

# Age and hearing impairments influence the perception of vowels in context.

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Normal-hearing college students and older adults (60 -79 years) with normal or impaired-hearing listened binaurally through headphones to sentences recorded with a Mid-western accent and convolved with reverberation and noise. Subjects responded in a two-alternative forced choice paradigm by selecting the word perceived from a pair presented visually on a computer screen. **The target word was one of a vowel pair (e.g. jam/gem, logs/legs) embedded as the second word in one of three sentence types.** The neutral sentence provided little context for the word. Target words in sentences that provided strong contextual cues could be congruent or incongruent with the expectations of the subject, for example, "The jam/gem was spread on the bread". An analysis of variance found no effect of age alone in the pattern of errors produced. However, interactions revealed that for older subjects, the impact of reverberation varied with context and vowel pair tested. Subjects with hearing impairments made more errors than other subjects and relied significantly more on sentence context.

## Methods

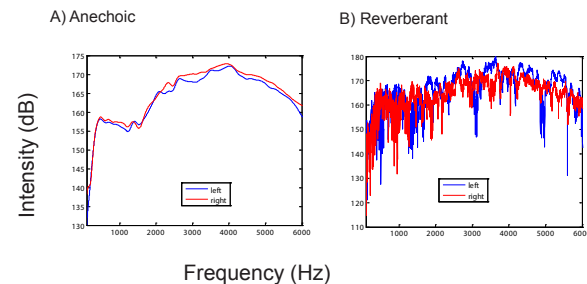
Sentences were convolved with Gaussian noise and then with either anechoic Head Related Transfer Functions (HRTFs) (Figure 1a) or reverberant HRTFs (Figure 1b) and played dichotically through headphones. College aged normal hearing adults (n=27), older adults (n = 13), older adults with assisted hearing (n = 4) and older adults with impaired hearing (n = 2) selected the word that matched what they heard. The vowels tested were A (æ), E (ε) and O (□) e.g. map, gem, mop.

## Predictions

- 1) Sentence context will be used by all groups  
Congruent context should improve performance compared to neutral condition. Incongruent context should cause more errors compared to neutral condition.
- 2) Older adults will make more errors in reverberation
- 3) In plots of formant (F1 vs F2) space E (ε)/A (æ) are close together and O (□) is further away in vowel space especially on F2.  
The A/E vowel pair will be hardest to distinguish and any combination with O should be easier.

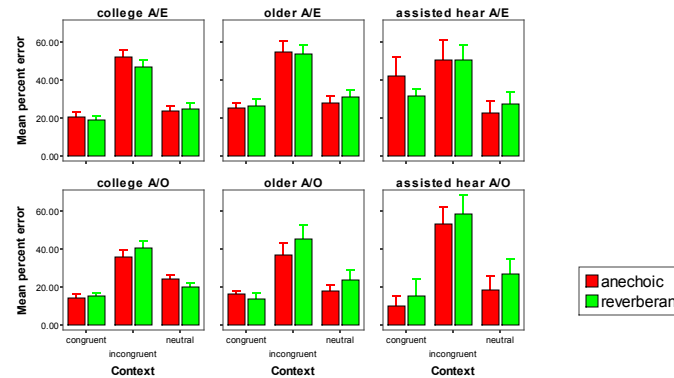
## Figure 1

Head related transfer functions for left and right ears measured on KEMAR in pseudo-anechoic and reverberant conditions.



## Figure 2

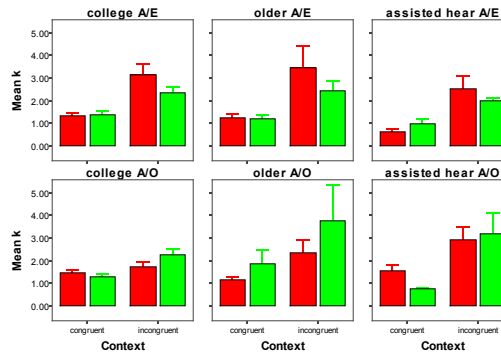
Mean percentage error in the sentence contexts for college-aged normal hearing, older normal hearing and older hearing assisted people.



There are no significant effects of age on the error percentages ( $F(1,38) = 1.37, p=0.25$ ). There are more errors in the incongruent context for all groups.  $F(2,76) = 57.5, p<.05$ . Reverberation makes the A/O distinction more difficult in the incongruent condition. ( $t_{39}=2.66, p<.05$ )

## Figure 3

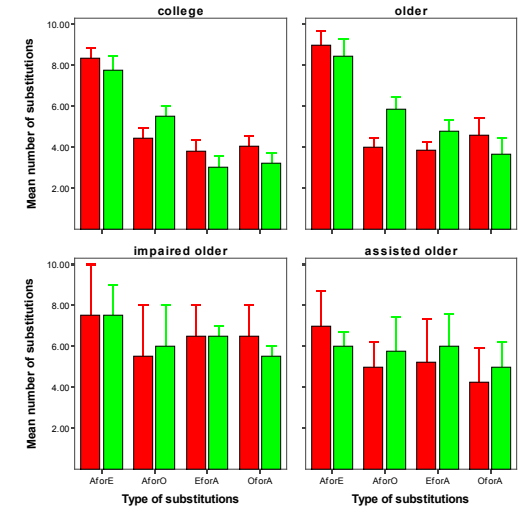
Mean k value for the congruent and incongruent contexts for the three groups.



To normalize the context effect relative to the neutral condition we calculated the metric devised by Boothroyd and Nittrouer (1988),  $k = \log_{10}(1 - pc) / \log_{10}(1 - pn)$  where  $pc$  is the probability of recognition in context and  $pn$  is the probability of recognition in no context. Subjects with zero errors for any condition were left out of the analysis to avoid infinite values. Values greater than one indicate reliance on context. The assisted group does not benefit from congruent context (AE anech  $t = -2.7$  rever  $t = -0.16$  AO rever  $t = -11.3$ ) as much as the other groups.

## Figure 4

The mean number of particular vowel substitutions



There is no effect of age. Normal hearing individuals of both age groups show the same pattern of substitutions. A for E is substituted more than any other error. (sum = 685) (A for O; sum = 426, E for A; sum = 324, O for A; sum = 317) In reverberation more A for O errors are made than in anechoic conditions ( $t_{18}=2.6, p<.05$ )

Both the impaired hearing and the assisted hearing groups spread errors across all substitution categories more evenly.

## Conclusions

- There was no significant effect of age.
- Normal hearing college age adults, older adults with normal hearing and older adults with assisted hearing all used context.
- Older people with assisted hearing used congruent context less effectively but relied on incongruent context more for the A/O vowel pair.
- Incongruent context produced more errors for all groups..
- The detrimental effect of incongruent context was greater than the advantage of congruent context for all groups.
- All groups showed a high rate of substitution of A for E .
- Hearing impaired and hearing assisted older adults made more errors because they had higher rates of substitution in the other categories too.

## References

Boothroyd, A. & Nittrouer, S (1988). Mathematical treatment of context effects in phoneme and word recognition. *JASA*, 84(1), 101-114.

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