Effect of Utterance Length on Intelligibility in Cerebral Palsy
Few studies have systematically investigated the effect of sentence length on intelligibility, especially in subjects with dysarthria secondary to cerebral palsy.

- Miller, Heise and Lichten (1951) found that dysarthric speakers were more intelligible to listeners when speaking sentences than when speaking isolated words.

- Frearson (1985), using the *Assessment of Intelligibility of Dysarthric Speakers (AIDS)*, found that utterance length did not have an effect on intelligibility.

- Yunusova, Weismer and Rusche (2005) found inconsistent relationships between breath group length and intelligibility.
  - For mild dysarthrics, intelligibility decreased as breath group length increased, while for moderate dysarthrics, intelligibility increased.
Therapy with individuals with dysarthria often focuses on reducing utterance length and/or taking frequent breaths. However, the assumption that these strategies will improve intelligibility has not been tested empirically.

The present study was conducted to investigate whether systematically increasing utterance length would have a negative effect on speaker intelligibility.
Research questions

- What constitutes a significant enough increase in utterance length so that it negatively impacts intelligibility?
- Does the size of the breath group vs. total utterance length influence intelligibility?
Subjects

- **Experimental group**
  - 7 subjects with dysarthria, secondary to cerebral palsy
  - The *Assessment of Intelligibility of Dysarthric Speech* (AIDS) was administered to determine overall intelligibility rating.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>AIDS Words</th>
<th>AIDS Sentences</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>37</td>
<td>8%</td>
<td>6.36%</td>
<td>Severe</td>
</tr>
<tr>
<td>Participant 2</td>
<td>52</td>
<td>84%</td>
<td>100%</td>
<td>Mild</td>
</tr>
<tr>
<td>Participant 3</td>
<td>24</td>
<td>98%</td>
<td>99.5%</td>
<td>Mild</td>
</tr>
<tr>
<td>Participant 4</td>
<td>43</td>
<td>30%</td>
<td>91.07%</td>
<td>Mild</td>
</tr>
<tr>
<td>Participant 5</td>
<td>42</td>
<td>78%</td>
<td>96.58%</td>
<td>Mild</td>
</tr>
<tr>
<td>Participant 6</td>
<td>32</td>
<td>6%</td>
<td>12.72%</td>
<td>Severe</td>
</tr>
<tr>
<td>Participant 7</td>
<td>33</td>
<td>58%</td>
<td>84%</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Severity

- Based on the results of the AIDS, subjects were grouped as Mild or Moderate/Severe for most analyses.
- 85% intelligibility was used as the cut-off.
  - 4 Mild
    - 91-100% AIDS sentence intelligibility
  - 3 Moderate/Severe
    - 6-84%
Listeners/transcribers

- 21 listeners, all Communication Disorders graduate students, who were enrolled in or who had previously taken a course in Motor Speech Disorders
- Transcription of the 6 stimulus sentences
  - % intelligible words was calculated for each sentence
- 3 different listeners for each subject
  - To control for the effects of speaker familiarity, listeners only rated the speech of one subject.
- Using a scale of 1-4, listeners also provided an overall intelligibility rating for each of the 6 sentences
  - 1 = completely intelligible
  - 2 = mostly intelligible
  - 3 = somewhat intelligible
  - 4 = completely unintelligible
Stimuli

- Sentences of 3 lengths: 6/7 words (Length 1), 10 words (Length 2) and 14 words (Length 3)
- 2 conditions for each length
  - One sentence was produced without taking a breath
  - Another sentence of the same length was produced taking a breath at a syntactically appropriate point.

- Length 1
  - He got some things dropped off.
  - She got several items, but left some.

- Length 2
  - She got the numbers added up to get a sum.
  - I got all of the answers, but some were wrong.

- Length 3
  - We got a flat tire and needed to have it filled with some air.
  - She got many toys, but she was not able to keep some of them.
Sentence durations (in seconds)

<table>
<thead>
<tr>
<th>Breath Condition</th>
<th>No Breath Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length 1</strong></td>
<td><strong>Length 2</strong></td>
</tr>
<tr>
<td>Breath</td>
<td>No Breath</td>
</tr>
<tr>
<td>Mild</td>
<td>3.63</td>
</tr>
<tr>
<td>Mod/Severe</td>
<td>4.53</td>
</tr>
</tbody>
</table>
### Sentence Duration: 2X3 Factorial Analysis

<table>
<thead>
<tr>
<th></th>
<th>Within Subject</th>
<th>Between Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breath</td>
<td>Significant effect F(2,10)=10.374, p=.004</td>
<td>No significant difference F(1,5)=3.139, p=.137</td>
</tr>
<tr>
<td></td>
<td>No interaction effect F(2,10)=.525, p=.607</td>
<td></td>
</tr>
<tr>
<td>No Breath</td>
<td>Significant effect F(1.07,5.352)=13.361, p=.012</td>
<td>No significant difference F(1,5)=1.500, p=.275</td>
</tr>
<tr>
<td></td>
<td>No interaction effect F(1.070,5.352)=1.420, p=.288</td>
<td></td>
</tr>
</tbody>
</table>

- As utterance length increased so did durations for both the breath and no breath sentences.
- There was no significant difference between the 2 groups of dysarthrics for either the breath or the no breath condition.
Relationship between intelligibility and ratings of severity
Intelligibility vs. Severity Ratings
Regression Analysis for All Sentences

- Pearson Correlation = –.831
- F(1,125) = 276, p < .001
- R² = .690
Intelligibility vs. Severity Ratings
Regression Analysis by Breath Condition

Breath
R = -0.833, p < 0.001
R² = 0.694

No Breath
R = -0.784, p < 0.001
R² = 0.614
Thus, there was a high correlation between derived intelligibility scores and perceptions of severity, irrespective of whether a sentence was produced as one or two breath groups.
Overall Intelligibility and Length

- No main effect of length
  - $F(2,12)=2.002$, $p=.178$
- No main effect of breath
  - $F(1,6)=.075$, $p=.794$
- Significant 1st order interaction for breath and length
  - $F(2,12)=4.713$, $p=.031$

<table>
<thead>
<tr>
<th>Condition</th>
<th>%Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breath</td>
<td>64.032</td>
</tr>
<tr>
<td>No Breath</td>
<td>63.041</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length 1</td>
<td>65.852</td>
</tr>
<tr>
<td>Length 2</td>
<td>59.286</td>
</tr>
<tr>
<td>Length 3</td>
<td>65.473</td>
</tr>
</tbody>
</table>
Breath Group Length and Intelligibility

- The overall length of a breath group had no systematic effect on intelligibility.
- With the exception of Length 1 sentences, the number of breath groups for a sentence of a particular length had no affect on intelligibility.
- In addition, the direction of the difference between breath conditions was inconsistent.
- Overall, intelligibility *increased* with sentence length in the breath condition.

<table>
<thead>
<tr>
<th>Breath Sentences</th>
<th>No Breath Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence Length</td>
<td>Mean % Intelligible</td>
</tr>
<tr>
<td>Length 1</td>
<td>60.549</td>
</tr>
<tr>
<td>Length 2</td>
<td>64.290</td>
</tr>
<tr>
<td>Length 3</td>
<td>68.019</td>
</tr>
<tr>
<td>Sentence Length</td>
<td>Mean % Intelligible</td>
</tr>
<tr>
<td>Length 1</td>
<td>70.483</td>
</tr>
<tr>
<td>Length 2</td>
<td>55.714</td>
</tr>
<tr>
<td>Length 3</td>
<td>62.927</td>
</tr>
</tbody>
</table>
Breath Group Intelligibility

Graph Illustrating the Effect of Breath on Overall Sentence Intelligibility in 3 Sentence Lengths

Percent of Words Correctly Identified

breath
- breath
- no breath

length
- 7 words
- 10 Words
- 14 Words
Breath Group and Intelligibility: Effect of Severity

Breath Sentences

No Breath Sentences
Effect of Length on Intelligibility
Mild vs. Moderate/Severe

A 2x3 Factorial Analysis (1 between with 2 levels/ 1 within with 3 levels) was performed on each condition.

Results of this analysis show that there is no significant differences between the lengths in either the breath or no breath condition; however there was a significant difference between the mild and mod./severe dysartrhics.

Breath Sentences
- Within Subjects
  - No significant difference
    - F(2,10)=1.272, p=.322
  - No interaction
    - F(2,10)=.327, p=.729
- Between Subjects
  - Approaches significance
    - F(1,5)=6.001, p=.058

No Breath Sentences
- Within Subjects
  - No significant difference
    - F(2,10)=3.554, p=.068
  - No interaction
    - F(2,10)=2.955, p=.098
- Between Subjects
  - Significant
    - F(1,5)=16.147, p=.01
Effect of Length: Pairwise Comparisons

- The % words correctly identified for each length was compared for each length (L1 vs L2, L2 vs L3, L1 vs L3)
- Breath Sentences
  - NO significant pairwise comparisons
- No Breath Sentences
  - Length 1 and 2 approach significance
    - P=.058
  - No other significant differences in intelligibility as a function of length
## Effect of Breath: Mild vs. Moderate/Severe

### 2X2 Factorial Analysis

<table>
<thead>
<tr>
<th>Length</th>
<th>Within Subject Effect of Breath</th>
<th>Between Subject Effect of Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length 1</td>
<td>No significant effect F(1.000,5.000)=2.543, p=.172 No interaction effect F(1.000,5.000)=.108, p=.756</td>
<td>Significant Difference F(1,5)=7.094, p=.045</td>
</tr>
<tr>
<td>Length 2</td>
<td>No significant effect F(1.000,5.000)=1.048, p=.353 No interaction effect F(1.000,5.000)=.842, p=.401</td>
<td>Significant Difference F(1,5)=10.502, p=.023</td>
</tr>
<tr>
<td>Length 3</td>
<td>No significant effect F(1.000,5.000)=1.932, p=.223 No interaction effect</td>
<td>Significant Difference F(1,5)=10.959, p=.021</td>
</tr>
</tbody>
</table>
Discussion

- **Overall Intelligibility**
  - There was no significant difference for intelligibility as a function of sentence length
    - That is, shorter sentences were no more intelligible than longer sentences for the dysarthric speakers.
  - There was also no significant difference in intelligibility between the breath and no breath conditions.
    - That is, intelligibility was not improved by producing a sentence on 2 breaths
    - Interestingly, in the breath condition, there was a trend of improving intelligibility as utterance length increased.
Effect of Severity

Although not significant, there was a trend of increasing % of words correctly identified in the breath sentences for both severity groups.

However, in the no breath sentences, there was no clear trend of increasing intelligibility.

Although the difference in intelligibility for the 2 groups of dysarthrics was almost always significant, neither group showed a significant effect of breath condition or length.
Limitations/Considerations/Implications for future research

- Number of Participants
- Impact of slow speaking rate
  - Same number of words produced by both groups, but durations were different
  - May also impact intelligibility and ratings of severity
- Clinical implications
  - Irrespective of severity, taking a breath within sentences does not appear, from this study, to increase intelligibility.
  - Shorter sentences/breath groups are not significantly more intelligible than longer sentences/breath groups.