Using Virtual Clinicians to Promote Functional Communication Skills in Aphasia

Persons with aphasia (PWA) re-enter their community after their rehabilitation program is ended. Thus it is incumbent on rehabilitation specialists to incorporate training in using residual language skills for functional communication [1]. Evidence indicates that language abilities improve with continued treatment, even during chronic stages of aphasia (refs) For optimal generalization, PWA need to practice language in everyday living situations.

Virtual reality technology is a method of providing home-based therapeutic interventions. A valuable potential of virtual reality technology is that it supports the successful generalization of residual language skills to functional communication situations. Traditionally, role-playing [2] and script training [3] have been used to improve functional communication in PWA. A more recent approach has been the adaptation of scripts through the implementation of virtual technology. [4].

We report progress on a project that aims to develop a virtual clinician that is capable of recognizing a variety of potential responses in the context of functional communication scenarios. Our goal is to develop a virtual clinician-human interaction system that can be used independently by PWA to practice and improve communication skills. This involves development of software that will support a spoken dialog system (SDS) that can interact autonomously with an individual and can be configured to personalize treatment [5].

As use of virtual technology in aphasia rehabilitation increases, questions about the physical and psychosocial factors that influence successful use of residual communication skills need to be resolved. Thus, a second aim of this project, the topic of this paper, is to determine whether interactive dialogues between a client and virtual clinician differ in the quantity and quality of the client's language output compared to dialogues between client and human clinician. Although the potential of using virtual clinicians is promising, it must be determined if individuals with aphasia (or other language disorder) will be responsive to the virtual clinician and produce as much language in this context as they would during dialogues with human clinicians.

We addressed two hypotheses in this study:

1. For PWA, practice with dialogues that focus on everyday activities will improve quality and quantity of verbal output in those dialogues.
2. For PWA, verbal output practiced in dialogues with a virtual clinician and a human clinician will yield similar amounts of verbal output as measured by information units in the dialogues.

Method.

Participants. Two individuals with aphasia, EH, a 50 year old female with anomia, and CN, a 55 year old male with Broca's aphasia, participated. Both participants were at least 1-year post onset LCVA.

Experimental design. We used a "Wizard of Oz" paradigm. The virtual clinician's verbal productions were driven by the "Wizard"(member of research staff) using text-to-speech software. (Figure 1). Participants were seated in front of a screen on which the virtual clinician was projected, or sat across from a human clinician. In both conditions, responses by the participant were recorded for later analysis.

Dependent variable. The dependent variable was the proportion of information units (IUs) relative to all words spoken by the PWA in the dialogues collected before and after practice (adapted from Nicholas & Brookshire, 1993[6]). Pre-post IUs were obtained for virtual and human clinician conditions.

Materials. Two scripts with pre-set questions by the clinician (human or virtual) were prepared for each of four common situations (e.g., ordering a meal in a restaurant). The scripts in each pair shared the context (e.g., travel agency) but varied the content (e.g., booking trip to Las Vegas vs. Florida). Half of these dialogues were treated and the remaining half were administered only in pre- and post-testing (Figure 2).

Pre-treatment testing. Four dialogues were tested before treatment over two days with one variant of each dialogue (e.g, booking trip to Las Vegas) assigned to the human clinician and the other variant (e.g., trip to Florida) to the virtual clinician. Variants of each dialogue were presented on different days and the order of dialogue with virtual and human clinicians was counter balanced (Figure 2).

Practice Sessions: Over four weeks, each participant practiced two conversations with the virtual clinician and two with the human clinician. Interactions with the human and virtual clinicians were counterbalanced within and across subjects.

In a typical session the virtual or human clinician greeted the participant. Two conversations were practiced twice within a single session with a 10 minute break after the first practice trial. The next day, the remaining two conversations were practiced following the same procedure.

Post-testing: In post-treatment sessions the client participated in the eight dialogues again (four that were practiced; four that were carried out only in pre-testing). Four dialogue-scenarios were conducted in each session, two with the human clinician and two with the virutal clinician (Figure 2).

Results.

Analysis 1. Rates of information units produced in dialogues with virtual vs. human clinician. Fisher Exact Tests were used for all comparisons, with two-tailed tests.

(1) CN: In the pre-test dialogues with the virtual clinician, CN produced .58 information units. With the human clinician, his rate of information units was significantly greater at .80 (p = .0001). In the post-test dialogues, the opposite pattern emerged. His rate of information units with the virtual clinician was .88 and with the human clinician, .75 (p = .0050)

(2) EH: In the pre-test dialogues with the virtual clinician, EH produced .82 information units. With the human clinician, her rate of information units was slightly lower (.77, p = .0804). In the post-test dialogues, her rate of information units with the virtual clinician was .81 and with the human clinician, .78. (p = .2623)

Analysis 2. Rates of information units produced in dialogues before and after practice with dialogues. (1) CN: Virtual Clinician: In the pre-test dialogues, CN produced .58 information units and in the post–test dialogues, he produced .88 information units which significantly greater than the pre-test rates (p = .0001).

Virtual Clinician, rates of pre-test information units (.80) and post-test information units (.75) were not significantly different (p = .4017).

(2) EH: Rates of information units for pre-test and post-test dialogues were not significantly different for interactions with the virtual clinician (.82, .81) or human clinician (.77, .78).

Discussion. These data provide support for our hypothesis that dialogues between persons with aphasia and virtual clinicians yield as much or more verbal output than with human clinicians. CN produced less verbal output with the virtual clinician before practicing the scenarios, but after practice, he produced more with the virtual clinician. Rates of information units in EH's output were similar for virtual and human clinicians. Regarding our second hypothesis, whereas CN's verbal output improved after practice, EH's was about the same before and after practice.

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Figure 1. Sample of set up with participant-virtual clinician dialogues.

Figure 2. Sample protocol for pre- and post-testing and training of dialogues for one participant

Training and Pre- and Post- testing Protocol for one Participant			
Pretreatment			
Day 1	**Human**	**2A (Post)**	**1B (TX)**
	Virtual Clinician	**4B (TX)**	**3A (Post)**
Day 2	**Virtual Clinician**	**1A (post)**	**2B (TX)**
	Human Clinician	**3B (TX)**	**4A (post)**
Treatment			
Day 1	**Human Clinician**	**1B**	**3B**
	10-minute break		
	Human Clinician	**1B**	**3B**
Day 2	**Virtual Clinician**	**2B**	**4B**
10-minute break			
	Virtual Clinician	**2B**	**4B**
Day 3	**Virtual Clinician**	**4B**	**2B**
10-minute break			
	Virtual Clinician	**4B**	**2B**
Day 4	**Human Clinician**	**3B**	**1B**
10-minute break			
	Human Clinician	**3B**	**1B**
Post-Treatment			
Day 1	**Virtual Clinician**	**1A**	**2B**
	Human	**4A**	**3B**
Day 2	**Human**	**1B**	**2A**
	Virtual Cli	**4B**	**3A**

Key to Scenarios for Dialogues	
1A	Restaurant: Capital Grille
1B	Restaurant: Hot Wok
2A	Doctor's visit: Sore Throat
2B	Doctor's visit: Stomach Virus
3A	Travel Agency: Florida
3B	Travel Agency: Vegas
4A	Deli: Surprise party for friend (Deli Counter)
4B	Deli: Planning BBQ (Garden Fresh)