Effects of adaptive distributed practice and stimuli variability in flashcard–based anomia treatment

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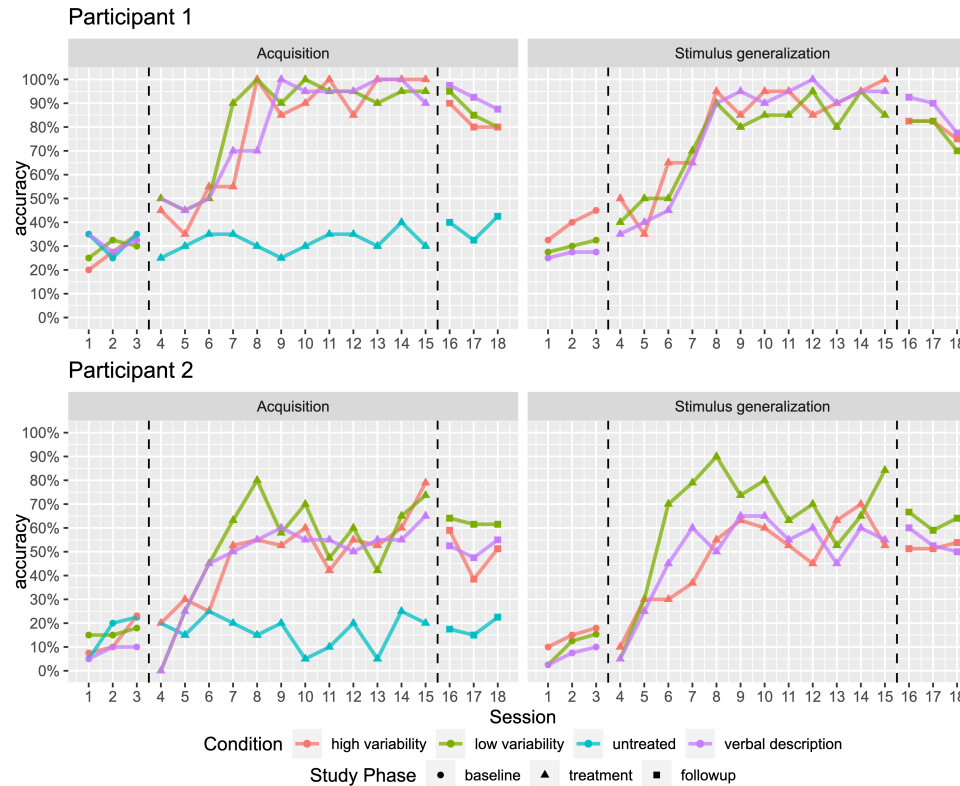
Introduction

- There is a need to improve treatment efficiency for people with aphasia (PwA).
- Self-managed computer-based treatments that incorporate learning principles are a promising option for offering efficient, low-cost, and accessible intervention.
- Distributed practice improves the long-term retention of anomia treatment in PwA (Middleton et al., 2020). Adaptive distributed practice (Settles & Meeder, 2016) may maintain desirable difficulty (Bjork & Bjork, 1992) and improve treatment efficiency by scheduling easily-learned words less frequently.
- Stimuli variability facilitates retention and generalization in developmental vocabulary learning (e.g., Aguilar et al., 2018). However, anomia treatments often train a single picture, potentially overtraining one stimulus-response mapping at the cost of stimulus generalization (Thompson, 1989).

The current study

We examined the impact of adaptive distributed practice and stimuli variability by implementing a self-managed anomia treatment using Anki open-source flashcard software.

- **Prediction 1:** this treatment will lead to efficient acquisition, retention, and stimulus generalization for more words than are typically targeted in anomia treatments.
- **Prediction 2:** Increasing stimuli variability would lead to improved stimulus generalization for both acquisition and retention.

Results

Participant 1

Participant 2

Condition: high variability, low variability, untreated, verbal description

Study Phase: baseline, treatment, followup

Methods

- 2 participants with post-stroke aphasia (out of seven assessed).
- Effortful retrieval adaptive distributed practice naming intervention using Anki (https://apps.ankiweb.net/); single-subject multiple baseline design.
- Participants taught to use Anki 1-on-1 2x/week for 2 weeks, followed by independent practice and 1-on-1 treatment 1x/week for ten weeks.

Treatment Probes - 40 untrained, 120 trained words across three stimuli conditions: low vs. high picture variability and written/auditory verbal description. - Naming performance assessed via three baseline probes, weekly treatment probes, and follow-up at 1-2 weeks, 1-2 months, and three months.
- Stimulus generalization: One trained and one untrained picture exemplar probed for each trained word.

Analysis: Statistical comparisons and effect sizes were estimated using Bayesian generalized mixed-effect models.

Demographics and Results

		P1	P2
Demographics	Age (years)	50	53
	Gender	M	M
	Months post-onset of aphasia	24	18
Baseline CAT	Comp. Spoken Language	50	38
T-scores	Comp. Written Language	50	43
	Repetition	32	48
	Naming	54	48
	Reading	49	49
	Writing	46	48
	Mean T-score	46.8	45.7
Treatment	Treated words, trained exemplars	77.24 [72.48, 82.68]	57.62 [50.94, 64.25]
Effect Sizes	Treated words, untrained exemplars	63.25 [57.27, 69.06]	48.06 [40.83, 55.37]
(num. words)	Untreated control words	2.4 [-0.47, 5.17]	-2.65 [-5.96, 0.63]
	Treated words, trained exemplars: 1-month	-8.88 [-14.23, -3.16]	-10.44 [-19.39, -1.62]
	Treated words, untrained exemplars: 1-month	-1.6 [-8.27, 5.25]	-6.14 [-15.06, 3.11]
	Treated words, trained exemplars: 3-month	-12.94 [-18.54, -7.10]	-2.67 [-10.97, 5.42]
	Treated words, untrained exemplars: 3-month	-14.49 [-21.64, -7.14]	-4.08 [-12.31, 4.19]

Discussion

- Effortful retrieval and adaptive distributed practice appear to be an efficient method for re-training more words than typically targeted in anomia treatments.
- An average of 6.5 hours of synchronous practice + 12.5 hours of independent practice (19 total) resulted in an average of 60 words retained three months post-treatment.
- Stimulus generalization was observed across conditions. Evidence of improved lexical access beyond trained stimulus response mappings; consistent with theories of post-stroke anomia (Jefferies & Lambon Ralph, 2006).
- This implementation of adaptive distributed practice provides a practical bottom-up approach to precision medicine for anomia treatment.
- Adaptive item-level practice may allow better dose optimization and allow for long-term practice options that address limited retention (Menahemi-Falkov et al., 2021).
- This promising treatment relies on freely available open-source flashcard software and asynchronous telepractice (Cherney et al., 2011), making it highly feasible for real-world implementation in limited treatment contexts.

Future directions

1. Train many more words. Participant 1 was only practicing an average of 6 minutes a day in the final week of treatment.
2. Apply adaptive distributed practice to other aphasia treatments (e.g., script training).
3. Develop more fine-tuned adaptive algorithms.
4. Replicate and extend these effects while considering treatment candidacy.

References & Acknowledgements

- Aguilar, J. M., Plante, E., & Sandoval, M. (2018). Exemplar variability facilitates retention of word learning by children with specific language impairment. Lang Speech Hear Serv Sch, 49(1), 72-84.
- Bjork, R. A., & Bjork, E. L. (1992). A new theory of disuse and an old theory of stimulus fluctuation. From learning processes to cognitive processes: Essays in honor of William K. Estes, 2, 35-67.
- Cherney, L. R., Kaye, R. C., & Hitch, R. S. (2011). The best of both worlds: Combining synchronous and asynchronous telepractice in the treatment of aphasia. Perspectives on Neurophysiology Neurogenic Speech Language Disorders, 21(3), 83-93.
- Middleton, E. L., Schuchard, J., & Rawson, K. A. (2020). A review of the application of distributed practice principles to naming treatment in aphasia. Topics in Language Disorders, 40(1).
- Huitema, B. E., & McKean, J. W. (2000). Design specification issues in time-series intervention models. Educational and Psychological Measurement, 60(1), 38-58.
- Jefferies, E., & Lambon Ralph, M. A. (2006). Semantic impairment in stroke aphasia versus semantic dementia: A case-series comparison. Brain, 129(8), 2132-2147.
- Kruschke, J. K., & Liddell, T. M. (2018). The bayesian new statistics: Hypothesis testing, estimation, meta-analysis, and power analysis from a bayesian perspective. Psychonomic Bulletin & Review, 25(1), 178-206.
- Settles, B., & Meeder, B. (2016). A trainable spaced repetition model for language learning. Proceedings of the 54th annual meeting of the association for computational linguistics (volume 1: long papers)
- Thompson, C. K. (1989). Generalization research in aphasia: A review of the literature. Clinical aphasiology, 18, 195-222.