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Vowel Articulation Index and Conversational Spontaneous Speech Intelligibility in Parkinson's Disease

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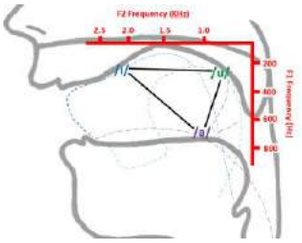
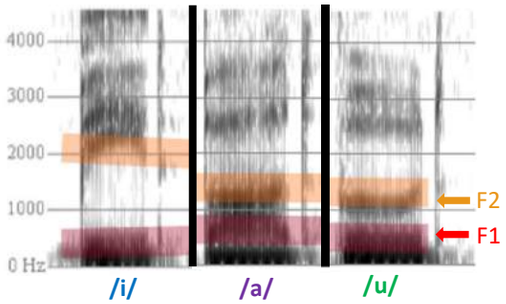
Introduction: In Parkinson's Disease (PD), Vowel Articulation Index (VAI) has been shown to be related to elicited speech intelligibility (ESI) [5]. VAI derives from F1 and F2 of the corner vowels /i/, /u/, and /a/, and is sensitive to mild hypokinetic dysarthria in PD; VAI= (F2/i/+F1/a/)/(F1/i/ +F1/u/ +F2/u/ +F2/a/) [6]. This effect has not been investigated in conversational spontaneous speech intelligibility (SSI_C). The complexity of the speaking tasks elicit different amounts of vowel articulation deficits; conversational spontaneous speech has the greatest complexity [4].

Goals: The objective of the pilot study is to investigate the relationship between VAI and conversational spontaneous speech intelligibility (SSI_C) in PD.



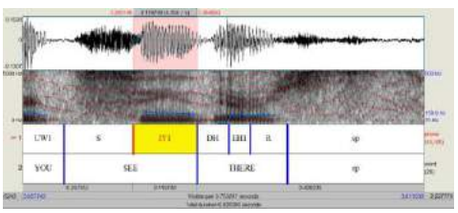
/i/, /a/ and /u/ in vocal tract. Tongue position is shown to identify point of articulation. Vowels are plotted based on average formant frequencies [1, 2].



Spectrogram of /i/, /a/ and /u/ [2].

Methods

- A pilot study was conducted using de-identified data from a previous study [1].
- 9 participants (7 male, 2 female; x̄ age=67) with PD with mild to moderate speech impairment due to hypokinetic dysarthria.
- Data was collected in the lab using a LENA recording device.
- Ten sentences were randomly selected for each participant and transcribed by three novel listeners.
- Transcriptions were compared to a key generated by researchers to determine the dependent variable, mean SSI_C ($\bar{x}SSI_C$).
- F1 and F2 for each vowel was obtained through a combination of a virtual machine utilizing soundfiles and text grids, Berkeley Phonetics Machine and Praat [7].



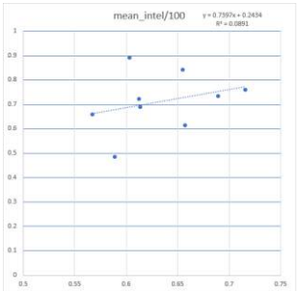
Spectrogram analysis of /i/

LENA digital recorder

- Vowel onset and offset was calculated, and 7 temporal measurements were taken for each vowel. The midpoint value of each vowel was used for analysis.
- F1 and F2 for /a/, /i/ and /u/ were selected and mean formant value (x̄FV) for each vowel was calculated for per participant.
  - Data was separated by gender.
- Mean VAI in conversation ($\bar{x}VAI_C$) for each participant was calculated using x̄FV for the corner vowel, determining the independent variable.
- The $\bar{x}VAI_C$ was compared to $\bar{x}SSI_C$ via linear regression and power analysis.

Results

- A linear regression revealed that there is a positive correlation between $\bar{x}VAI_C$ and $\bar{x}SSI_C$.
  - $\bar{x}SSI_C$ increased by 10% for each .148 unit increase in $\bar{x}VAI_C$.



Linear regression was performed to evaluate the relationship between mean VAI (independent variable) and mean intelligibility (dependent variable).

- Data was pooled to calculate mean VAI of entire group ($\bar{x}VAI$= 0.632).
- A power analysis was performed based on the linear regression showed no statistical significance in the correlation (p= .13)
  - Significant level of 5% and effect size of 0.1
  - 80 participants are needed for p= .80

Discussion

Mean Conversational Spontaneous Speech Intelligibility and Mean VAI

- No statistical significance was found between $\bar{x}SSI_C$ and $\bar{x}VAI_C$
- Potential limitations:
  - Lack of variability of sample due to heterogeneity of participants with only mild-moderate dysarthria
  - Small sample size
- Future studies require:
  - Range of mild to severe disease progression to increase variability and query the impact of disease progression on VAI_C
  - Larger sample size
  - Analysis of overall analysis of vowel density

Clinical Significance

- Clinically significant increase in $\bar{x}SSI_C$ as $\bar{x}VAI_C$ increases
  - In clinical settings, VAI_C in PD may be used as a future measurement of hypokinetic dysarthria and identify early articulatory markers of PD
- Continued study of $\bar{x}VAI_C$ in relation to $\bar{x}SSI_C$ is worthwhile for:
  - Ecological validity
  - More functional baseline and outcome measures

Conversational vs Elicited Speech Tasks

- x̄VAI was much lower in conversational spontaneous speech tasks than in previous studies of elicited speech tasks.
- Conversational spontaneous speech $\bar{x}VAI$= 0.632
- Elicited speech $\bar{x}VAI$:
  - $\bar{x}VAI$ of 0.96 [5]
  - Male $\bar{x}VAI$=0.734 and female $\bar{x}VAI$=0.820 [6]
  - Passage reading $\bar{x}VAI$=0.88 and sentence repetition $\bar{x}VAI$=0.85 [4]

References

1.Peterson, G. E., & Barney, H. L. (1951). Control Methods Used in a Study of the Vowels. *The Journal of the Acoustical Society of America*, 23(1), 148. doi:10.1121/1.1917300
2.Raphael, L. J., Borden, G. J., & Harris, K. S. (2011). Speech Sciences Primer: Physiology, Acoustics, and Perception of Speech (6th ed.) Lippincott Williams & Wilkins.
3.Rountrey, C.E. (2015). Speech Function in Persons with Parkinson's Disease: Effects of Environment, Task and Treatment
4.Rusz, J., Cmejla, R., Tykalova, T., Ruzickova, H., Klempir, J., Majerova, V., … Ruzicka, E. (2013). Imprecise vowel articulation as a potential early marker of Parkinsons disease: Effect of speaking task. *The Journal of the Acoustical Society of America*, 134(3), 2171–2181. doi: 10.1121/1.4816541
5. Sapir, S., Ramig, L., Spielman, J., & Fox, C. (2011). Acoustic Metrics of Vowel Articulation in Parkinson's Disease: Vowel Space Area (VSA) vs. Vowel Articulation Index (VAI). *Models and Analysis of Vocal Emissions for Biomedical Applications- 7th International Workshop, MAVEBA 2011*, 173–175.
6.Skodda, S., Visser, W., & Schlegel, U. (2011). Vowel Articulation in Parkinson's Disease. *Journal of Voice*, 25(4), 467-472. doi:10.1016/j.jvoice.2010.01.009
7.Sprouse, R. L., & Johnson, K. (2016). The Berkeley Phonetics Machine. *UC Berkeley PhonLab Annual Report*, 12.