Automated Analysis of Fluency Behaviors in Aphasia

Davida Fromm[a], Brian MacWhinney[a], Steffi Chern[b], Zihan Geng[b], Mason Kim[b], Joel Greenhouse[b]

[a]Department of Psychology, [b]Department of Statistics and Data Science

Background & Research Aims

- **Fluency is fundamental to assessment, diagnosis, and treatment in aphasia.**
- **Yet, the definition and measurement of fluency can be difficult (Gordon, 1998).**
- The easy, smooth flow of speech can be disrupted in different ways for different reasons:
  - basic word-finding problems can manifest in frequent pauses, revisions, and false starts
  - agrammatism can manifest in telegraphic speech
  - coexisting apraxia of speech can manifest in effortful groping and self-corrections
- Fluency is scored with subjective ratings on traditional aphasia batteries
- **Research Aims:**
  - To improve efficiency, reliability, and validity of fluency measurement in aphasia
  - To determine how aphasia groups differ on outcome measures of fluency
  - To determine which fluency variables predict type of aphasia

Methods

Database

- Cinderella storytelling transcripts from all AphasiaBank (MacWhinney et al, 2011) participants (from first session, if multiple) – **228 controls, 289 PWAs** (103 Anomic, 72 Broca, 57 Conduction, 26 Wernicke, 31 NotAphasicByWAB-NABW)
- Transcripts were done in CHAT format by trained and experienced transcribers

Transcript Analysis

- FLUCALC – CLAN command, provides preconfigured analyses of raw and proportioned counts of individual types of disfluencies from CHAT transcripts time-linked to audio/video files
  - Non-task related utterances were excluded
  - **flucalc +t*par +a +b *.cind.cex**
  - +a gets pause time values from %wor tier, +b selects word mode analyses

Outcome Measures

- **% filled pauses** (&-uh, &-um), **% word and phrase revisions** ([//]), **% word and phrase repetitions** ([/]), **% fragments** (&+sh) – manually coded into speaker line transcription, for example:

*PAR: <and &-um she's all> [//] &+e well they're all excited (a)bout it.
*PAR: and &-um &-um &-um the [/] the king wants the prince to get married .

- **intra-utterance pause time** (total unfilled pause time, msec), **inter-utterance pause time** (msec)-- automatic computation from word and utterance alignment

*PAR: and she heard a giggle . •3148977_3151347•
%wor: and •3148977_3150027• she •3150357_3150477• heard •3150617_3150817• a •3150817_3150867• giggle •3150867_3151347• .

*PAR: and she looked . •3153128_3153928•
%wor: and •3153128_3153318• she •3153318_3153408• looked •3153408_3153928• .

- **total utterances**, **total words**, **words/minute** – automatic computation from transcript

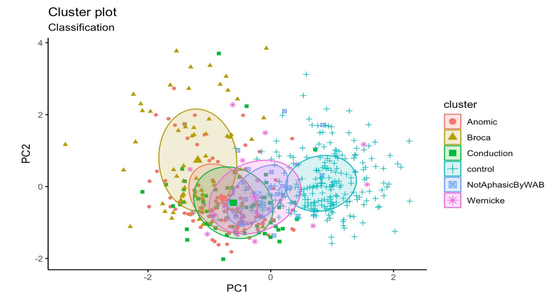
Data Analysis & Results

1. Group Differences: ANOVA Tests and Tukey's Honest Significant Difference (HSD) test

GROUP	% word repetitions	% phrase repetitions	% word revisions	% phrase revisions	% fragments	% filled pauses	intra-utterance pause time	inter-utterance pause time
Control	< every aphasia group	< every aphasia group	< every aphasia group	< every aphasia group	< every aphasia group	< every aphasia group EXCEPT Wernicke	< every aphasia group	< every aphasia group
NABW		< Broca < Cond.	< Cond.	< Cond.				
Broca								> every aphasia group

2. Principal Components Analysis: Correlation between Variables and PCs, Scatterplot by Groups

	PC1	PC2
Log Number of Utterances	0.27	0.40
Log Number of Words	0.36	0.37
Log Words Per Minute	0.42	0.09
Log % Whole Word Repetition	-0.26	0.36
Log % Phonological Fragment	-0.28	0.33
Log % Phrase Repetitions	-0.16	0.34
Log % Word Revisions	-0.16	0.38
Log % Phrase Revisions	-0.07	0.41
Log % Filled Pauses	-0.35	0.07
Log Internal Utterance Pause Duration	-0.40	-0.04
Log Between Utterance Pause Duration	-0.37	-0.16



Discussion & Future Work

- FLUCALC greatly increases the speed, efficiency, and reliability of measuring objective fluency behaviors in language samples.
- Aphasia groups differ from controls on all fluency variables with one exception (Wernicke, filled pauses).
- Together, PC1 and PC2 captured ~60% of the total variance (34.76 and 25.29%, respectively).
- PC1 relates mostly to quantity and rate of speech; PC2 relates to fluency (e.g., revisions and repetitions).
- The log *number of utterances* and log *number of words* are positively correlated with each other, while log % *phrase repetitions* and log % *word revisions* are positively correlated with each other.
- Some NABW and Wernicke participants in the Control group, suggesting good fluency.
- The PCA scatterplot and Gaussian Mixture Modeling suggests 3 major clusters based on these fluency variables.
- The clusters correspond to Controls, Nonfluent aphasia (Broca's), and Fluent aphasia (NABW, Anomia, Conduction, Wernicke's), illustrating the validity of these clinically relevant fluency outcome measures.

- We want to repeat these analyses with the same groups on other discourse tasks.
- We want to continue to develop and explore the uses of FLUCALC for this population.

References

Gordon, J. K. (1998). The fluency dimension in aphasia. *Aphasiology, 12*(7-8), 673-688.
Ratner, N. B., & MacWhinney, B. (2018). Fluency Bank: A new resource for fluency research and practice. *Journal of Fluency Disorders*, *56*, 69-80.
MacWhinney, B., Fromm, D., Forbes, M., & Holland, A. (2011). AphasiaBank: Methods for studying discourse. *Aphasiology*, *25*(11), 1286-1307.