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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; Sebastián-Gallés 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 volunteers with an average age of approximately 70 years. All participants had good vocabulary scores were screened for peripheral hearing acuity.

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 ratios. For example, even at 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 resulting in compressed frequency representation.

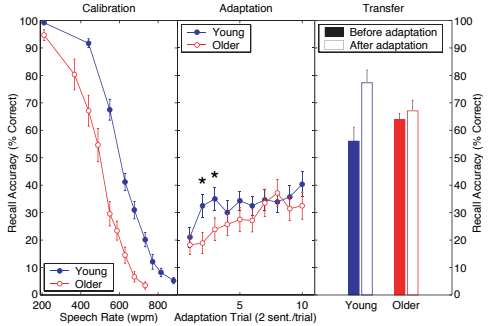
Results

1 Older adults adapt to time-compressed speech

To equate participants for starting accuracy levels, listeners participated in a calibration session in which they heard and recalled 4 sentences at each of 9 speech rates.

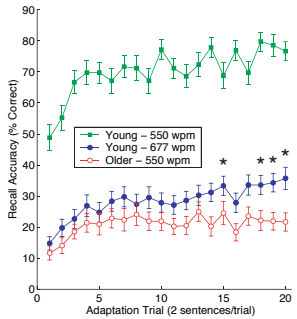
Following a ~10 minute break, participants heard 20 sentences at a fast rate of speech (average of 669 wpm for young, 569 for older adults).

Immediately following the adaptation sentences, listeners heard 4 sentences at a second, slower speech rate. Performance on this rate was contrasted between the calibration session and this transfer phase.



- 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.

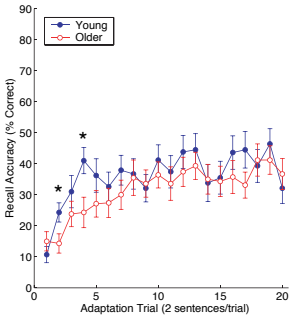
2 Young adults benefit from increased practice



- 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 differencesin initial improvement for accuracy matched groups suggests this difference in Exp. 1 was due to better retention for young adults

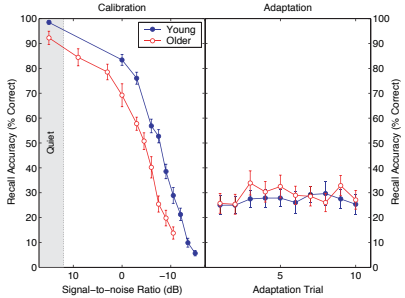
3 Older adults also adapt to spectrally-compressed speech

- 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 spectrally compressed noise-vocoded speech.
- 16 bands were used in vocoding to maximize intelligibility. The 16 bands were logarithmically distributed along frequencies up to 8000 Hz. Spectral compression was accomplished by specifying lower frequencies for the output bands. Young adults heard speech with a top frequency of 2594 Hz, older adults at 2828 Hz.
- To test for potential effects of proactive interference on participants recall, listeners heard and recalled 2 short paragraphs before the adaptation trials, and a second set of 2 pagraphs afterwards.



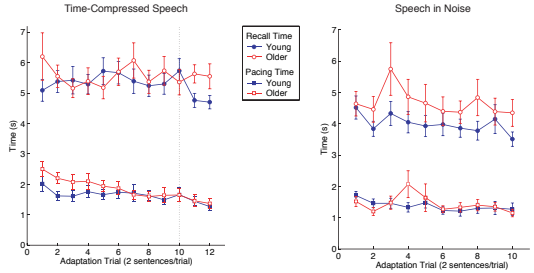
- As with time-compressed speech, young and older adults' improvement was comparable, with a hint of quicker improvement for young adults.
- Listeners' recall was slightly better for the post-adaptation paragraphs compared to the pre-adaptation paragraphs, arguing against proactive interference effects. There were not significant age differences in paragraph recall.
- A similar study was conducted to assess potential proactive interference in the time-compressed speech condition, with identical results (data not shown).

4 Listeners do not adapt to speech in noise



- An experiment analagous to Experiment 1 was conducted using white noise to mask the stimulus. Accuracy-matched young and older adults failed to adapt, indicating that observed adaptation is not simply due to general task familiarity.

5 Task familiarity affects time-to-recall and self-pacing 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 levles-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.

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