The Effects of Frequency, Competition, and Noise on Spoken Word Recognition in Young and Senior Adults

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Disclosures

- **Sarah Grace Hudspeth** receives a graduate assistantship from the University of South Carolina and has no relevant non-financial disclosures.
- **James Nye** has no relevant financial or non-financial disclosures.
- **Dan Fogerty** and **Jessica Richardson** receive salary from the University of South Carolina and have no relevant non-financial disclosures.
Introduction
What is Spoken Word Recognition (SWR)?

- Perception, processing, and comprehension of words

- Successful SWR underpins broader communication efforts
  - If we do not understand the single words being produced we will not be able to combine the meaning to process the overall message
Factors Affecting Spoken Word Recognition

- Word Frequency
- Competition
  - Phonemic
  - Semantic
  - Visual
- Target/Competitor Neighborhood Density
- Age of Acquisition
- Noise
- Age
During a visual world paradigm task,

1. What effect do noise, competitor type, word frequency, and age have on spoken word recognition accuracy?

2. What effect do noise, competitor type, word frequency, and age have on eye gaze patterns?
Methods
Stimuli

- Single words were recorded in a sound proof booth, and loudness was normalized to approximately 75dB SPL.
- Speech spectrum noise was created from all of the target words concatenated into a single file.
- Noise was overlaid onto the normalized sound files.
  - Young: -4dB SNR
  - Senior: 0 dB SNR
Stimuli

- High and low frequency targets with semantic or phonemic competitors
- Approximately half of trials were presented in noise, half in quiet
- This resulted in eight conditions:

```
   Noise       Quiet
     |            |
    |            |
   Semantic    Semantic    Phonemic    Phonemic
     |            |            |            |
    |            |            |            |
   High       High        High        High
    |            |            |            |
   Low        Low        Low        Low
```
Participants

• **29 young individuals**
  - Age 19 - 24
  - Undergraduate students at the University of South Carolina

• **11 senior individuals (1 excluded due to poor accuracy)**
  - Age 60 - 80
  - Recruited from the community surrounding the University

• Participants completed a hearing screen
  - All young individuals passed at 20 dB
  - Senior individuals exhibited no to mild hearing loss
    - Those with moderate to severe hearing loss were not eligible to participate
Data Analysis
Accuracy

- **Target selection** was defined as gaze duration of 750 milliseconds or more
- Divergence measures were computed for all words
  - Divergence for semantic target “eye” was 27 ms
  - Divergence for phonemic target “leaf” was 248 ms
- A general linear mixed model was computed to determine the variables affecting target selection accuracy
  - Fixed Effects:
    - Noise
    - Competition Type
    - Word Frequency
    - Age
  - Random Effects:
    - Participant
First Fixation to Target

- *First fixation to target* records the time that has elapsed in each trial before the participant directs his/her gaze to the target picture.
  - Proxy measure of impact of distractors on target selection
  - Only analyzed for correct trials

- A general linear model was computed to determine the variables affecting target selection accuracy
  - Fixed Effects:
    - Noise
    - Competition Type
    - Word Frequency
    - Age
  - Random Effects:
    - Participant
Results
Accuracy

- Accuracy collapsed across age groups for all trials was 80%
- Significant main effects and interactions:

<table>
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<th></th>
<th>F</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>15.063</td>
<td>&lt;.001</td>
<td>.289</td>
</tr>
<tr>
<td>Competitor Type</td>
<td>104.768</td>
<td>&lt;.001</td>
<td>.739</td>
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<tr>
<td>Noise*Competitor Type</td>
<td>7.018</td>
<td>.012</td>
<td>.160</td>
</tr>
<tr>
<td>Competitor Type*Frequency</td>
<td>10.728</td>
<td>.002</td>
<td>.225</td>
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</table>
Fixation Time to Target

- Significant effects:

<table>
<thead>
<tr>
<th></th>
<th>$F$</th>
<th>$p$</th>
<th>Partial $\eta^2$</th>
</tr>
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<tbody>
<tr>
<td>Noise</td>
<td>34.001</td>
<td>&lt;.001</td>
<td>.461</td>
</tr>
<tr>
<td>Frequency</td>
<td>5.350</td>
<td>.026</td>
<td>.111</td>
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</table>

- No significant interactions were revealed
Discussion – Accuracy

- No significant differences between young and senior participants
- Noise, Frequency, and Competitor Type interact to effect accuracy of SWR
- Overall, trials in noise were more difficult than trials in quiet
  - Accuracy decreased for phonemic trials in noise more sharply than for semantic trials in noise
  - Semantic trials had higher accuracy in both noise and quiet
Discussion – Accuracy

- Performance on high frequency phonemic trials was lower than low frequency phonemic trials, semantic trials were reversed.
- The interaction between competitor type and word frequency may be caused by neighborhood density.
  - Larger neighborhood density leads to more possible competitors, making already difficult phonemic competition even more impactful.
Discussion – Fixation Time to Target

• Fixation time to target was increased for trials in noise and for trials with low frequency targets.

• The greatest factor impacting fixation time to target was the presence or absence of noise, followed by word frequency.
Conclusions

- Our findings are generally consistent with previous research, lending more support to the effects of noise and word frequency on SWR.

- Young and senior participants performed similarly but had different SNRs.
  - It is possible that older individuals do not have processing differences, and previous differences were driven by perceptual difficulties.

- Additionally, we report a novel side-by-side comparison of phonemic and semantic competition on SWR.
Limitations and Future Directions

- Quantify abilities of participants to ensure groups are comparable
  - IQ, language, etc.
- Control for degree of overlap between phonemic targets and phonemic distractors
- Complete time course analysis of eye-tracking data to determine if variables have differential effects during a trial
- Examine effects of semantic and phonemic competition within single trials
- Examine effects of word frequency, noise, age, and competitor type in sentences and discourse, as these are more ecologically valid
References

Questions

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