Introduction

Most treatment for people with chronic aphasia relies on face-to-face treatment in a clinical setting. However, some people with aphasia may not have access to outpatient centers or transportation. As computers become more prevalent, their usefulness as a therapy tool also increases. Effective computerized telerehabilitation removes transportation concerns while improving the patient's computer skills, which are vital for modern communication.

Many computerized treatments have been developed for chronic aphasia (Adrian, Gonzalez, Buiza & Sage, 2011; Katz, 2010), including some with promising results, but few have been used via telerehabilitation, so participants must still travel to receive treatment. The purpose of the current study was to adapt Verb Network Strengthening Treatment (VNeST) (Edmonds & Babb, 2011; Edmonds, Nadeau, & Kiran, 2009), a treatment to aid lexical retrieval in sentence context, for computer use. This Computerized VNeST program (VNeST-C) was used to adminster VNeST via the Internet, allowing the participant to receive treatment without transportation concerns. This study also allowed us to integrate typing of responses into the treatment, thereby potentially improving lexical retrieval in spoken and typing modalities.

Specifically, this study sought to answer three research questions: Will treatment result in improvement in pre- to post-treatment changes in 1) sentence description of pictures containing trained and untrained semantically related verbs in both typed and spoken modalities, 2) confrontation naming of nouns and verbs in typed and spoken modalities, 3) sections of the Western Aphasia Battery - Revised.

Method

Participants. Two participants were enrolled and completed this study. Participant 1 (P1) is a 55 year old, native English-speaking right-handed Caucasian male (with exposure to Japanese and German years ago when he was in the service). He has a history of a single ischemic stroke 6 years prior to enrolling in the study. Participant 2 (P2) is a 54 year old, monolingual, right-handed Caucasian male with a history of a single ischemic stroke 4 years prior to the study. Neither participant reported depression, history of other neurological disorders, learning disorders or alcohol/drug addiction.

Stimuli. The VNeST-C program was written in Java. The treatment steps from published VNeST reports (e.g., Edmonds & Babb, 2011) were retained, with the addition of type responses by the participant. See Figure 2.

The verbs used in treatment as well as the sentence probe pictures were also taken from previous VNeST studies. Fourteen pairs of semantically related verbs (e.g., boil/fry) were used. The sentence elicitation pictures are line drawings designed to elicit a simple sentence with these verbs (e.g., "The chef is boiling corn.").

Two control tasks were administered: 1) PALPA subtest 8 (Nonword repetition) for P1, PALPA subtest 13 (Digit Span) for P2. P1 was unable to perform digit span at baseline, thus nonword repetition was chosen.

Design. This study was performed with a single-subject, multiple-baseline design. The baseline phase evaluated sentence probes and control tasks over three sessions. After baseline testing, ten pairs of semantically-related verbs were selected for each participant, with one half of each pair being treated. Verbs which tested at ceiling during baseline were excluded from treatment. The treatment phase consisted of 24 sessions over an 8-week period. Sentence probes and controls were tested after session 8, session 16, and again post-treatment. The Western Aphasia Battery – Revised (WAB-R), Cognitive Linguistic Quick Test (CLQT), and An Object and Action Naming Battery (O&A) were also tested before and after treatment.

Treatment protocol. Both participants completed 24 two-hour treatment sessions using the VNeST-C program. Treatment was performed using Adobe® Connect™ software to facilitate communication between the researcher in the laboratory and participants at home. All sessions were guided by the first author or a trained assistant.

The treatment consists of four main steps. First, the participant is given a verb (e.g., boil) and asked to provide an agent and patient (e.g., chef and pasta). The participant creates three to four triads by saying then typing the word. Then, the participant reads each triad aloud and selects one to describe further by answering where, when and why the action may occur (e.g., "Chef boils pasta in the kitchen at dinnertime for the customers"). After this, the participant makes semantic judgments on 10 sentences with the target verb. Given "a snake boils corn," the participant would determine that the sentence is incorrect and then identify the implausible word. The clinician then minimized the program window and asked the participant to recall the target verb. The final step is the same as the first with no cues provided. This process is repeated to complete 3-4 verbs per session.

Results

Participant 1. Effect sizes (Cohen's *d)* between baseline and post-treatment were calculated to determine magnitude of change for the sentence probes and control tasks. See Figure 1 for graphed results. For the sentence probes, P1 showed notable improvement on both trained and untrained items in the verbal modality. As seen in Table 1, trained sentences showed an effect size of $d = 10.00$. The untrained sentences showed a 10 percent improvement; however, an effect size could not be calculated because the pre-treatment standard deviation was zero. For typed responses, trained items improved from 0 percent correct to 50 percent correct (an effect size could not be calculated). Control was maintained and post-treatment control task did not exceed baseline.

P1 showed increases in both the spoken and typed modalities for single-word naming of nouns and verbs, with spoken responses showing more improvement than typed responses (increases of 20.6% and 9.2% respectively). P1 also showed a clinically significant improvement to his WAB-R aphasia quotient (51.2 to 58.2) as well as a mild increase on the reading and writing subtests. See Table 2.

Participant 2. P2 showed increases on trained and untrained items in both the spoken and typed modalities on the sentence probes. For spoken responses, trained and untrained sentences

exhibited effect sizes of 5.77 and 1.15 respectively (Table 1). For typed responses, trained and untrained sentences showed effect sizes of d = 6.35 and d = 8.00 respectively. The control task did not improve in post-treatment testing (d = -2.00). P2 showed generalization at the single-word naming level primarily for spoken nouns and typed verbs on the O&A (23.7% and 25% respectively). P2 also showed improvements on the WAB-R Reading subtest (to ceiling) and notable improvement the Writing subtest (60 to 79.5) with negligible improvement on his Aphasia Quotient. See Table 2.

Discussion

The results of this preliminary study indicate that VNeST-C may be effective in improving typed and spoken production for people with aphasia. It may also be used as a teletherapy tool. As with previous VNeST studies, both participants showed improved lexical retrieval on the spoken sentence probe task. This study also showed improvement to typing, which was previously untested, and which is a functional language skill for which there are few treatments. Further generalization for lexical retrieval was observed in both participants, with improvements in confrontation naming of untrained nouns and verbs. Additionally, P1's improvement on the WAB-R and both participants' improvement on the Writing subtest of the WAB-R indicate generalization to other untrained aspects of language, including writing-by-hand. Though promising, further research is needed with VNeST-C to fully evaluate its effects on more persons with aphasia.

Tables

Table 1. Sentence probe and control task results for both participants.

	Participant 1			Participant 2		
Probe Tasks	Baseline average	Post-tx Probe	Cohen's *d*	Baseline average	Post-tx Probe	Cohen's *d*
SPOKEN						
Trained sentences	1.00	6.00	10.00	5.00	10.00	5.77
Untrained sentences	1.00	2.00	N/A*	3.66	4.00	1.15
TYPED						
Trained sentences	0.00	5.00	N/A*	5.33	9.00	6.35
Untrained sentences	0.00	0.00	N/A*	5.00	9.00	8.00
CONTROL TASK	3.67	5.00	2.31**	2.00	1.00	-2.00

* N/A – Cohen's *d* could not be calculated because baseline standard deviation was 0.
** Post-treatment accuracy on control task did not exceed the highest baseline point despite effect size

Table 2. Pre- and Post-treatment testing results for both participants.

		Participant 1		Participant 2	
Test	Max Score	Pre-tx	Post-tx	Pre-tx	Post-tx
*WAB-R**					
Aphasia Quotient	100	51.2	58.2	84.8	84.3
Reading subtest	100	80	80	96	100
Writing subtest	100	48	55.5	60	79.5
*O&A***					
Nouns List A – Spoken	81	39	52	59	73
Verbs List A – Spoken	50	18	23	36	38
Nouns List B – Typed	81	11	19	73	76
Verbs List B – Typed	50	2	6	36	45
*CLQT****	4	2.2 (mod.)	2.6 (mild)	3.4 (mild)	3.2 (mild)

* Western Aphasia Battery – Revised
** An Object & Action Naming Battery
*** Cognitive Linguistic Quick Test

Figures

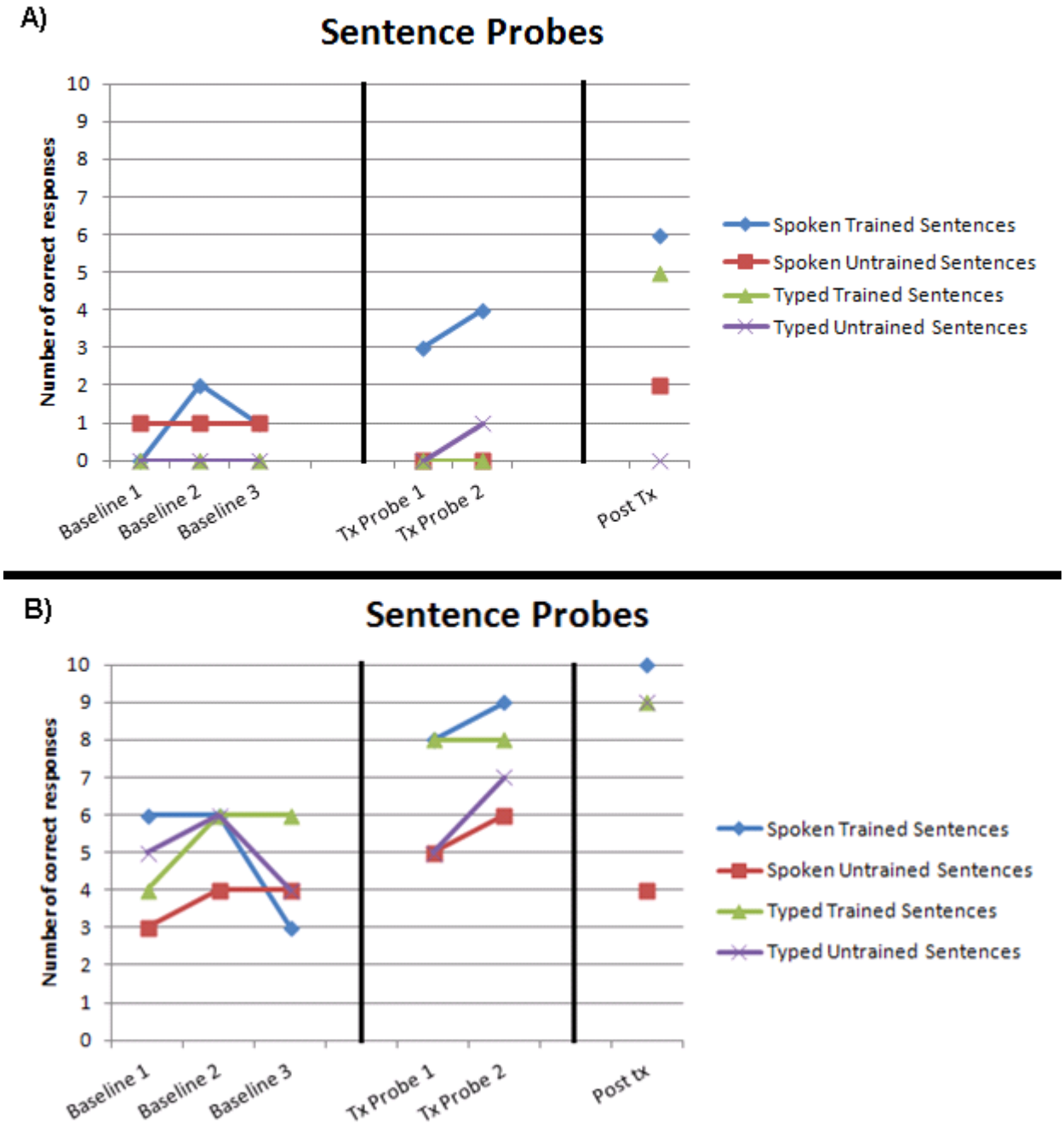

Figure 1. Sentence probe results for A) Participant 1 and B) Participant 2

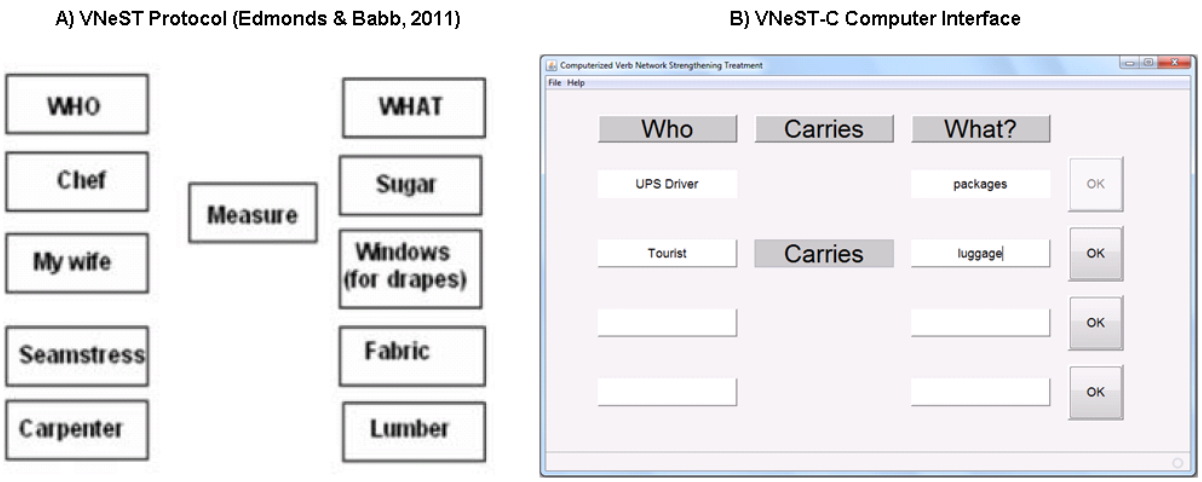

Figure 2. Comparison of step 1 in the treatment protocol from A) Traditional VNeST (cards written on a table) and B) VNeST-C (presented via computer)

References

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