

## Tele-Rehabilitation Therapy vs. Face-to-Face Therapy for Aphasic Patients

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**Abstract**— Though the application of telecommunication technology for rehabilitation of aphasic patients has been proposed as an appropriate mode for the delivery of speech and language services in general and for aphasic patients in particular, systematic research into the delivery of therapy via telerehabilitation (TR) is limited. The present study attempts to fill this gap by comparing the effects of TR to the effects of a conventional face-to-face (FtF) therapy. Eight patients with aphasia participated in a within-subject case study design (ABAC/ACAB). Patients received a 14-session block of TR at their homes via a custom-made Internet server, as well as a 14-session block of conventional FtF treatment in the clinic. Each patient was evaluated four times, before and after each of the two series of therapy. Patients also completed self-reported satisfaction questionnaires regarding the two treatment modes. All participants benefited from therapy, regardless of therapy mode. There was no significant difference in the effect of therapy on most measures in the formal assessment, as well as on the satisfaction measures. When a significant difference was found between the two treatment modes, TR was found to be more beneficial. Our results provide evidence that TR is not only feasible and suitable for the treatment of aphasic patients but that it may also be as effective as FtF therapy. Despite the promising results of the present study, future research is required in order to investigate the effect of TR in populations with more diverse speech and language disorders.

**Keywords**-Tele-rehabilitation; Aphasia therapy

### I. INTRODUCTION

Telerehabilitation (TR) is a branch of telemedicine, in which health services are delivered to patients from a distance through information technology and telecommunication systems. The main motivation for developing telemedicine in general and TR in particular was to offer accessible treatment to individuals who live relatively far from health centers, in geographically remote regions, as well as to individuals with physical disability for whom travel is difficult [9][13]. The earliest reports on treatment of speech and language disorders from a distance appeared in the 1980s. Since then, service delivery has been examined with the use of technologies such as telephone, television, computers, and satellite [1]. In the last decade, technological developments have enabled the use of videoconferences and internet-based features [1][2]. According to a recent review by Mashima and Doarn [9], these developments led to the implementation of tele-services in various areas within the speech language and hearing therapy. For instance, TR was examined as part of treatment of swallowing disorders, voice disorders, stuttering, and speech disorders in individuals with Parkinson's disease, cleft palate, autism, and hearing impairment.

Technologically-based rehabilitation of individuals with brain damage has great potential. Yet, this potential has to be established through careful research. It is important to study

the feasibility and effectiveness of both assessment and treatment from a distance. One of the main questions with which researchers have been concerned is whether assessment of language and speech disorders following brain damage could be as reliable as face-to-face assessment. Brennan et al. [3] and Gerogeadis et al. [4] reported that when using a picture description task, no difference was found between assessment from a distance through computer-based videoconference and conventional FtF assessment.

Further analysis that looked at the effects of background variables of age, gender, education level, and experience with technology on TR and FtF treatments revealed no significant differences between linguistic performances in either environment for TBI patients [3]. In addition, Palsbo [10] administered a more comprehensive assessment of functional communication, using three subtests from the Boston Diagnostic Aphasia Examination [5]. In this study, very high levels of agreement were recorded between stand-alone videoconference and FtF assessment.

Though these results were encouraging, the study did not control for impairment severity and type of communication disorder. In a later study, Hill et al. [6] showed that aphasia severity had little effect on assessment accuracy for the majority of tests.

The feasibility and reliability of technologically governed assessment from a distance are very important for planning and monitoring speech and language therapy programs. However, it is not enough to examine assessment if treatment is to be evaluated. There is some evidence regarding TR for people who suffer from voice disorders [8] as well as for people suffering from speech disorders in Parkinson's disease [12]. These studies used both objective measures and self-report to examine the efficacy of treatment. They documented no difference in outcome measures between patients treated via TR technology and those treated through conventional therapy.

Nonetheless, it is unclear whether the results of treatment to one population can be generalized to treatment of another population, especially when aphasia patients are concerned. If the goal is to develop and implement a TR protocol to aphasia patients, it is important to show that the mode of therapy delivery is not only feasible but that it is as effective

as the traditional FtF therapy. Such research might promote the use of TR as the treatment of choice, and might help in allocating insurance funding to this line of treatment.

Thus, the present study aims at establishing the feasibility and effectiveness of TR to patients with aphasia. The study compares the outcome of speech and language therapy provided through both TR and FtF modes. The two treatment modes will be compared through both objective measures, mainly the change in scores in formal tests, and subjective measures that included self reported satisfaction. Our main question was whether TR via the Internet could be as efficient as is conventional FtF therapy.

The remainder of the paper is structured as follows: Section II describes the research method. Section III introduces the results of the comparisons between the two modes of therapy. First, we present scores on the objective assessment battery and then we present scores on the satisfaction questionnaires. Finally, Section IV presents the main conclusions of the study.

II. METHOD

**Participants:** Eight native Hebrew speaking individuals with aphasia participated in the study. Table 1 presents background characteristics of these patients. All participants were right handed with at least 11 years of education, between age 46 and age 72. They all suffered a single left cerebrovascular accident (CVA), most of them in the distribution of the middle cerebral artery. Lesions were confirmed by CT or MRI scans. Participants were 4-50 months post CVA. They all passed an audiometric hearing screening test that demonstrated normal hearing levels (< 35db HL 500-4000Hz).

The diagnosis of aphasia was determined on the basis of the Hebrew version of the Western Aphasia Battery [7][11]. Five participants were diagnosed with Anomic Aphasia, two participants were diagnosed with Conduction Aphasia and one was diagnosed with Broca's Aphasia. The WAB Aphasia Quotient at study entry ranged between 12.6 and 91, with a mean of 68.5 (SD = 24.14).

**Study design:** The study used a within-subject case study design (ABAC/ACAB). All eight participants received two types of treatment (TR and FtF). Each type of treatment included 14 therapy sessions that took place twice to three

TABLE I. BACKGROUND CHARACTERISTICS OF STUDY PARTICIPANTS

	P1	P2	P3	P4	P5	P6	P7	P8	
Age (years)	63	70	46	64	71	72	68	54	
Gender	M	M	F	M	M	M	M	M	
Handedness	Right	Right	Right	Right	Right	Right	Right	Right	
Education	17	12	11	15	15	15	12	16	
MPO	50	30	30	21	32	12	4	28	
Lesion location	Left MCA	Left MCA	Left MCA	Left MCA	Left ganglia	Basal	Left MCA	Left parietal	Left Basal ganglia
AQ	12.6	72	73	91	76.6	87	66	69.8	
Aphasia type	Broca's	Anomic	Conduction	Anomic	Anomic	Anomic	Conduction	Anomic	

Note. P=participant; F=female; M=male; MPO=months post onset; MCA=middle cerebral artery; AQ=aphasia quotient

times a week. There was a six-week recess in between the two types of treatments to minimize the effect that the first treatment could have on the results of the next treatment. Four participants received TR first and then FtF (hereafter Group 1) and the other four participants received FtF first and then TR (hereafter Group 2). Each patient was evaluated four times, before and after each of the two series of therapy sessions (that is, before and after TR, before and after FtF).

**Assessment:** An independent clinician who did not provide therapy to a given patient evaluated him or her. The assessment was conducted in two sessions and included the Hebrew version of the Western Aphasia Battery [7][11], commonly used to diagnose aphasic syndrome and severity. For each patient a measure of Aphasia Quotient (AQ) was calculated as a summary of scores of the oral language subtests of the WAB: spontaneous speech (content and fluency), auditory comprehension, repetition, and naming. AQ scores can range from 0 up to 100, with 100 representing intact abilities.

In addition, an assessment of the participant's satisfaction with the therapy process was conducted at the end of each session series, using structured questionnaires designed for each type of treatment. Both questionnaires consisted of 13 identical questions. Following the TR session series, the questionnaire contained the same 13 questions plus five additional questions that focused on technical aspects. The questionnaires included both positive and negative statements about the treatment. Each patient was asked to specify his/her level of agreement with each statement, on a 1-4 scale. For example, the patients were asked to state their level of agreement with statements such as: "Using a computer for treatment is easy", "The treatment was stressful", "I was happy with the interaction I had with the clinician during the treatment".

In addition, six weeks following the completion of the second treatment series, each patient was requested to fill a questionnaire that contained 17 statements. The patient was asked to indicate for each statement which mode of treatment s/he would prefer. Responses could be TR, FtF, both or neither. The patient was encouraged to explain his/her decision. For example, the patient heard statements such as "I understood the clinician better", "I made greater progress". After each statement the patient was asked to choose TR or FtF, or to say "both" if s/he thought that both treatments were equally good or "neither" if no treatment could be selected.

**Treatment:** At the beginning of the treatment session series each person was presented with a set of pictures and was requested to name them. A different set of pictures was used in each treatment program. Following this initial naming test, a set of 20 pictures that the patient failed to name was defined separately for every person. This set was then divided into two subsets of ten pictures – one set was used for training and the other set was used to assess generalization following all therapy sessions. Each treatment session lasted 45 minutes. The session began with a short spontaneous conversation, followed by a diagnostic naming test of the ten words. The next twenty minutes were dedicated to improving naming of these 10 pictures. In the remaining time, several other language tasks were chosen

and tailored by the SLP to fit the patient's individual needs and personal goals. The same structure applied in both the TR and the FtF protocols. During the period of the study none of the participants received any other treatment for aphasia.

**System:** A custom-made web application that provides videoconference along with a shared whiteboard was used for the TR. This system contains more than 50 various language-related tasks, such as naming, semantic relations, hearing comprehension, reading and so on.

### III. RESULTS

This section first presents scores on the aphasia assessment and then scores on the satisfaction questionnaire

#### A. Aphasia assessment

For each patient, we calculated the difference between score before and after each treatment in AQ as well as in each of the four subsets scores of the WAB. Differences were then averaged across participants, separately for the TR mode and FtF mode. Figure 1 presents the percent of improvement following treatment in both AQ and in the four WAB sub-scores.

As can be seen in Figure 1, there was improvement in all skills in both modes of treatment. A paired t-test that examined improvement in both modes of treatment showed no significant differences on any of the assessment subsets (speech, auditory comprehension, repetition, naming). The difference between improvement in AQ following TR and following FtF was significant ( $t_{(DF=7)} = 2.606$ ,  $p = 0.035$ ) (see also Table 2). It should be noted that the AQ score is combined of the other four sub-scores, and thus, the difference in AQ was stronger than the differences in each subtest.

In order to further estimate the effect of treatment mode (TR vs. FtF) and treatment order (1st vs. 2nd), we used linear regression model for panel data, with person as a subject (panel) and period and treatment mode as factors (covariates).

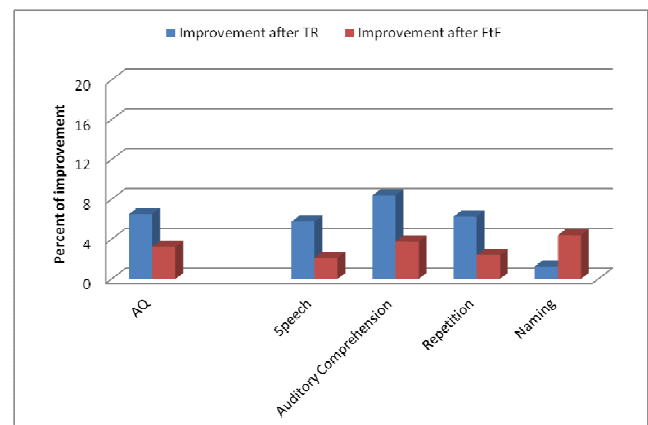


Figure 1. Improvement in language skills, by treatment mode

TABLE II. MEAN IMPROVEMENT (AND SD) ON ASSESSMENT SCORES BY MODE OF TREATMENT, AND PERIOD

Scale	Paired t-test				Regression	
	Effect of TR Mean (SD)	Effect of FtF Mean (SD)	t* (df=7)	p-value	Period effect (SD, p-value)	Mode effect (SD, p-value)
AQ	6.51 (2.82)	3.21 (2.59)	2.6	0.04	-1.67 (SD=1.02, p=0.1)	3.3 (SD=1.02, p=0.001)
Speech	0.25 (2.49)	0.87 (1.24)	-0.72	0.49	-1.37 (SD=0.75, p=0.03)	-0.62 (SD=0.75, p=0.33)
Auditory comprehension	0.62 (0.73)	0.29 (0.83)	0.96	0.36	-0.45 (SD=0.35, p=0.19)	0.39 (SD=0.35, p=0.26)
Repetition	8.37 (10.42)	3.75 (13.08)	1.55	0.16	0.87 (SD=2.78, p=0.75)	4.62 (SD=2.78, p=0.096)
Naming	0.57 (0.63)	0.21 (0.69)	0.9	0.39	-0.24 (SD=0.30, p=0.43)	0.36 (SD=0.30, p=0.23)

\* t-test compared improvement in TR to improvement in FtF. Df = degrees of freedom

Table 2 presents the regression analyses (effect and SD of mode and period and the p-value). As can be seen in Table 2 there was no effect of treatment order for most of the sub-scores, except for the Speech subtest which had significant order effect (that is, there was greater improvement after the first treatment than after the second one). The regression showed significant effect of treatment mode for the AQ score only, as did the t-test analysis.

In sum, TR led to a greater improvement in AQ than did FtF therapy. Improvement in scores on the Speech subtest were higher following the first treatment session series than following the second session series, regardless of treatment mode.

Next, we examined whether the order of treatment affected the carry over between the two treatments. A paired t-test analysis compared the total change in AQ scores between the two groups. That is, we computed the difference (delta) in AQ scores between the 4<sup>th</sup> and the 1<sup>st</sup> assessments for each group separately (Group 1: TR then FtF; Group 2: FtF and then TR) and then compared those deltas. This test is based on an assumption of no interaction between period and treatment mode. Any possible interactions were examined through an analysis of variance (ANOVA) with period and mode as factors, which resulted in these p-values for the AQ score: period p=0.25, mode p=0.034 and interaction period\*mode p=0.97. The t-test analysis showed no significant difference in deltas between groups: Group 1

mean delta=10.2 (SD 3.51) and Group 2 mean delta=7.35 (SD. 6.09),  $t_{(6)} = 0.81$ ,  $p=0.45$ . Therefore, there was no significant difference between the two groups in the carry over effect. That is, in both groups, improvement between testing times was similar and the order of treatment mode had no effect on scores on the aphasia test battery.

*B. Satisfaction questionnaires*

In this section, we present participants' answers on the satisfaction questionnaire, as provided at the end of each 14-session treatment series (at the end of either the TR or the FtF treatment). We also present the answers that were provided at the end of both treatments regarding the comparison between the two modes, as collected a month and a half after the end of the second treatment.

*1) Satisfaction from each treatment mode separately*

Overall, the participants showed similarly high satisfaction from both treatment modes. They felt that each treatment was as simple to understand, as comfortable, as available, as interesting, and as helpful as the other.

*a) Satisfaction regarding common questions for TR and FtF*

For each of the 13 common questions, we estimated agreement between answers for TR and FtF using Kappa statistics (that is, testing the relation between the observed agreement and the expected agreement according to the given distribution of answers). We analyzed cases of disagreement between satisfaction ratings using exact generalized McNemar statistic. This test analyzes each pair of symmetrical cells and compares the observed distribution with a uniform (50%-50%) distribution. No result was significant (as might be expected because of the small sample size). Table 3 presents the distribution of answers to the satisfaction questionnaire in each treatment mode, as well as the agreement between treatment modes (in percent), Kappa score, and p-value.

As can be seen in Table 3, there was high agreement between ratings of the two treatments, with 5 out of 13 questions receiving the same ratings by all participants (Agreement=100%), and the remaining questions receiving highly similar ratings.

TABLE III. DISTRIBUTION OF ANSWERS TO SATISFACTION QUESTIONNAIRE IN EACH TREATMENT MODE, AGREEMENT BETWEEN TREATMENTS, AND KAPPA SCORES

No.	Question	Mode	Grades (n) **				% Agreement	Kappa (p <sup>^</sup> )
			1	2	3	4		
1	I would recommend this treatment to someone else	TR	0	0	0	8	100%	-
		FtF	0	0	0	8		
2	I felt uncomfortable during treatment	TR	8	0	0	0	100%	-
		FtF	8	0	0	0		
3	The treatment was too complicated	TR	7	0	1	0	37.5%	0.0 (0.5}
		FtF	3	2	3	0		
4	I would like to participate in this treatment again	TR	0	0	0	8	100%	-
		FtF	0	0	0	8		
5	The treatment was interesting	TR	0	0	0	8	87.5%	0.0 (-)
		FtF	0	0	1	7		
6	The treatment was stressful	TR	8	0	0	0	75%	0 (-)
		FtF	6	0	2	0		
7	I was satisfied with the quality of the pictures	TR	0	0	1	7	75%	-0.14 (0.66)
		FtF	0	0	1	7		
8	There was a change in my speech after treatment	TR	0	1	3	4	75%	0.54 (0.03)
		FtF	0	0	3	5		
9	The quality of speech therapy was (choose from options)	TR	0	0	4	4	50%	0.2 (0.16)
		FtF	0	2	1	5		
10	The clinician helped me	TR	0	0	1	7	75%	0.38 (0.08)
		FtF	0	0	3	5		
11	The treatment met my expectations	TR	0	0	7	1	100%	1 (0.002)
		FtF	0	0	7	1		
12	The interaction with the clinician was (choose from options)	TR	0	0	8	0	100%	-
		FtF	0	0	8	0		
13	The availability of treatment was (choose from options)	TR	0	0	0	8	75%	0.0 (-)
		FtF	0	0	1	7		

\*\*1=Not at all / poor, 2=Low / Adequate, 3=Medium / Good, 4=High / Excellent

^ One tailed: Agreement higher than expected

b) Satisfaction regarding TR treatment

Table 4 presents the distribution of answers that participants gave on the five questions that addressed the TR alone.

As can be seen in Table 4, most responses indicated high satisfaction from TR. Participants reported no difficulty in learning how to use the TR system, they felt that the TR system was easy to use, and they were satisfied with the quality of the materials.

2) Comparing satisfaction between treatment modes

Next, we analyzed responses on the satisfaction questionnaire filled a month and a half after the end of second treatment. Figure 2 presents participants' preferences of either on of the treatments or answers that indicated no preference.

TABLE IV. NUMBER OF PARTICIPANTS WHO ENDORSED SPECIFIC ANSWERS ON TR SATISFACTION QUESTIONS

Question	High	Medium	Low	Not at all
Easy to use	4	2	1	1
Learning how to use is effortful	2	1	1	4
Need technical assistance	1	0	3	4
Most people will learn easily	7	1	0	0
	Excellent	Good	Adequate	Poor
Audio quality	5	3	0	0

The overall agreement and asymmetry tests between the two modes showed 68.4% agreement with Kappa=0.193 (p=0.0095) and asymmetry of 29 vs. 14 (p=0.03).

As can be seen in Figure 2, for most statements (93/136) participants had no preference for either treatment (chose "both" or "neither"). For example, for statements such as "There was more frustration in the treatment" all participants chose "neither" or "both", and for statements such as "I will recommend to people in my condition to participate in this kind of treatment", most participants chose "both".

When showing a preference for one treatment over another, FtF was more favorable (29/136) than TR (14/136).

■ FtF ■ TR ■ Both ■ Neither

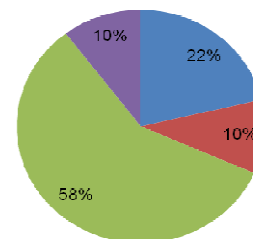


Figure 2. Comparing satisfaction between treatment modes

For example, when asked to rate statements such as "I was satisfied from the interaction with the clinician", and "I advanced more through treatment", more participants chose FtF than TR. When asked to rate a statement such as "I was satisfied with the treatment availability", more participants chose TR than FtF. When examining the content of the statements on which no agreement was found, we saw that most of these statements revolved around the interaction with the clinician. In those statements participants preferred FtF over TR.

In sum, when examining satisfaction levels, participants had no preference of one mode over another, except when asked about the interaction with the clinician, which they rated as more favorable in the FtF mode.

#### IV. CONCLUSION AND FUTURE WORK

The current study sought to explore whether speech and language therapy delivered via telerehabilitation had similar effects as did conventional face-to-face therapy. The effect of therapy was examined by using objective scores obtained from a formal assessment of aphasia, as well as by collecting subjective satisfaction data.

Overall, the results show that the delivery of speech and language therapy via telerehabilitation at home yields at least the same results as similar therapy delivered in the clinic. The results of the present study add to former reports about the reliability of the assessment of speech and language difficulties [4][6][10]. In addition, the results suggest that the technology is not only suitable for assessment but that it is also effective when used for therapy. These results are similar to several earlier reports that found that TR was effective in treating people with voice disorders [8][12]. The novel contribution of the current study is that it shows for the first time the beneficial effects of TR in the treatment of aphasia.

It is important to note that TR resulted in higher general aphasia scores relative to FtF treatment. It could be the case that the technological novelty of the TR added both to the participant's motivation and to the therapist's motivation. As for the subjective report, we found that participants were satisfied from both modes of treatment. However, when asked to choose between the two modes, participants showed a preference toward the FtF mode, mainly in reference to questions that addressed personal contact with the clinician. As in an earlier report [3], participants were generally satisfied with TR with regards to audiovisual quality, and ease of use, yet some individuals may still require help in solving technical problems during TR sessions at home.

Despite of the small sample in the present study, we believe that our results are promising. They add evidence regarding the efficiency of TR and thus make it possible to offer such treatment either alone or in combination with FtF therapy to people suffering from aphasia. TR expands the accessibility of speech and language therapy to this population, overcoming obstacles such as lack of rural services, geographical distance, transportation difficulties, or lack of mobility.

Although the results of the present study are encouraging, future research is still needed to investigate the effect of TR

in diverse populations in terms of the nature and severity of the speech and language disorders.

#### V. ACKNOWLEDGMENTS

The authors acknowledge Dr. Iliia Novikov and Prof. Laurance Freedman from Gertner Institute for Epidemiology and Public Health Policy for the statistical analyses. The authors also acknowledge Yuri Fayans for his assistance in development of the custom-made web application.

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