Introduction

Apraxia of speech (AOS) is an impairment of speech production that results in articulatory errors and distortions, disrupted speech fluency and a loss of speech intelligibility. The consensus view is that the disorder is a post-phonological impairment, and that processing fails in translating an abstract phonological representation to a motor program that is capable of driving the speech production system. The motor program is often seen as consisting of a sequence of individual sound segment movement plans, containing the spatial and temporal co-ordinates for a particular segment. The traditional conceptualization of the impairment in AOS is one of failure to access segmental plans, or disruption of the spatial and temporal co-ordinates of the plan, or difficulty in the combination of individual segment plans in order to form cohesive syllables.

There are, however, alternative conceptualizations of the mechanisms of speech control. In a series of articles, Levelt and colleagues have postulated the existence of a syllabary that contains movement plans for high-frequency syllables (Levelt, et al., 1999). Whiteside & Varley (1998) applied the notion of storage of high-frequency suprasegmental plans to AOS (Varley & Whiteside, 2001), suggesting that the condition represents disrupted activation of stored schemata for higher frequency words.

The conceptualization that one adopts for a disorder should determine the principles of therapies designed to ameliorate that disorder. The standard view of AOS, that it represents disruption of the segmental access and assembly routines, motivates therapies that focus on rebuilding or re-accessing segment-sized movement patterns (e.g., Wambaugh, et al., 1998). In addition to these segmental therapies, there is a further group of therapies that Square and Martin (1994) neatly characterise as *macro-structural* therapies. Common elements among these approaches are a focus on the use of rhythm to facilitate production and use of words, phrases and sentences rather than segments and articulatory features.

In this study, we examined the effect of a word-level, macrostructural therapy on the speech of people with AOS. Therapy was administered via a software program that allowed high-dosage, remotely delivered therapy. The general effects of computer-administered therapy were examined by comparing the effects of the speech program with a visuo-spatial placebo program. The study utilized a multiple baseline design with control behaviors in order to control for the effects of spontaneous recovery and general language stimulation on performance. The study also investigated whether therapy organized around a word set with a common onset structure (e.g., kiss, kid, king) was more effective than that organised around word sets with a common rime structure (e.g., sat, hat, cat).

Methodology

Participants

We report here the results from three women with AOS (JF, JS, SST, age range 53-69). All were at least 6-months post-onset of a single vascular lesion to the left hemisphere. All had some degree of co-existing aphasic impairment. (In the conference presentation, results from a further seven cases will be included).

Experimental Design

Each participant received two computer treatments: (1) a word-level speech intervention program; (2) a visuo-spatial program. Each treatment was administered for a 6-week period, with a 4-week rest phase between interventions. The order of administration was counterbalanced across participants. Prior to treatment, baseline assessments of treated and control behaviors were taken. Control behaviors were spoken sentence-picture matching and written word-picture matching, which were not predicted to change as a result of the speech program.

With regard to words targeted in treatment, there were 30 treated items that were sub-divided into sets of shared onset structure or shared rime. There were a further 30 items that were drawn from the same onset or rime cohorts but which did not appear in treatment. These words allowed evaluation of whether treatment generalized to structurally-related words. Finally, there were 30 control words, clustered into onset or rime cohorts but which were structurally unrelated to the treatment words and did not appear in treatment. All word sets were matched on frequency and phonetic complexity. Production of these words and the control behaviors were assessed at baseline, at the termination of each intervention, and at a follow-up assessment 8-weeks after the end of treatment. Outcomes were assessed through perceptual accuracy scores in word repetition and naming, and in acoustic measures of utterance duration before and after intervention.

Software Programs

Software programs were designed for the purposes of the study[1]. The placebo visuo-spatial program involved a series of matching and short-term memory tasks and a constructional jigsaw task. The Apraxia Program (SAP) was designed around the following principles:

(1) high dosage therapy delivered under conditions of high motivational drive;
(2) maximization of errorless learning strategies;
(3) auditory and visual stimulation prior to production.

Results

<u>Word Repetition</u>

Figure 1 displays the results for accuracy of word repetition of the onset-related sets at baseline and after treatment, and Figure 2 provides the same data for the rime-related sets. The data reveal that repetition accuracy increased for treated words in both onset- and rime-related sets following treatment. There was also improvement of structurally related untreated words in both shared onset and rime sets. Generalisation to untreated items was variable.

<u>Picture Naming</u>

Accuracy of word production in picture naming conditions showed an improvement (Figure 3).

<u>Utterance Duration</u>

Utterance duration measures were used to assess the degree of fluency and cohesiveness of word forms. The results of the acoustic analysis are presented in Figure 4 (onset-related set) and 5 (rime-related set). The data reveal that there were significant changes in utterance duration across all word sets, with durations becoming shorter and reflecting greater articulatory cohesiveness (paired *t*-tests, $p<0.05$, with Bonferroni adjustment). Improvements were not limited to treated words, but generalized to structurally related words and untreated words.

[1] Software was engineered by Geoff Cookmartin.

Control Behaviors

There was no evidence of a generalized placebo effect, as control behaviors of spoken sentence-picture matching and written word-picture matching were unchanged. (Figures 6 a & b).

Discussion

This study indicates that treating AOS at the level of the word, rather than sub-syllabic units, represents an effective intervention for the condition. Word-level treatment resulted in improvements in the speed of word production, and in the accuracy of words in both repetition and picture naming. The effects of the program were not limited to treated words, but improvement generalized to both structurally related and unrelated word forms. This suggests that the intensive therapy resulted in a generalized improvement in word production.

References

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Whiteside, S. P. & Varley, R. A. 1998. A reconceptualisation of apraxia of speech: a synthesis of evidence. *Cortex,* 34, 221-231.

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Figure 1. Total accuracy scores for repetition task: onset data sets

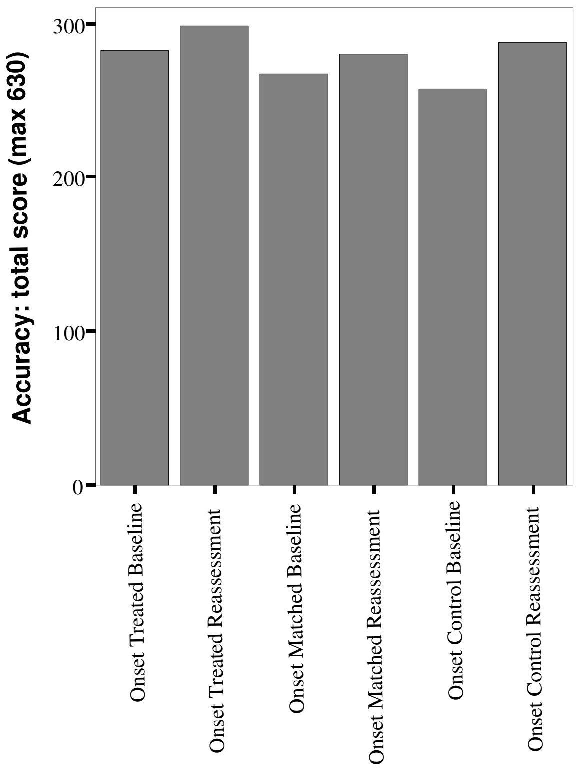


Figure 2. Total accuracy scores for repetition task: rime data sets

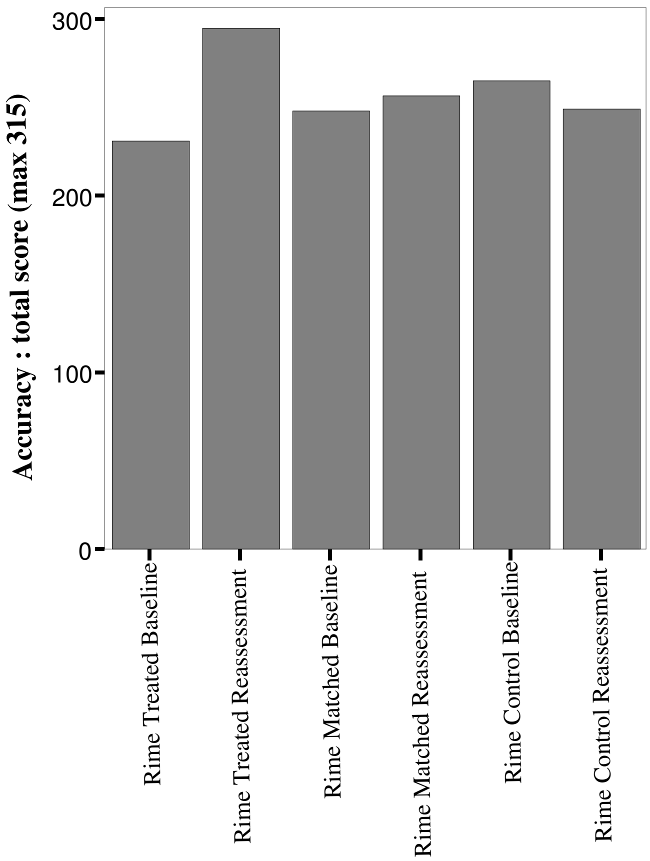


Figure 3. Total accuracy scores for picture naming task (onset and rime data combined)

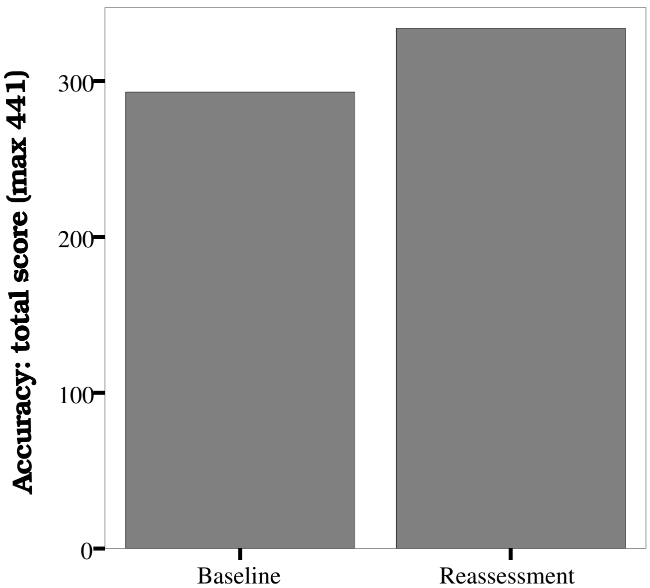


Figure 4. Utterance duration values (ms) for baseline and reassessment samples for treated, matched and control items with shared onsets

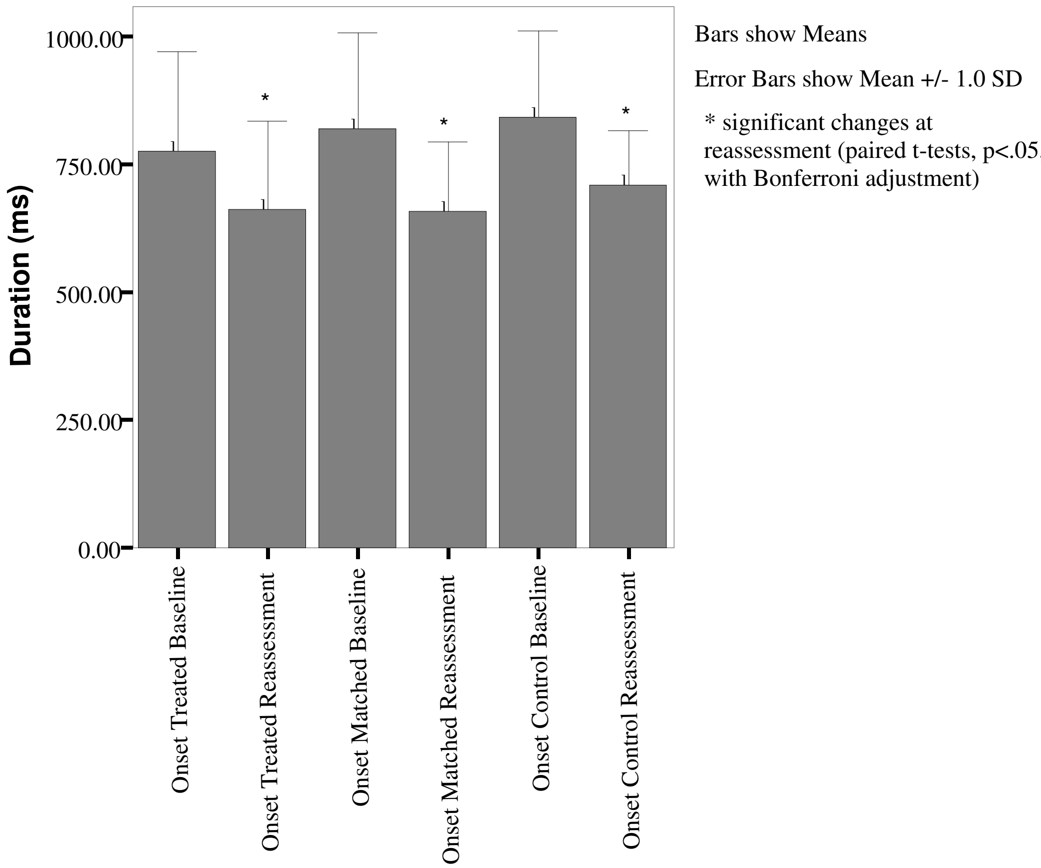
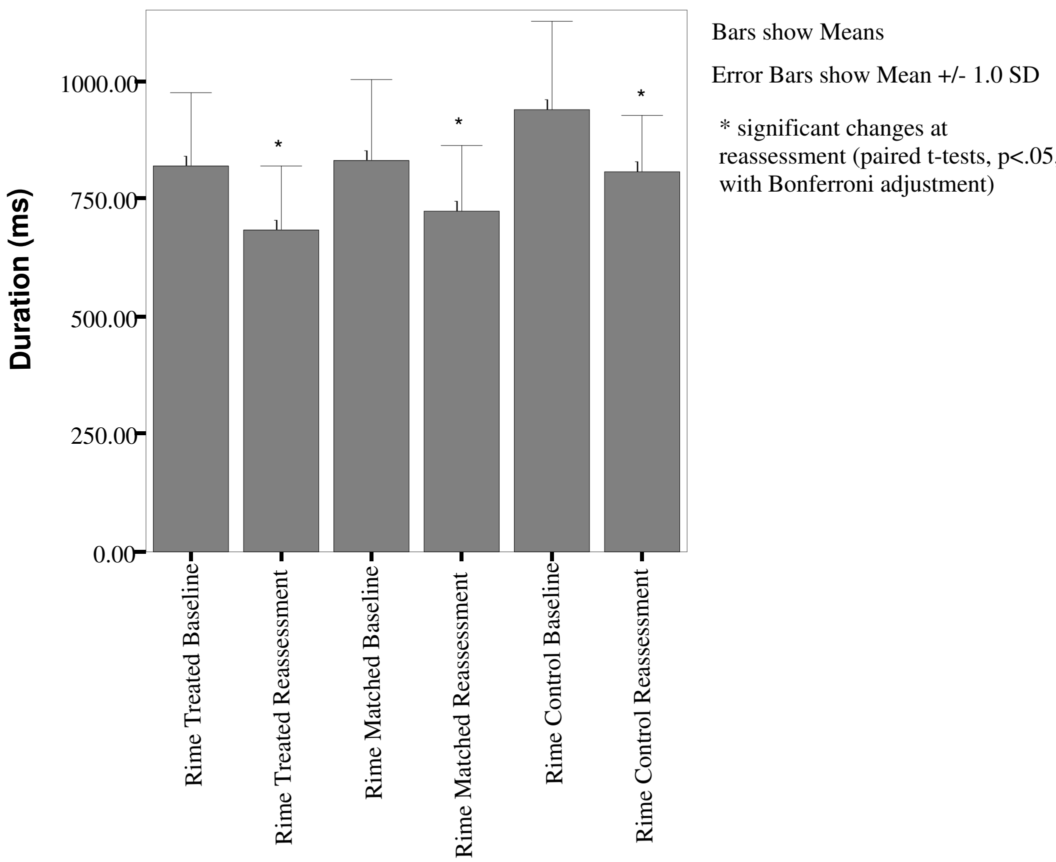


Figure 5. Utterance duration values (ms) for baseline and reassessment samples for treated, matched and control items with shared rimes



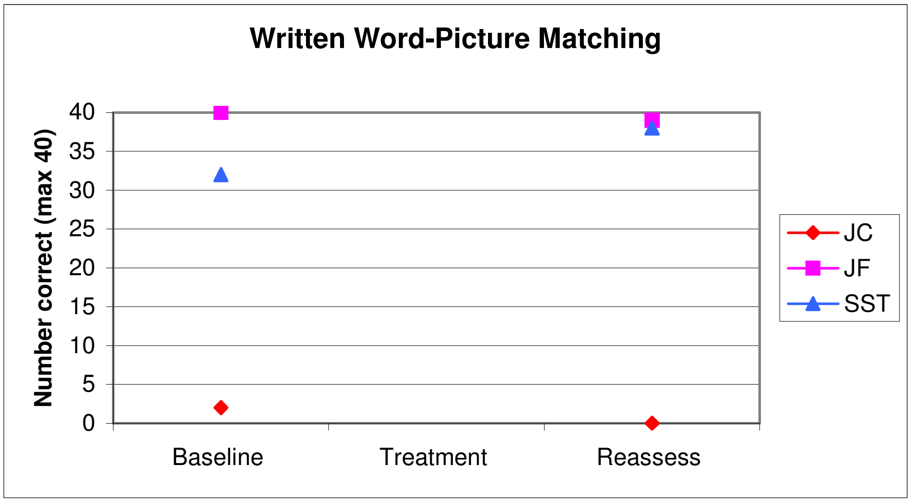


Figure 6a: Control behavior (written word-picture matching) at baseline and after intervention.

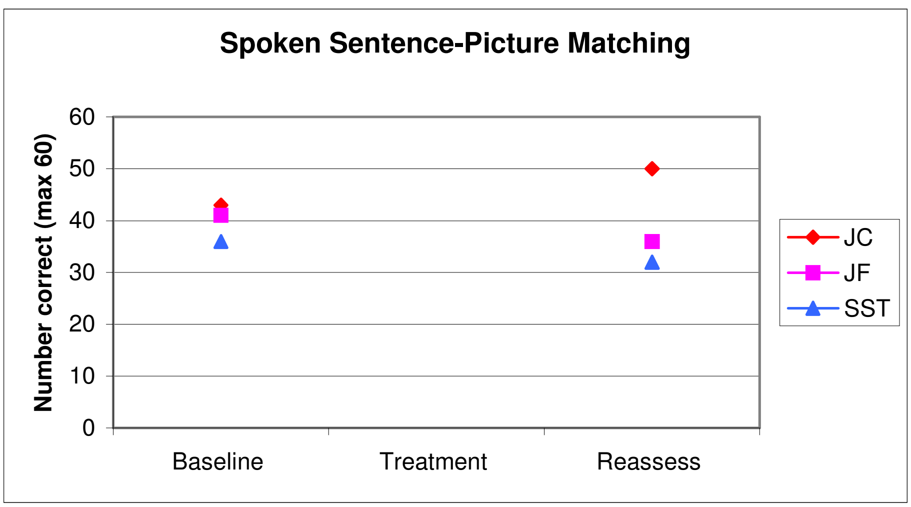


Figure 6b: Control behavior (spoken sentence-picture matching) at baseline and after intervention.