Effects of Adult Aging on Adaptation to Time- and Frequency-Compressed Speech

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Introduction

- Due to declines in auditory processing and cognition, older adults have special difficulty comprehending perceptually-degraded stimuli (Wingfield et al., 1999, 2003).
- With sufficient training, younger adults consistently adapt to various forms of time- and frequency-distorted speech (Dupoux & Green, 1997; Pallier et al., 1999; Rosen et al., 1999; Sebastian-Galles et al., 2000; Shannon et al., 1995).
- The studies presented here investigate the extent to which older adults can adapt to time- and frequency-compressed speech.

General Methods

- All sentences contained 10 words (7 content words, 3 function words).
- Young participants were generally university undergraduates with a mean age of approximately 20 years; older adults were healthy, community-dwelling volun-

TIME COMPRESSION

- Time compression was accomplished using a variation of the PSOLA method in which small segments are deleted regularly, with the remaining segments abutted in an overlapping fashion.
- Relative temporal patterning, pitch, and word stress was thus preserved, leaving speech intelligible even at significant compression rates. For example, at even 50% of original duration, participants understand > 80% of the words.

FREQUENCY COMPRESSION

- Frequency compression was accomplished by noise vocoding the speech with 16 bands. Output frequencies were specified to be lower than input frequencies re-

Results

1 Older adults adapt to time-compressed speech

- To equate participants for starting accuracy levels, listeners participated in a calibration sequence in which they heard 5 sentences at a fast time rate for young adults followed by 5 sentences at a fast time rate for older adults.
- Following the calibration blocks, listeners heard 28 sentences at a fast time rate (adaptation) for young adults and 20 at a fast time rate (adaptation) for older adults.
- Incredibly, after following the adaptation sentences, listeners heard 6 sentences at a fast time rate (transfer) for young adults and 5 sentences at a fast time rate (transfer) for older adults.
- When equated for starting accuracy via a calibration session, older adults show adaptation that is comparable in rate and magnitude with young adults.
- Unlike young adults, older adults are not able to transfer this learning to a second, slower speech rate.
- Young adults may adapt more quickly. This could be faster perceptual learning or greater carryover from the calibration session.

2 Young adults benefit from increased practice

- In a second experiment, participants did not participate in a calibration session; rather, average values from Experiment 1 were used to equate participants.
- Two groups of young participants were used: one equated with older adults for accuracy, another that received speech at the same rate.
- All participants heard 40 sentences instead of 20.
- Lack of age difference in initial improvement for accuracy matched groups suggests this difference in Exp. 1 was due to better retention for young adults.

3 Older adults also adapt to spectrally-compressed speech

- To see whether similar age-similar patterns of adaptation could be observed in response to other types of distorted speech, we presented young and older adults with perceptually-compressed time-distorted speech.
- 16 bands were used in vocoding to maximize intelligibility. The 16 bands were loga-

4 Listeners do not adapt to speech in noise

- An experiment analogous to Experiment 1 was conducted using white noise to mask the stimulus. Accuracy-matched young and older adults failed to adapt, indi-

5 Task familiarity affects time-to-recall and self-paced time

- Trends in time taken to recall sentences and participant-controlled pause between sentences were comparable regardless of perceptual adaptation, indicating that these were due to general task familiarity and not related to perceptual learning.

Conclusions

- Despite age-related cognitive and sensory declines, older adults—when matched for starting accuracy levels—show adaptation that is comparable to young adults.
- Significant age differences are present in:
  1. Retention of perceptual learning over time
  2. Transfer of learning to a different stimulus
  3. Longer-term learning (> 20 sentences)

- This dissociation suggests multiple stages of perceptual learning that are differentially impacted by older age.

References

Dupoux E, Devin R (1997) Perceptual adjustment to highly compressed speech: Effects of order and rate changes. Journal of Experimental Psychology: Human Perception and Per-

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