Introduction

About 795,000 Americans each year suffer a new or recurrent stroke (NIDCD.gov). Also, about 1.7 million individuals suffer from traumatic brain injury each year (CDC.gov). Individuals with language and cognitive deficits following brain damage likely require long-term rehabilitation. Consequently, it is a huge practical problem to provide the continued communication therapy that these individuals require. The present project examines the validity of an iPAD based continuous rehabilitation language and cognitive program. Patients were evaluated and initiated with a treatment plan in the clinic and then required to practice the therapy tasks at home on a daily basis but at individualized times/durations. The treatment plan in the clinic and at home was delivered to the patient via the Constant Therapy Software (www.constanttherapy.com) platform. The level of patient compliance (did they practice the therapy tasks), patient engagement (how long did they practice the therapy tasks) and amount of improvement on each task (percent change over time) was measured. Results from the patients using iPAD Constant Therapy are compared to patients who practice therapy on the iPAD with the clinician but do not take the iPAD home. These data are further compared to patients who receive traditional flashcard based therapy.

Methods

Participants.

Twenty four individuals with aphasia within the Boston area participated in the experiment (our enrollment goal is N = 36). All participants either suffered a stroke or a traumatic brain injury, ranged in age from 37- 76 years (*M* = 61 yrs); and were at least ten months post-onset their brain injury (*M* = 62 months). For each participant, standardized language (*Western Aphasia Battery, Boston Naming Test, Pyramids and Palm Trees, Cognitive Linguistic Quick Test, and ASHA FACS*) were administered prior to initiation and following completion of a 10 week therapy.

Stimuli and Therapy Tasks.

Therapy tasks were divided into language and cognitive tasks and were developed based on a review of evidenced based treatment recommendations (Kiran & Sandberg, 2011; Sohlberg & Turkstra, 2011; Togher, 2011)(see Figure 1a for a sample task). Under language, the following tasks were developed 1) Naming Therapy: (a) rhyme judgment, (b) syllable identification, (c) phoneme identification, (d) category matching, (e) feature matching and (f) picture naming; 2) Writing therapy: (a) word copy, (b) word spelling, (c) picture spelling, (d) letter/phoneme to phoneme/letter matching; 3) Reading therapy: (a) spoken word-written identification, (b) written word category identification, (c) reading passages, (d) reading maps. Under cognitive tasks, the following tasks were developed 1) Visuospatial processing: (a) symbol cancellation, (b) telling time/analog clock, 2) Memory: (a) visuospatial picture/word memory matching, (b) visuospatial auditory memory matching, (c) auditory (spoken) passage memory; 3) Mental flexibility: (a) response inhibition; 4) Problem solving: (a) analytical reasoning (alphabetical word/picture ordering), (b) arithmetic (addition, multiplication, subtraction and division), (c) quantitative reasoning on a time estimation task. The language tasks were drawn from a database of 680 single concrete words distributed across semantic categories. Reading passage comprehension ranged across ten topics (e.g., menus, general facts, reading prescriptions) with ten paragraphs and map comprehension comprised approximately 150 items. Stimuli for cognitive tasks ranged anywhere from 100 items per task to a large set of items (e.g., addition of five digit numbers) in other tasks.

Design

Of the 24 patients, 22 patients met with a clinician once a week for therapy and were asked to practice the iPAD based therapy excercises (Constant Therapy's iTherapy app) at least once a week and upto seven days per week at home (see Figure 1b for sample display of patient compliance in logging and completing therapy). Two control patients met with clinician once a week only to perform therapy tasks with the iPAD. Our target control group is 10 patients. The Constant Therapy software logged the amount of time and the amount of therapy that the patient spent performing the therapy excercises.

Based on the initial language evaluation, all participants were assigned between four to six language and/or cognitive therapy tasks at a given time as long as the initial performance on task was below 90% accuracy. Each task was practiced until accuracy on task reached 100% on multiple occasions. In several cases, therapy was continued even after 100% accuracy was achieved when participants expressed interest in improving their speed on specific tasks.

Results

In addition to the one hour/week clinician-interaction session, participants logged into the iPAD therapy software between 1- 6.5 times/week with the average duration of a therapy session lasting 37 minutes. For each patient, for each treatment task, a trendline was computed on the time series data and the coefficient of determination (R^2) was computed. As long as the R^2 value was > .2, indicating a trend in data (for both accuracy and latency), average change was computed as the difference between the last two therapy sessions and the first two therapy sessions for that treatment task. For example, patient #28 showed changes on (a) category matching (55% to 70% accuracy, 17 to 8.6 sec latency), (b) feature matching (43% to 53% accuracy, 18 to 14.5 sec latency), (c) word copy (92% to 96% accuracy, 114 to 63 sec latency), (d) letter to phoneme matching (31 to 23.4 sec latency). Another patient #23 (See Figure 2 for this patient's results), showed changes on (a) letter to phoneme matching (62% to 85% accuracy), (b) addition (40% to 95% accuracy, 33 to 22.5 sec latency), (c) category identification (70% to 90% accuracy), (d) map task (68% to 80% accuracy, 59 to 40 sec latency). For this patient, completion of post- pre assessments showed changes on *WAB Aphasia Quotient* (42.2 to 86.6), *BNT* (46.6% to 76.6%), *Pyramids and Palm Trees* (82%-94%) and composite severity changes on *CLQT* from moderate deficits to within normal limits. Based on the large sample size, a large amount of data has been generated in the study; we will present the aggregated results (across patients) at the time of the conference.

Discussion

The results of this study highlight that patients with brain damage are extremely motivated to practice therapy at home when provided with appropriate access to therapy (delivered via an iPAD) and monitored by a weekly session with a clinician. Relative to control patients who received treatment once/week, experimental patients logged in to complete therapy tasks up to 6 times/week. In addition, therapy tasks were tailored for each patient, based on pre-treatment standardized tests and initial baseline performance. Consequently, motivation was high and participants expressed interest in practicing therapy tasks at home on a regular basis. Participants showed improvements in latency and accuracy on several therapy tasks that was dependent on the initial level of impairment, the level of task difficulty and the frequency of treatment.

Conclusions

This study examines the effectiveness of a language therapy program delivered through an iPAD (Constant Therapy software platform) for individuals with brain damage. Results demonstrate the feasibility and preliminary success of such a structured continuous therapy in terms of determining language and cognitive treatment outcomes.

References

Kiran, S & Sandberg, C. (2011). Treating communication problems in individuals with disordered language. R. Peach and L. Shapiro (Eds.). *Cognition and Acquired Language Disorders: A Process-Oriented Approach.* Elselvier. London. Pp 298-326.

Togher, L. (2011). Clinical approaches to communication impairments due to executive dysfunction. R. Peach and L. Shapiro (Eds.). *Cognition and Acquired Language Disorders: A Process-Oriented Approach.* Elselvier. London. Pp 326-346.

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Figure 1: (a) Example task (rhyme judgment) on Constant Therapy software platform, (b) sample patient dashboard showing patient overall accuracy, current therapy tasks and corresponding accuracy. This dashboard also displays overall therapy time in hours, proportion of therapy tasks completed, and patient compliance (displayed by date). Each green dot represents an "in home" therapy session.

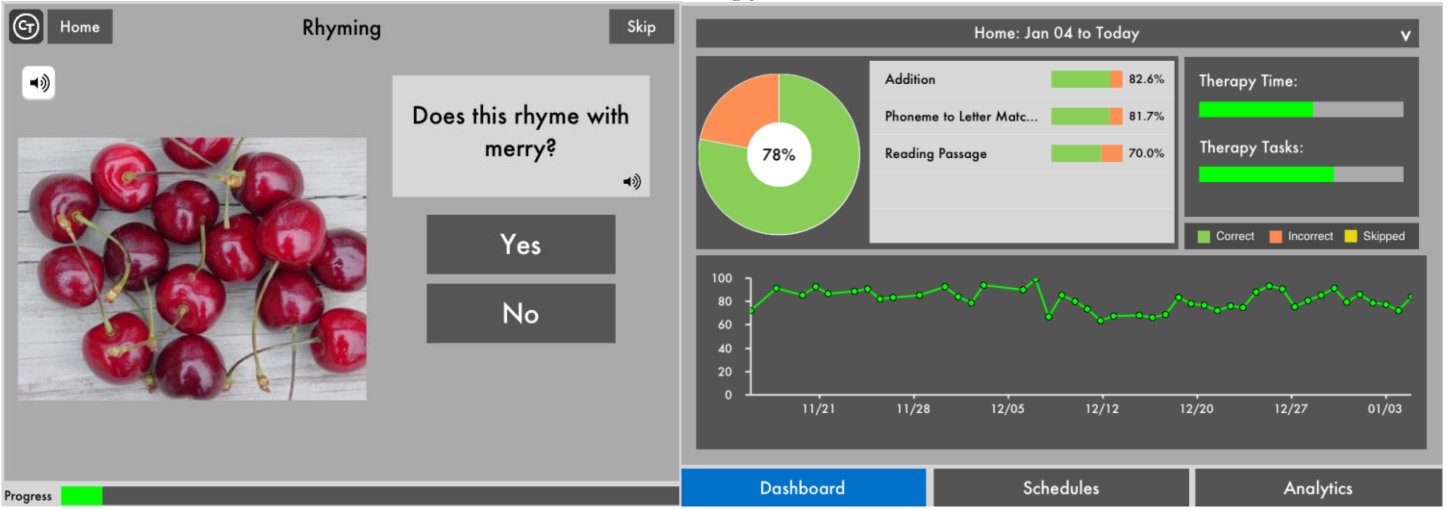

Figure 2: Sample patient (#23) who received several language and cognitive therapy tasks. This patient logged into the software 40 times during the 10 week therapy program. This graph displays only average accuracy per session (not average latency, although that measure is also computed).