Measuring articulation rate:

A comparison of two methods

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Introduction

An inappropriate rate of speech can interfere with a person’s ability to communicate effectively.

- Too fast: The listener will be overloaded with information and cannot understand the message upon first hearing.
- Too slow: The flow of information is interrupted. The listener’s attention will decrease and the number of his responses will be reduced.

Rodero, 2012; Sturm & Seery, 2007
Introduction

Speech rate is of interest for SLPs working with fluency clients because:

- It has been used to define speech fluency.
- It has proven to be a sensitive measure for describing important speech behaviours (together with stuttering frequency and speech naturalness).
- It is a frequent target of treatment, especially in adults and adolescents.

Chon, Sawyer, & Ambrose, 2012; Ingham & Ingham, 2011; Sturm & Seery, 2007
# Introduction

## Speech rate
- Speaker’s management of global aspects of speech production
- Overall time used for spoken delivery of a message

## Articulation rate (AR)
- Speed of movement of the articulators
- How quickly sound segments are produced

## Disfluency
- Speaker-specific ways of conveying information, such as pausing, hesitations, …

Chon et al., 2012; Jacewicz, Fox, & O’Neill, 2009; Sturm & Seery, 2007
Introduction

Main approach
- Mark all hesitations, pauses, interjections, …
  - > 250 ms: hesitancy
  - < 50 ms: articulatory
    - 50-250 ms: mixed
- Subtract disfluent time from total duration.

Alternative
- Select perceptually fluent utterances.
- Determine AR.
- Calculate mean.
- “MAR”

Robb, Maclagan, & Chen, 2004; Van Zaalen – op ’t Hof, Wijnen, & De Jonckere, 2009

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Methods: Participants

- 80 normally fluent adults
- 20 – 59 years
  - Mean = 40.25 years
  - SD = 12.075 years
- Flemish native speakers

Table 1. Number of participants according to age group and gender

<table>
<thead>
<tr>
<th>Age</th>
<th>♂</th>
<th>♀</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>30-39</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>40-49</td>
<td>8</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td>50-59</td>
<td>11</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>41</td>
<td>80</td>
</tr>
</tbody>
</table>
Methods: Data collection

Speech samples were audio-recorded using a condenser microphone, a laptop, and Praat (Boersma & Weenink, 2014).

- Spontaneous speech (work, family, leisure activities, …)
- Reading a standardized text (“De kapitein”; Boey, 2007)
- Microphone to mouth distance = 30 cm
Methods: Data analysis

Sample → 600-syllable fragment

- Orthographic transcription
- Extract fragment

AR global

- Analyse according to main approach

MAR

- Analyse according to alternative approach
Global method

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Global method

- Click
- Pause < 250 ms
- Pause > 250 ms
- Inhalation
- Euh
- Euh
- Inhalation

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Global method

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Global method

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MAR

Perceptually fluent speech of minimally 10 to maximally 20 syllables

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Results

Figure 1. Scatter plot showing global method vs. MAR for spontaneous speech

Figure 2. Scatter plot showing global method vs. MAR for reading

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## Results

Table 2. Results of the paired samples t-tests

<table>
<thead>
<tr>
<th>Task</th>
<th>Method</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Global</td>
<td>5.39</td>
<td>0.677</td>
<td>-13.69</td>
<td>79</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td>MAR</td>
<td>6.21</td>
<td>0.863</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Global</td>
<td>4.98</td>
<td>0.614</td>
<td>-17.29</td>
<td>79</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td>MAR</td>
<td>5.47</td>
<td>0.653</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = Spontaneous speech  
R = Reading
Results

Table 3. Results of linear regression

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ct</td>
<td>0.321</td>
<td>0.012</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>SMAR</td>
<td>- 0.021</td>
<td>0.002</td>
<td>- 0.784</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Ct = Constant
SMAR = MAR for spontaneous speech

\[ S_{global} = \frac{1}{0.321 - 0.021 \times SMAR} \]

Figure 3. Scatter plot showing 1/global method vs. MAR for spontaneous speech

\[ R^2 = .62 \]
Results

Table 4. Results of linear regression

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ct</td>
<td>-0.251</td>
<td>0.022</td>
<td>-0.913</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>RMAR</td>
<td>-0.081</td>
<td>0.004</td>
<td>-0.913</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Ct = Constant  
RMAR = MAR for reading

\[ R_{global} = \frac{1}{10^{-0.251-0.081\times RMAR}} \]

Figure 4. Scatter plot showing log(1/global method) vs. MAR for reading  
\[ R^2 = .84 \]
Discussion

Global method and MAR cannot be used interchangeably.

‣ Do not lead to the same results
‣ Significantly higher values for MAR
‣ Probably due to inclusion/exclusion of pauses
  • Global method: < 250 ms were retained
  • MAR: No pauses at all
Discussion

One can be computed from the other.

‣ For spontaneous speech, 62% of the variation in global method is explained by MAR.
‣ For reading, 84% of the variation in global method is explained by MAR.
‣ Probably due to more AR variation in spontaneous speech
Discussion

MAR is less time consuming than the global method, making it attractive for clinical use. However, Further research is needed and should focus on:

› Number of rate measurements
› Type of utterances used
› Reliability
› …
References


References
