Apraxia of Speech:
Change in Error Consistency Following a Multimodal intensive Treatment (MMiT)

## Background

Post-stroke apraxia of speech (AOS) is a motor speech disorder thought to result from disrupted motor planning and/or programming (Darley et al., 1969; Ogar et al, 2006; McNeil et al, 2000) and often seen in combination with aphasia or other motor speech disturbances. Historically, AOS has been associated with a reduction in the consistency, quality, and intelligibility of speech that can severely impact communication. Among originally implicated features of the disorder is the pattern of error inconsistency, or variability in performance across repeated attempts at the same utterance (Johns and Darley, 1970; Deal and Darley, 1972). Several recent studies have challenged this as a defining feature of AOS, suggesting that errors may instead be highly predictable for specific phonemes (Odell, McNeil, Rosenbek, & Hunter, 1990; Mauszycki et al., 2007; Wambaugh et al., 2004) and within word location across repeated productions of the same utterance (McNeil et al., 1995). While follow-up studies have investigated this pattern across occasions (Mauszycki et al., 2010; Mauszycki & Wambaugh 2006) there are no studies to date examining change in error consistency following a theoretically grounded intervention.

During previous intervention efforts with patients enrolled in a Multimodal intensive Treatment (MMiT) for phonological alexia, a post-stroke reading disorder, subjective changes in verbal praxis were reported (Conway, et al., 1998; Kendall, et al, 2003; 2006; 2008). Thus, it was proposed that this treatment's focus on training both sensory and motor features of phonemes in speech may provide a mechanism for improved motor programming in individuals with AOS. Therefore, the purpose of this Phase I research project was to examine change in error consistency in number and location across successive repetitions of the same utterance, before and after MMiT in participants with AOS and aphasia.

# Methods

## Study Design

This study was appended to an ongoing single-subject repeated measures study of phonological alexia which incorporated 120 hours of MMiT across participants with AOS and aphasia. Participants were three right-handed, monolingual English speakers who experienced a left hemisphere stroke (see Table 1. for demographic information). A speech-language pathologist (SLP) reviewed audio-recorded samples of speech to confirm presence of AOS in all three participants. We administered the Repeated Trials subtest of the Apraxia Battery for Adults, second edition (ABA-2) at pre- and post-treatment. Participants repeated 10 target words three times in succession (e.g., “computer, computer, computer”) and the total number of errors was calculated to determine change across repetitions.

## Phonetic Transcription and Error Analysis

Audio-recorded speech samples were broadly transcribed using the International Phonetic Alphabet by a trained transcriptionist who was blinded to assessment time points. Two SLPs, blind to participant and time point, used the transcriptions to rate the total number and location of errors for each response. A third SLP provided a consensus rating for discrepant items.

## Rater Reliability

Reliability of transcription ratings was calculated as percent agreement in the total number of errors for each session, location of errors (percent of phonemes scored as incorrect by both raters), and item-to-item agreement (percent of items which matched in both number and location of errors for both raters).

## Total number of errors

Total number of errors across all 30 responses (three repetitions for each of 10 items) was calculated at each time point and the difference from pre- to post-treatment for each subject was recorded.

**Error inconsistency across repetitions**

A variation of Cohen's *d* was used (Busk and Serlin, 1992) to measure effect size of change in error inconsistency across successive repetitions. As noted by Beeson and Robey (2006) this variation may be calculated with representative data points (items within a session) as a measure of change in untrained items. This was calculated as follows:

where $A_1$ and $A_2$ represent the *average* standard deviation (SD) in number of errors across successive repetitions and across all items at pre- and post-treatment, respectively. $SD_1$ is the standard deviation of calculated SD values across all items at pre-treatment. Effect sizes were classified as small (.3 to .5), medium (.5 to .7) and large (>.7), as appropriate for studies which use untrained stimuli as dependent measures.

**Consistency of Error Location**

To replicate and extend previous reports suggesting that individuals with pure AOS who demonstrate an error on a given sound segment are likely to show errors in the same location (or sound segment) on subsequent responses (see McNeil et al., 1995), consistency of error location was calculated. The total number of errors occurring two or three times on the same sound segment within an item was summed and a percentage across all errors was calculated.

**Treatment Description**

Treatment was hierarchically organized, and composed of three distinct stages:

*Stage I*, Multimodal discovery of phonemes, trains associations between visual, auditory, oral kinesthetic, oral tactile, & metalinguistic features of phonemes.

*Stage II* trains phonological awareness through problem-solving tasks, where participants must identify a single change between two nonwords in a series (e.g. number, order, or identity [add/omit/substitute/shift/repeat]).

*Stage III* trains generalization of Stage II to reading (blending phonemes) and spelling (segmenting nonwords), while training accuracy and self-correction of errors during tasks.

## Results

### Rater Reliability

Percent agreement was 96% for total number of errors. Agreement in error location (percentage of phonemes scored as incorrect by both raters) was 95%. Raters demonstrated 91% overall item-to-item agreement.

### Total number of errors

Total number of errors produced across all 30 responses decreased from pre-to post-treatment assessment for Participant1 (from 65 to 41) and Participant2 (from 14 to 4). Participant3 did not show this reduction, demonstrating a total of 5 errors at both pre- and post-treatment.

### Error inconsistency across repetitions

Participant1 showed reduced error inconsistency (change in total number of errors across successive repetitions of an item) from .58 to .40 ($d$ =.24, no effect). Participant2 showed a reduction from .39 to .06 ($d$ = .78, large effect) and Participant3 demonstrated a reduction from .23 to .12 ($d$ = .39, medium effect).

### Consistency of Error Location

All three participants demonstrated increased consistency of error location (percentage of errors occurring on the same target phoneme within an item, across more than one repetition) with a small range at both pre- (40-51%) and post-treatment (60-85%). These data are shown in Figure 1.

**Treatment Progress**

All three participants completed all treatment stages and demonstrated consistent progress. Participant1 reached training of 3-phoneme, single-syllable pseudowords, but no multisyllable words. Participant2 reached 4-phoneme, single syllable pseudowords, and 5-syllable pseudowords. Participant3 also reached 4-phoneme, single syllable pseudowords, and 5-syllable pseudowords.

## Conclusion

It was proposed that MMiT, which trains distinctive sensory and motor features of phonemes through problem-solving activities with novel phoneme sequences, might increase overall accuracy of phonemes. Indeed, two of the three participants improved in overall accuracy. The participant who made the least treatment progress also continued to show the most errors at post-treatment. Importantly, all participants improved in consistency of error location. Errors which remained support previous reports that some phonemes may be more susceptible to error than others in AOS (see Mauszycki et al., 2010 for review). Therefore, these results appear to support subjective reports of improved verbal praxis following MMiT and suggest it may improve consistency and/or accuracy of performance in AOS. Additional participant data is needed to determine the efficacy of MMiT and to identify patient-specific characteristics which might influence treatment outcomes.

Table 1. Participant Demographic Information

| | Age | Gender | Education (years) | Time Post Onset (months) | WAB AQ |
|---|---|---|---|---|---|
| Participant1 | 60 | M | 15 | 113 | 64.6 |
| Participant2 | 43 | M | 12 | 19 | 93.2 |
| Participant3 | 60 | M | 16 | 12 | 90 |

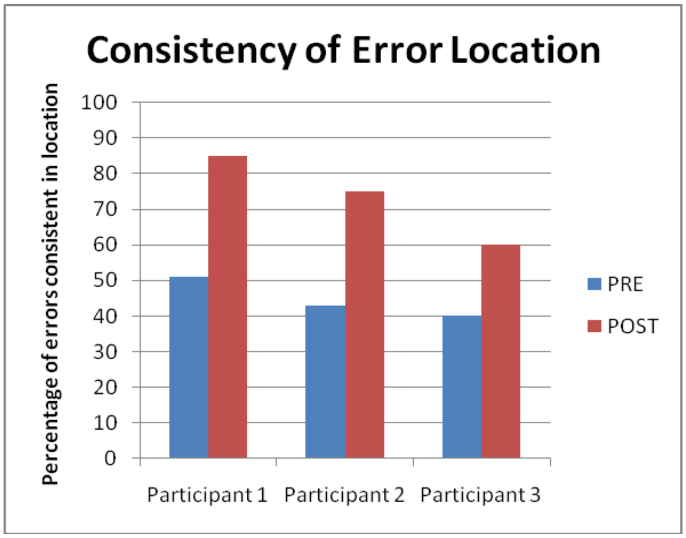

*Figure 1*. Consistency of error location for all three participants at pre- and post-treatment

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