Exposure-induced and training-induced learning of distorted speech: Does learning fail those who need it most?

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1 Introduction

★Older adults with either normal hearing or age-related hearing loss have substantial speech perception difficulties in ecological listening situations.
★ Perceptual learning contributes to speech perception in normal-hearing young adults.
★ The effects of healthy aging and age-related hearing loss on the perceptual learning of speech are not well understood [1,2,3].

2 Aim

To study the effects of age and hearing loss on the rapid ('exposure-induced') and training-induced learning of time-compressed speech and its generalization to natural-fast speech.

3 Methods

★ Three groups of participants:
Normal-hearing young adults (YA, ages: 20-38, n = 55)
Normal-hearing older adults (ONH, ages: 65-86, n = 52)
Older adults with hearing loss (OHL, ages: 65-81, n = 36)

★ Stimuli:
- ✓ 5-6 word sentences in Hebrew, presented by 2 female talkers with natural-fast rates of 162/166 words/min.
- ✓ One of the talkers also produced the sentences in a natural unhurried rate of 103 words/min; these were used to create time-compressed tokens.
- ✓ Stimuli were compressed with a WSOLA algorithm to 0.3-0.4 of their uncompressed durations (257-343 words/min) during the rapid-learning and test phases; initial compression during training was 0.63.

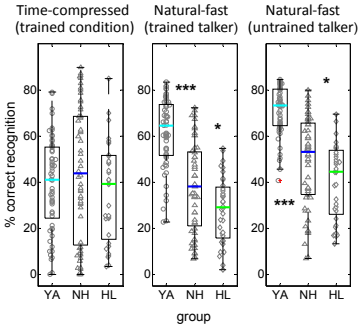
★ Protocol:
- ✓ All participants completed two test sessions (pre- and post-test)
- ✓ During each test the recognition of 20 time-compressed and 40 natural-fast sentences was assessed
- ✓ Half of the participants in each group participated in further training on time-compressed speech (5 blocks of 60 trials)
- ✓ During training, listeners judged the semantic plausibility of the sentences; compression was adapted using a 2 down/1 up staircase procedure

★Measures of performance:
Three indices of performance were calculated for each participant and compared across groups:
- ✓ Baseline: recognition accuracy in blocks of 20 sentences
- ✓ Rapid (exposure-induced) learning: changes in performance over 20 time-compressed sentences during the pre-test
- ✓ Training-induced learning: changes in performance from pre- to post-test

★Data analysis:
Age- and hearing-effects were explored by comparing:
YA and ONH participants → **age effects**
ONH and OHL participants → **hearing effects**

4.1 Results: Baseline performance

★ Consistent with previous reports, older age and hearing loss were both associated with reduced recognition accuracy of natural fast speech; time-compression rates were pre-selected to match performance across groups.

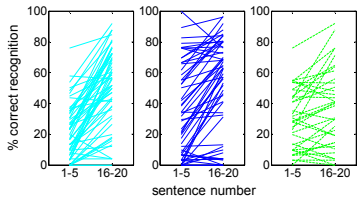


Age effects: NH vs. YA
Mann-Whitney
Trained talker: Z=-5.9, p < 0.001
Untrained talker: Z=-6.4, p < 0.001

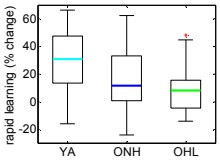
Hearing effects: HL vs. NH
Mann-Whitney
Trained talker: Z=-2.4, p = 0.017
Untrained talker: Z=-2.3, p = 0.021

Trained talker: Kruskal-Wallis $X^2(2) > 60$, p < 0.001
Untrained talker: Kruskal-Wallis $X^2(2) > 61$, p < 0.001

4.2 Results: Rapid learning of time-compressed speech

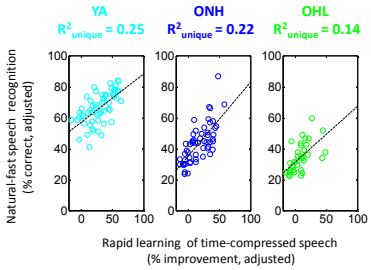


★ The proportion of individuals who improved over the course of brief exposure decreased with age and hearing loss.
★Binomial tests: significant proportions of YA (0.88) and ONH (0.77) participants improved with brief exposure; In the OHL group the proportion (0.61) was not significantly different from chance.



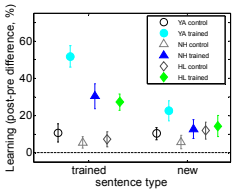
★ The amount of rapid learning significantly decreased with both age and hearing loss.
★Kruskal-Wallis X2(2) = 24.1, p < 0.001
★**Age effect**: Mann-Whitney Z = -3.05, p = 0.002
★Hearing effect: Mann-Whitney Z = -2.08, p = 0.037

4.3 Results: Rapid learning of time-compressed speech and the perception of natural-fast speech

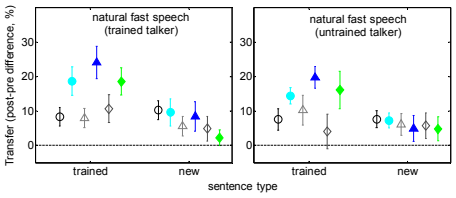


★ The recognition of natural-fast and time-compressed speech are highly correlated.
★Across groups, the amount of rapid learning of time-compressed speech accounted for additional variance in the recognition of natural-fast speech (YA: β = .51, p < .001; ONH: β = .48, p < .001; OHL: β = .38, p < .001).

4.4 Results: Training-induced learning and transfer



★ Significant training-induced improvements in the recognition of sentences from the training set were observed in all 3 groups
★Generalization to new time-compressed tokens was reduced with age, but not with hearing loss
★2 age/hearing groups x 2 training statuses x 2 sentence types ANOVA:
Age effect: age x training: F > 8, p = .005; age x training x sentence: F > 4, p = .037
Hearing effect: hearing x training: F = 1.57, p = .21; hearing x training x sentence: F = 0.002



★ Transfer of learning to natural-fast speech was observed in all 3 groups
★The effects of **age** and **hearing** were insignificant
★Transfer was not talker specific
★Transfer was limited to sentences that were encountered during training in time-compressed form

5 Conclusions

★ Rapid adaptation to time-compressed speech decreases with age and hearing loss.
★ Across groups, unique variance in the perception of natural-fast speech can be explained by the degree of rapid adaptation to time-compressed speech.
★Training yields significant learning in older adults with and without hearing loss, **but** generalization to new tokens is even more limited in older than in younger listeners.
★Because age-related declines in rapid learning were observed despite matching initial levels of performance current findings imply that declines in rapid learning could account for some of the perceptual difficulties encountered by older adults.

References

[1] Gordon-Salant et al (2010), J. Acoust. Soc. Am.
[2] Karawani et al (2016), Front. Psychol.
[3] Peelle & Wingfield (2005), J. Exp. Psychol. HPP.

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