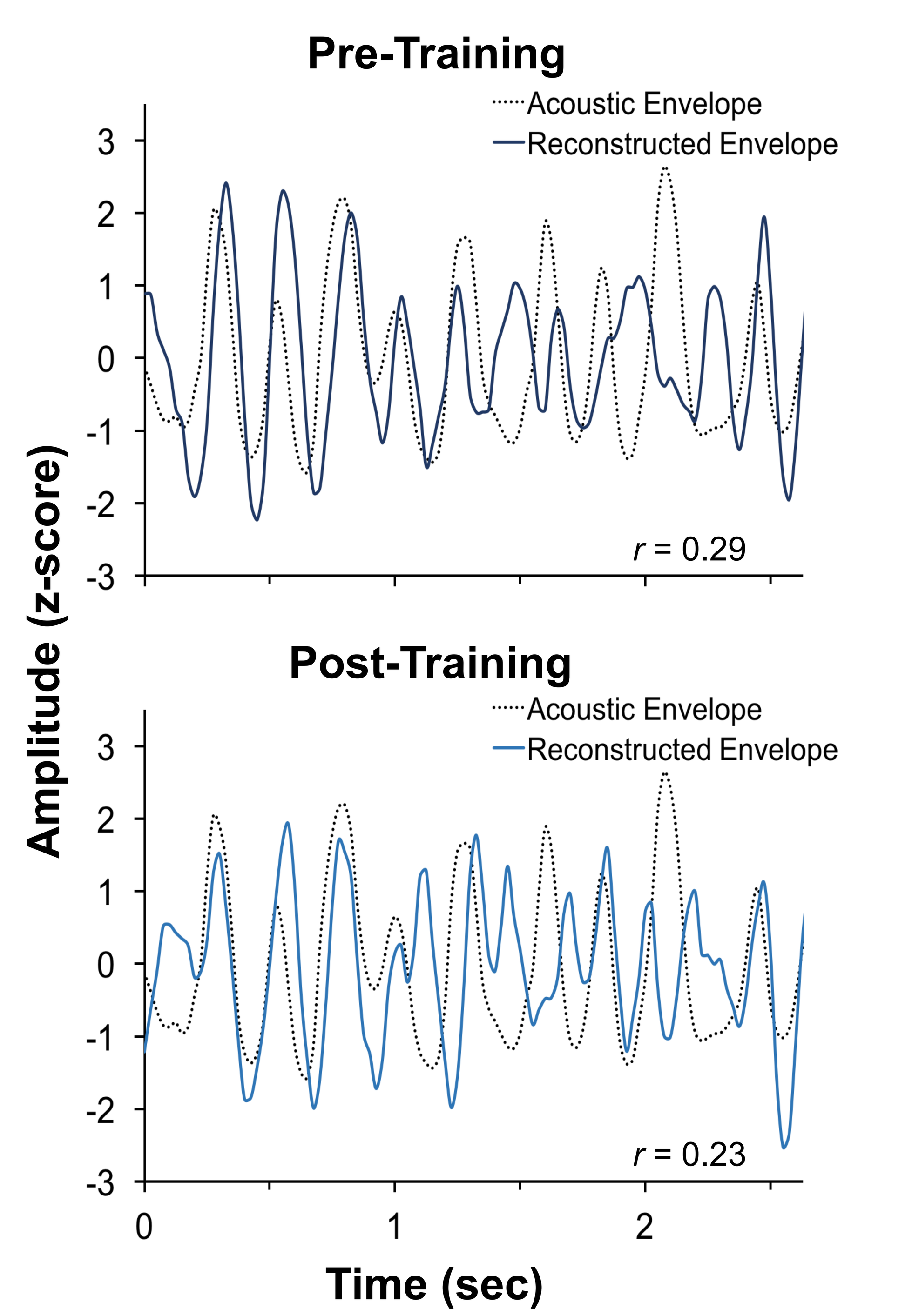


Fig 5. Example of neural encoding in the most challenging condition (-6dB SNR, English competitor) from a representative participant before and after LACE training. Correlation value reported for the time window shown.

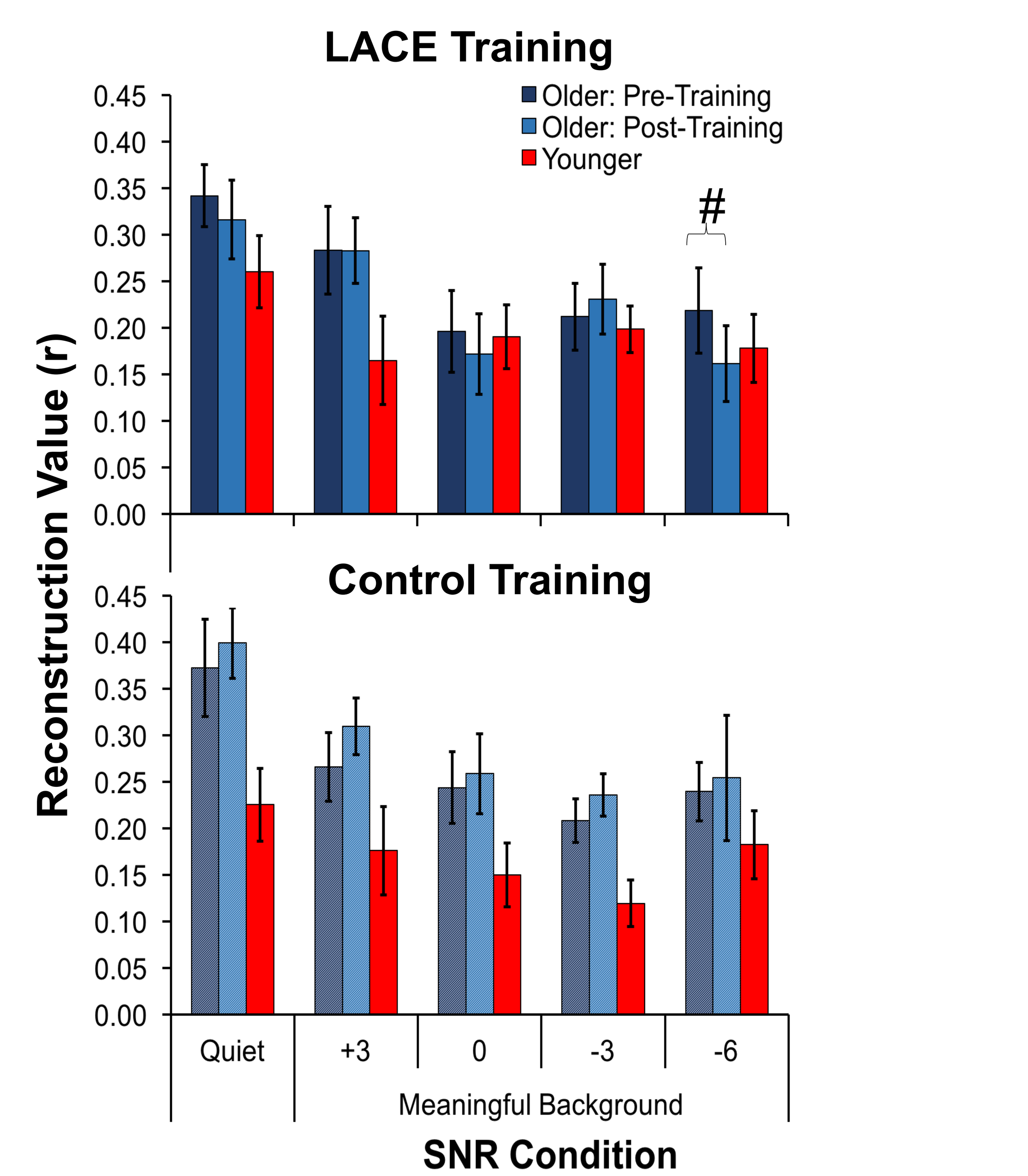


Fig 6. Patterns of training-related changes in neural encoding. The largest training-related decrease in over-representation (i.e., more similar to younger adults) was observed for the LACE training group in the most difficult listening condition. This trend was not observed for the Dutch competitor conditions or the control group. Younger adult data were randomly sampled from Presacco et al. (2016) to match each training group's N, though the same pattern exists in the full data set (N = 17). Error bars represent SE. #$t(6) = 2.26$, $p = .06$

Discussion

Summary

- In line with previous studies[5], sentence recognition in noise generally improved with LACE training.
- Preliminary results suggest that both types of training tended to yield improvements in processing speed on trained and on untrained tasks.
- Auditory-cognitive trainees (LACE) exhibited patterns of cortical encoding of speech information more similar to that of younger adults in the most challenging condition (i.e., a decrease in over-representation).
- This change in encoding was not observed for an active control group that engaged in cognitive-focused training (BrainHQ).

Conclusions and future directions

- These **preliminary** data support the hypothesis that auditory-cognitive training drives changes in the temporal encoding of the speech signal and in speech understanding for older adults with normal hearing.
- Future work aims to:
  - Link behavioral and neural changes in a larger sample in order to identify the specific mechanisms that underlie training benefits.
  - Examine the extent to which the observed improvements reliably transfer and persist following brief computer-based training.

References

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