# Effects of Adaptive Distributed Practice and Stimuli Variability in Flashcard-Based Anomia Treatment

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## Introduction

There is a need to improve the treatment efficiency for people with aphasia (PwA). The current study investigated two promising treatment components, adaptive distributed practice and stimuli variability, which are hypothesized to promote learning, retention, and stimulus generalization in anomia treatment.

Distributed practice improves the long-term retention of naming practice in PwA (Middleton et al., 2020). *Adaptive distributed practice* (Settles & Meeder, 2016) may better maintain desirable difficulty (Bjork & Bjork, 2011) and improve treatment efficiency by reviewing easily-learned words less frequently over time, thereby allowing more total words to be practiced per a given number of trials. Therefore, the current study examined whether computer-based flashcard software using adaptive distributed retrieval could successfully train more words (120) than are typically targeted in anomia treatments (e.g., ≤ 40 words, Snell et al., 2010).

If adaptive distributed practice can improve the efficiency of directly training, it is important to ensure this training generalizes beyond the treatment context (i.e., stimulus generalization, Thompson, 1989). The developmental literature has shown *stimuli variability* helps improve the retention and generalization of new vocabulary (Aguilar et al., 2018). However, anomia treatments for PwA often rely on training a single picture exemplar, potentially overtraining one stimulus-response mapping at the cost of stimulus generalization. Therefore, the current study also examined whether varying the prompt type (description vs. picture) and the number of trained exemplars would facilitate stimulus generalization in an easily-measured 'proof of concept' transfer context: untrained picture exemplars of trained words.

## Methods

Two participants with post-stroke aphasia completed an effortful retrieval adaptive distributed practice naming intervention using Anki (https://apps.ankiweb.net/) in a single-subject multiple baseline design. Naming probes consisted of 40 untrained and 120 trained words balanced across three stimuli conditions: low vs. high picture variability (one vs. three trained pictures for each target word) and written/auditory verbal description. One trained and one untrained picture exemplar was probed for each trained word. Participants were taught to use Anki during one-on-one sessions 2x/week for two weeks, followed by daily independent practice and one-on-one treatment 1x/week for ten weeks. Naming performance was assessed via three baseline probes, weekly treatment probes, and follow-up probes at one, four, and twelve weeks post-treatment. Statistical comparisons and effect sizes were estimated using Bayesian generalized mixed-effect models (Bürkner, 2017).

## Results

Compared to direct training effects in previous anomia treatments (e.g., Quique et al., 2019), participants showed excellent acquisition and retention three months post-treatment for both trained and untrained picture exemplars (Figure 1). Effects of stimuli variability and type were not reliably different from zero (Table 1).

## Conclusions

These case studies suggest that combining effortful retrieval and adaptive distributed practice is a highly effective way to re-train more words than can typically be targeted during anomia treatment. The treatment resulted in stimulus generalization across conditions, indicating improved lexical access beyond what could be attributed to simple stimulus-response mapping. Finally, 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.


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**Figure 1.** Anki naming treatment probe performance during baseline, treatment, and follow-up for 120 trained words and 40 difficulty-matched untreated control words over time. Final timepoint = 3 month follow-up.

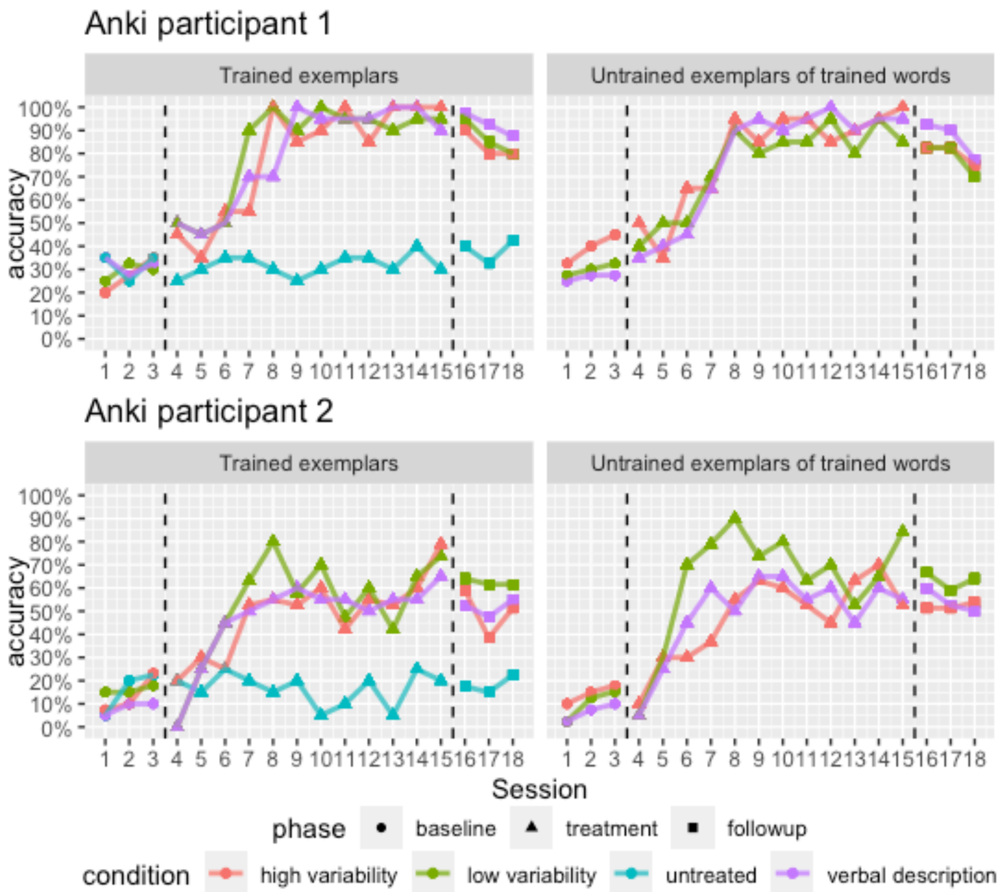

**Table 1.** Participant demographics, language assessment performance, and treatment effect sizes.

| | | Participant 1 | Participant 2 |
|---|---|---|---|
| Demographics | Age (years) | 50 | 53 |
| | Gender | M | M |
| | Months post-onset of aphasia | 24 | 18 |
| Baseline Comprehensive Aphasia Test T-Scores | Comprehension of Spoken Language | 50 | 38 |
| | Comprehension of Written Language | 50 | 43 |
| | Repetition | 32 | 48 |
| | Naming | 54 | 48 |
| | Reading | 49 | 49 |
| | Writing | 46 | 48 |
| | Mean modality T-score (severity) | 46.8 | 45.7 |
| Treatment effect sizes (90% credible intervals in parentheses) | Treated words, trained exemplars | 74.77 (69.11, 80.32) | 48.07 (40.74, 55.42) |
| | Treated words, untrained exemplars | 63.26 (57.37, 69.21) | 48.14 (40.95, 55.4) |
| | Untreated control words | 2.79 (-0.21, 5.78) | -1.64 (-5.29, 1.82) |
| | Treated words, trained exemplars at 1-month follow-up | -8.91 (-14.5, -3.28) | -10.55 (-19.53, -1.75) |
| | Treated words, untrained exemplars at 1-month follow-up | -1.73 (-8.16, 5.17) | -6.1 (-14.91, 3.27) |
| | Treated words, trained exemplars at 3-month follow-up | -12.92 (-18.77, -7.27) | -2.71 (-11.03, 5.31) |
| | Treated words, untrained exemplars at 1-month follow-up | -14.43 (-21.44, -7.06) | -4 (-11.93, 4.7) |

*Note:* effect size estimates and 90% credible intervals calculated using a Bayesian implementation of interrupted time series mixed-effect models (Huitema & McKean, 2000). Follow-up effect sizes calculated as change from the end of treatment to one-month follow-up, and from one-month follow-up to three-month follow-up, respectively.

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