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In-Person versus Telehealth Assessment of Discourse Ability in Adults with Traumatic Brain Injury

Lyn S. Turkstra, Ph.D.[*], **Maura Quinn-Padron, M.S.**[+], **Jacqueline E. Johnson, M.S.**[*], **Marilyn S. Workinger, Ph.D.**[+], and **Nina Antoniotti, Ph.D.**[+]

[*]Department of Communicative Disorders, University of Wisconsin-Madison

[+]Marshfield Clinic

Abstract

Objectives—To compare in-person (IP) vs. telehealth (TH) assessment of discourse ability in adults with chronic traumatic brain injury (TBI).

Design—Repeated-measures design with random order of conditions.

Participants—Twenty adults with moderate-to-severe TBI.

Method—Participants completed conversation, picture description, story-generation, and procedural description tasks. Sessions were video-recorded and transcribed.

Measures—Measures of productivity and quality of discourse.

Results—Significant differences between conditions were not detected in this sample, and feedback from participants was positive.

Conclusions—These preliminary results support the use of TH for the assessment of discourse ability in adults with TBI, at least for individuals with sufficient cognitive skills to follow TH procedures.

Keywords

brain injury; rehabilitation; telehealth; telerehabilitation; communication; language; assessment

TH refers to the use of telecommunications and information systems for the clinical care of patients, and encompasses a variety of electronic functions that support clinical care at a distance [1]. Over the past decade there has been growing interest in telehealth (TH) applications for individuals with traumatic brain injury (TBI). TH provides a mechanism to reach patients who have limited access to services because of geographical location, poverty, or physical and cognitive impairments [2], characteristics that describe many individuals with TBI. A 2002 survey [3] found that most adults with TBI would accept TH, particularly for cognitive rehabilitation. Respondents also indicated that Internet access reduced their feelings of isolation, thus TH has potential psychosocial benefits as well. TH is an established component of service delivery for veterans with TBI [2, 4], and has been used for many years in civilian TBI settings [5-7].

One area in which TH could be expanded is in the assessment and treatment of individuals with cognitive-communication disorders after TBI. There are many reasons to consider TH

Correspondence to: Lyn S. Turkstra, Ph.D., Department of Communicative Disorders, University of Wisconsin-Madison, 1975 Willow Drive, Madison WI 53706, lsturkstra@wisc.edu, Phone: 608-262-7583.

for this population. First, communication problems are common and chronic among individuals with TBI, particularly in social interactions outside of the structured rehabilitation environment [8-10]. TH has the potential to provide a medium for intervention in the very settings in which communication problems occur – home and community – and at the stage post-injury when these problems are most socially handicapping. Second, both researchers and clinicians have identified a need for practical and effective mechanisms to evaluate and treat communication ability in an everyday-life context [11], and TH could help meet that need. Third, impairments in communication functions have been linked to long-term negative outcomes such as depression [12], social isolation [13], and unemployment [14], so *not* treating individuals in the chronic stage may be costly. Added to this, there is growing evidence supporting the efficacy of treating adults with TBI in the chronic stage post injury (e.g., [15-19]), including treatment via TH [20] and treatment focused on remediation of communication disorders [21-23]. Fourth, TBI disproportionately affects individuals from traditionally underserved populations [24], including those in rural settings, who are likely to have limited access to speech-language pathology specialists in TBI and could benefit from TH. Last, there is a national shortage of speech-language pathologists in healthcare [25], and shortages are expected to increase by more than 10% over the next five years [26], creating a need to develop innovative and efficient service delivery methods.

When considering TH applications in place of IP service delivery, it is important to compare results using these two media. As stated in the report of the Ad Hoc Committee on Telepractice in Speech-Language Pathology of the American Speech-Language-Hearing Association (ASHA) [27], “the quality of services delivered via telepractice must be consistent with the quality of services delivered face-to-face [IP]” (p. 1). A few studies have compared TH vs. IP services for the purpose of diagnoses related to cognitive function, and although these studies have been criticized for methodological limitations [28], in general the results have shown good agreement between media. This includes studies of standardized testing in populations with similar cognitive profiles to TBI, such as assessment of adults with dementia [29, 30]. The findings, however, might not generalize to assessment of conversations in adults with TBI. Previous research in TeleMental Health has shown that some adults are more comfortable communicating over video and at a distance than when physically present in the same space. Patients with TBI, however, often have impairments in reading social cues [31, 32] and might need visual information such as interpersonal space and depth perception cues, which a computer screen might not be able to provide. Video-based interactions are becoming more common, however, and might not be unnatural to participants, and the significant practical advantages of remote assessment might outweigh the costs to naturalness.

Technical factors also might play a role: poor video image resolution might decrease the ability to detect subtle affective or behavior changes in one’s conversation partner, turn-taking could be altered by signal transmission lags, and the need to restrict movement so that the person stays within the video frame might make individuals with communication disorders more conscious of their nonverbal behavior and therefore less fluent. Conversely, the patient might be more focused and relaxed communicating over video than in person, so the TH interface might not capture difficulties that present themselves when a patient with a communication disorder is physically present with a clinician. Thus, communication problems might be over- or underestimated in a TH assessment and treatment environment. Perhaps most important, the patient might have cognitive, sensory, or physical impairments, such insufficient visual acuity to see test stimuli or dysarthria that necessitates assistance with a communication device. These could be addressed in IP interactions but would preclude the use of computer-mediated communication [33]. These considerations illustrate the importance of evaluating the equivalence of IP versus TH for the assessment of cognitive-communication functions.

The notion of TH for cognitive-communication disorders is not new. In a review of TH in speech-language pathology, Mashima and Doarn [1] identified 40 articles on TH applications, from swallowing and speech to aphasia and TBI rehabilitation. Most were case studies, program descriptions, or policy statements, but two experimental studies are directly relevant to the present study. In the first, Brennan and colleagues [5, 6] compared IP versus TH performance on a story-retelling task, in adults with TBI, left-hemisphere stroke, or right-hemisphere stroke, all of whom were less than one year post-onset. Results showed no significant effects of IP versus TH on the content of retold stories. Exit interview results, however, were somewhat unexpected. The TBI group was significantly younger than the other two groups, and therefore might be expected to be more comfortable with TH technology, but this younger group was least likely to prefer TH to IP care as a medium for future interactions. Comments from participants with TBI also were relevant to concerns noted earlier about the effects of social information processing and attention problems in this group: “you can’t really see expressions over telerehab”, “in face-to-face…I was listening closely to you and I wasn’t distracted”, and “It was really easy just to look away from the computer and not pay attention” ([5], p. 651). Thus, the overall lack of a significant difference between IP and TH in this study did not necessarily apply to the subgroup with TBI.

In the second study, Duffy et al. [7] summarized the Mayo Clinic experience with TH for patients with speech, language, or voice disorders, including the use discourse tasks such as those in the present study. Four patients were described as having a “cognitive-communication impairment”, but specific information about etiology was not available. Results showed that TH methods were accepted by patients in both contexts and diagnostic error rates appeared to be similar. Relevant to the present study, however, the authors noted that “some patients with language or cognitive problems may have difficulty grasping the nature of the interactive process over television monitors…[which] may be overcome with explicit efforts to orient such patients” (p. 1121). This raises questions about the feasibility of TH for patients with TBI, at least those with more severe cognitive impairments.

In summary, TH offers the opportunity to expand services to individuals with cognitive-communication disorders, and has generally received positive reviews by recipients of speech-language pathology services [1]. There is, however, a lack of data comparing IP versus TH service delivery, particularly for assessment of individuals with cognitive-communication disorders [1]. This study was a first step in addressing this gap by comparing TH and IP assessment of discourse functions in adults with TBI. The study questions were:

1. Do participants talk as much in a TH environment as they do in person? If patients are uncomfortable and talk less, they might produce insufficient samples for discourse analysis.
2. Are participants less fluent in a TH environment, i.e., have more repeated or abandoned utterances and use less diverse vocabulary? This could occur if participants were less comfortable talking via video than in person. Verbal fluency is a common measure of discourse, and a TH effect could lead to over-diagnosis of communication problems.
3. Does the clinician talk more or less using TH compared to IP? There were no a priori reasons to expect that the clinician would speak more in one condition or the other, but analysis of discourse requires a sufficient sample from participants, and if the clinician dominated the conversation it would reduce the sample available for analysis.

Methods

Participants

Participants were 13 male and 7 female Caucasian adults from the American Midwest, ages 21-69 years, and all in the chronic stage post-TBI (1.4-29 years). Inclusion criteria were age 18 years or older; adequate hearing to complete the study tasks in both the IP and TH conditions, by self-report; no history of pre-morbid medical or neurological disease affecting the communication function, or language or learning disability, verified through medical records; English as a primary language, by self-report; moderate or severe TBI, determined using a combination of the lowest non-paralyzed Glasgow Coma Scale (GCS; [34]) score in the ambulance or the hospital of first admission, the number of minutes or days of loss or disruption of consciousness, whether the patient had neurosurgical intervention, and the presence or absence of parenchymal lesions on neuroimaging; Rancho Los Amigos Level of Cognitive Functioning [35] Level VI (Confused, Appropriate: Moderate Assistance) or higher, to ensure that level of cognitive function was adequate to participate in a conversation; injured at least 6 months prior to enrollment in the study; and oral communication skills sufficient for a conversation, as determined by medical records review by the rehabilitation center staff. Fifteen participants had a severe TBI; three had a moderate TBI; and two had complicated mild TBI with parenchymal lesions, and thus met the criteria for moderate.

The first 14 participants were recruited by phone from among consecutive discharges within the last seven years from a regional rehabilitation unit, and were tested in the offices of an outpatient clinic. The remaining participants were recruited from among participants in previous studies by the first author and were tested in a dedicated testing space in the laboratory of the first author. Each participant was paid $25 and travel costs were reimbursed. All procedures were approved by the relevant institutional research review boards and met HIPAA guidelines.

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; [36]) was administered as a brief test of cognitive function, based on national guidelines for assessment of adults with cognitive-communication disorders after TBI [11],. This was done to characterize the sample for purposes of generalization and to compare scores between IP and TH administration. The RBANS was administered twice to each participant, once at the end of each condition (i.e., TH and IP), using alternate RBANS forms. Standard total scores were used for data analysis.

Study Tasks

The Mediated Discourse Elicitation Protocol (MDEP) [37]. was used in the current study to elicit natural and varied conversations. The MDEP allows the systematic collection of meaningful interaction data in a clinical setting [37]. The format is based on theories from the communication literature, refined through pilot studies by the investigators. The clinician partner is trained to interact as a peer rather than an “expert”, so the conversation is symmetrical between the two participants. Use of the MDEP yielded naturalistic and reliable data in a preliminary study [37] and thus was chosen for the present study. MDEP tasks were combined with the protocol for AphasiaBank, which is a subarea of TalkBank (http://talkbank.org), an online interdisciplinary research project of Carnegie Mellon University, the University of Pennsylvania, and Stanford University. TalkBank is an international archive of language samples from children and adults, submitted with a standard protocol to permit the combination of samples for large-scale analyses of language features. The AphasiaBank protocol was developed by researchers in aphasia and TBI, including the first author, based on previous research on neurogenic language and cognitive disorders in adults, and clinical experience. The AphasiaBank protocol includes four genres of discourse tasks with two to four stimuli in each: personal event description, story re-telling, picture description, and procedural narrative.

Following the MDEP procedures, the role of the clinician (second author) changed in each task. In the conversation, the clinician acted as an equal partner. In the story-telling task, the clinician acted as a good audience. In the picture description task, the clinician acted as a teacher, making sure the participant talked about everything he or she saw in the picture. In the procedural description task, the clinician acted as a student and recorded information spoken by the participant then read it back to verify content. The second author served as the communication partner for all tasks and administered all tests. The clinician/author was trained using previous MDEP video materials, with observation and feedback by project personnel prior to the start of data collection.

Pilot testing in four typical adults indicated that although all of the AphasiaBank prompts elicited sufficient discourse for analysis, some participants had longer responses for some items than others. To ensure that there was no systematic bias due to stimuli used in any condition, stimulus order was randomized by method (IP or TH) and condition order (IP first or TH first). The final protocol combined the AphasiaBank stimuli with the MDEP clinician training, and was comprised of the following:

1. Ten minutes of extemporaneous conversation between the client and clinician, on topics of mutual interest (e.g., sharing experiences, discussing current events).
2. Narrative discourse elicited using two of the four AphasiaBank story-generating prompts in the first condition (IP versus TH) and the other two in the second.
3. Descriptive discourse elicited using two of the four AphasiaBank pictures in the first condition (IP versus TH) and the other two in the second.
4. Procedural discourse, elicited with two of the four AphasiaBank procedural prompts in the first condition (IP versus TH) and the other two in the second.

Procedures and Equipment

Once participants had signed the consent form and completed a case-history form, they were randomized to either the IP-first or the TH-first method. In each method, participants completed the discourse tasks in the same order. All tasks were completed in a single session.

For the IP method, the participant and clinician were seated at 90 degrees to each other at a regular clinic table. Sessions were recorded with a tripod-mounted digital video camera and remote microphone. For the TH condition, the participant was seated in a testing room and the clinician was in a separate room within the same building. The clinician was seated approximately 18" away from a flat-panel computer monitor on which the participant was a full-screen image, with a camera and microphone either mounted on the monitor (at the regional rehabilitation unit) or embedded in the device (at the laboratory). Details about TH equipment are available as supplemental digital content (see Telehealth Equipment, Supplemental Digital Content 1). Equipment used at the rehabilitation clinic site was standard TH equipment routinely available in similar sites. The clinician partner (MQP) and other study authors detected no difference in quality of video or audio signal or transmission speed between these two settings.

An attendant was present in the participant's room to monitor safety and equipment, in compliance with the rehabilitation clinic protocol for telemedicine. The assistant also assisted the participant with materials (e.g., handing him or her task stimuli, positioning test forms).

Data Analysis

Conversations were transcribed and analyzed using the Codes for the Human Analysis of Transcripts (CHAT) and Computerized Language Analysis (CLAN) software [38]. CHAT was developed for the analysis and interpretation of language samples, and allows analysis of the structural forms of language, pragmatic behaviors, and semantic content. Transcripts were segmented into communication units (c-units), defined as an independent clause and any associated clauses [39]. C-units are roughly equivalent to terminable units (t-units), which are a common measure of language productivity in studies of discourse in TBI (e.g., [40, 41]).

Data were analyzed for quality and quantity of spoken language, using measures that had been validated in previous studies of discourse and conversations in adults with TBI [42]: total number of words, total number of c-units, type-token ratio (a measure of lexical diversity), and number of mazes (revisions and repetitions). The number of words produced by the clinician also was calculated. The two versions of the story, picture, and procedural tasks in each method were combined to generate IP versus TH averages for each task.

The third author completed the analysis of transcripts. Inter-rater reliability was addressed by training prior to task administration and having a trained speech-language pathologist who was blinded to condition re-analyze data for 20 percent of participants. Scores were then compared on a point-to-point basis and percent agreement was calculated.

Statistical Analysis

Preliminary analysis revealed that the total number of words and number of C-units were highly correlated (e.g., .93 on the picture description task), as would be expected given that both are measures of discourse quantity. The number of words was the denominator in the type-token ratio and mazes variables, and thus was not an independent measure. This variable was thought to be more meaningful to clinicians, however, compared to c-units; therefore, the total number of words is reported but was not included in the data analysis.

Statistical analysis addressed the three research questions listed. As the four tasks were expected to generate qualitatively and quantitatively different language samples, each task was analyzed separately. To determine whether participants differed in amount of talking or in fluency between the TH vs. IP conditions for each task, the number of C-units, type-token ratio, number of mazes, and number of clinician words were compared between conditions using paired t-tests. Confidence intervals (95%) were calculated for pair-wise differences on each measure for each task. Data for number of words spoken by participants were not analyzed statistically, as this value was the denominator in C-unit, type-token ratio, and maze data. Possible order effects also were evaluated using paired t-tests. The criterion p-value was Holm adjusted task-wise for multiple comparisons, so the criterion p value was .0125 for each set of analyses. All data were analyzed using STATA© Version 10.1.

For the RBANS, total scores were compared between the two conditions using a t-test. From a clinical perspective, it was of interest whether the participant scored in the same category (i.e., normal vs. impaired) on both versions of the test. This was explored descriptively.

Results

No statistically significant effect of condition order was detected on any task for any measure (i.e., TH first vs. IP first). Thus, data were combined for each condition.

Reliability

Inter-rater reliability for c-unit segmentation was 92%. This was considered adequate based on typical reliability criteria for discourse analysis [42]. Dependent variables were calculated automatically by the CLAN program.

Discourse Measures

Scores for discourse measures are summarized in Table 1. No statistically significant effect of condition was detected on any task for any measure. One difference that approached significance was the number of c-units produced by participants in the conversation task, which was higher in the FTF condition. Examination of the data revealed that this was due to participants who had TH first talking about the novelty of TH in their initial IP conversation, as this was the first task in the IP condition. This was considered an artifact of the experimental procedure (i.e., in an actual clinical setting, patients would be tested in one condition or the other, not both).

RBANS

No statistically significant difference in RBANS scores was detected between the two conditions, $F(3,1) = .09$, $p = .77$. Eight participants scored in the impaired range on one administration of the RBANS and not the other. In six cases differences were small and were scores close to the cutoff of 85 for normal performance (e.g., 82 vs. 86). In two cases differences were large: 77 (FTF) vs. 100 (TH) for one participant, and 81 (TH) vs. 98 (FTF) for another. Descriptive analysis revealed no clear pattern in relation to TH vs. IP administration: of the eight participants with discrepancies, five had higher scores in the FTF condition and three had higher scores in the TH condition. Six of eight had higher scores on the second administration, regardless of condition.

Consumer Comments

While elicitation of participants' opinions of TH vs. FTF was not planned, eight participants offered opinions about the two methods and they are included here as anecdotal data. Of the eight participants who offered comments, four reported no difference between conditions. One of these four said he saw the value in using the web for therapy but would like to meet the therapist IP first, as this interaction would be "more friendly" and "build rapport". A fifth participant preferred the live interaction because the full view of the examiner provided her with useful non-verbal cues. The remaining three preferred the TH condition. One participant said she liked "the space" in TH and did not feel "watched over" as she did in the live condition. She said it was "nice to have a helper for the telehealth condition," but could have done it herself. Another participant said he felt the TH condition allowed him to focus better on the computer screen, versus the IP method where he was distracted by "stuff". He said he could see a problem if TH was used at home, however, because of distractions in the home environment and the need to manage the equipment. He also said could see the benefit of TH time and cost savings, efficiency, and ability to take advantage of resources at a distance. The last participant said he preferred TH because he felt more pressure using the IP method.

The researcher who served as the conversation partner for the study tasks had the following observations:

- Having an assistant to help the participant access the TH setup made the process more comfortable for the clinician and the participant. It also ensured that formal testing followed standard administration procedures, rather than relying on the participant to handle materials in a standard fashion.

- The clinician had to ensure that the assistant was well trained in use of materials, equipment set-up, and troubleshooting. It was necessary to be very clear with instructions to the assistant and participant, recognizing that they were in a “barrier”-type activity so the language had to carry more of the message than nonverbal cues such as pointing to key items, as these cues were limited in the TH environment.
- TH required more advance planning than a typical IP evaluation, primarily because the participant had to have all relevant materials in advance. This might be a challenge in dynamic assessment, where test materials might need to be adapted depending on the client’s response.

Discussion

In this preliminary study of TH assessment in adults with chronic TBI, no statistically significant difference was detected between telehealth and in-person discourse performance on measures of language productivity, variety, or fluency or clinician behavior. There likewise was no statistically significant difference in scores on a cognitive screening test. The study was conducted at two sites, a freestanding clinic and a university research lab. The equipment used in the former was typical for clinical telehealth uses and is likely to be available at most medical settings where telehealth is used. In the university clinic, the equipment was comprised of two laptop computers with free software and hardware that are standard on laptops of that type. Thus, the methods used here would be viable in many clinical settings.

Although between-conditions differences were very small, the small sample size was clearly a limitation and the study must be replicated in a larger sample so that formal tests of equivalence can be completed (see [43] for further discussion of equivalence testing). The results also should be viewed with two caveats. First, the TH environment was simulated by testing participants in an adjacent room rather than in an actual satellite clinic or at home, which was done because of budget, privacy, and IT considerations. While not expected to alter signal transmission quality or the nature of the physical surroundings (e.g., the adjacent clinic room was much like a satellite clinic room), it might have made participants more comfortable than if they were at home or in their local clinic. As one participant commented, however, home also could be more distracting, which might be beneficial in a diagnostic interview because it could reveal problem behaviors that would not occur in a controlled TH environment. In future studies, it would be helpful to examine TH in the conditions in which it ultimately will be delivered, including settings in which an assistant might not be available to help with equipment setup (such as in the home), or settings in which quality of signal transmission might be inferior to that observed here. For example, some facilities currently are delivering services via Skype, which has significant limitations in signal speed, quality, and reliability.

A second caveat was an unintended sample bias: participants who responded to the recruitment letter were those with sufficient cognitive ability to independently consent to participate in the study, which means that individuals with more severe impairments were not included. It may be that this latter group would have difficulty with a TH interface for the reasons noted by Duffy and colleagues [7] in the introduction to this paper: difficulty grasping the notion of video-based interactions. In a study by Bourgeois and colleagues [20], one participant in particular had severe declarative memory and abstract thinking impairments, and needed an initial IP interaction to show her how therapy over the telephone would work. Thus, future studies should consider severity of the cognitive and communication impairment as a factor in candidacy for TH assessment and intervention, and also consider the possible need for a trained assistant to support the patient in accessing TH.

The present study included only Caucasian adults from the Midwest, as these represented patients receiving services at the participating clinic. Future studies should include a variety of racial and ethnic groups, the latter because ethnicity might influence patient acceptance of TH as a medium for service delivery. Although the sample was homogeneous with respect to race, participants came from a variety of socioeconomic, educational, and employment backgrounds, with pre-injury occupations that included college students, manual laborers, and semi-skilled workers. Given the range in age, it also is likely that participants varied in their familiarity with computers and video conferencing in particular. These did not appear to affect performance, given the similarities between the two conditions. Overall, however, the sample characteristics and small sample size must be considered when generalizing these results to other groups.

Recommendations

TH can provide benefits at all levels of outcome in the ICF framework [44], from improving performance on therapy tasks by providing the opportunity for more intensive practice, to improving confidence and self esteem [45]. Electronic media are now ubiquitous in personal communication, and with advances in technology the use of TH will continue to grow. Over time, with the aging of the "digital immigrant" generation (i.e., adults who did not grow up with digital technology) [46], TH is likely to become a staple of clinical service delivery for individuals with acquired language and cognitive disorders.

The opportunity to provide more intensive intervention via TH is particularly relevant given the growing body of literature supporting the efficacy of high-dose rehabilitation in the chronic stage after neurological injury [18, 47]. In addition, evidence to date clearly shows benefits of treatment in the context where the target behavior will be used, particularly for patients with declarative memory impairments who rely on procedural learning [17]. The combination of high-dose therapy and systematic instruction in the target context can provide a powerful and effective tool for cognitive rehabilitation.

A key consideration in TH for cognitive-communication disorders is identifying patients who can manage the logistical aspects of TH and would benefit from this mode of service delivery. Participants in the current study met the eligibility criteria identified by Mashima and Doarn [1], indicating that they were physically and cognitively capable of participating in the TH activities (with the assistance of an aide) and that they were computer literate. As also required by Mashima and Dorn, the study provided access to appropriate computer resources, including not only equipment but also high-speed, secure, digital signal transmission. The report of the ASHA Ad Hoc Committee on Telepractice in Speech-Language Pathology [48] identified additional factors that should be considered when implementing TH for cognitive-communication disorders. First, the role of facilitators must be clear. In the present study, aides were used to assist with equipment and test stimuli. These individuals had received training in patient management and were given explicit instructions about the study protocol, and their role was clearly defined. This is a critical consideration in assessment, particularly if family members serve as assistants and might wish to "help" the patient respond. For example, although it was not statistically significant the clinician spoke more in the TH condition for the picture-description task than she did in the IP condition. This was the only task in which the clinician and participant were required to jointly attend to a visual stimulus that the clinician could not see easily. Examination of transcripts revealed that the clinician made statements such as, "Okay look at the next picture please", which might not have been necessary if the family member was trained to present the stimuli.

Second, stakeholders must be willing to support TH. This includes not only healthcare administration personnel but also IT support personnel, who were a key factor in the implementation of the present study. Third, some protocols may need to be adapted. For example, some tests cannot be administered if an aide is not available to turn pages or present stimuli. Last, and perhaps most important, are considerations about privacy and confidentiality of health-related information, which may be the most significant barrier to home-based TH. Other challenges include state licensure requirements when services cross state lines and also restrictions on insurance reimbursement [1, 49].

Conclusions

TH has substantial potential benefits for adults with TBI: service delivery can be based on the patient's needs rather than the availability of specialists [4]; service delays can be reduced and amount of service delivery time can be increased; service can be provided over a larger geographic region; and follow-up services can be provided that can substantially improve outcomes [1]. The use of TH can mean delivering care in either the patient's home or at satellite clinics, as was the case in this study. A major potential advantage of TH is the ability to deliver high-intensity, individualized practice in the context in which skills will be used, which is the optimal model for cognitive rehabilitation according to current research evidence. If replication of this study in a larger sample shows that TH does not differ substantively from IP for assessment of cognitive-communication disorders, TH also will provide a mechanism for identifying problems that might need IP treatment. While there are many challenges in TH service delivery for individuals with TBI, the many potential benefits make TH worth pursuing, particularly for civilians and veterans who have limited access to services. In addition to testing equivalence of the two conditions in a larger and more diverse sample, future studies should consider factors such as quality of equipment, the need for and availability of an assistant, injury severity, and familiarity with a digital interface, to aid in the identification of patients for whom telehealth is a feasible and effective method of service delivery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Summary data for discourse tasks. IP = in person; TH = telehealth. Data are means with SDs in parentheses.

	IP (n=20)	TH (n=20)	Differences (95% C.I.)	P-Value*
Conversation				
Number of Words	734.95 (330.48)	612.60 (309.08)	-122.35 (-236.57, -8.13)	
C-Units	69.25 (25.51)	58.70 (23.52)	-10.55 (-19.24, -1.86)	0.08
Type-Token Ratio	0.40 (0.07)	0.43 (0.07)	0.03 (0.00, 0.06)	0.17
Mazes	0.019 (0.015)	0.022 (0.013)	0.004 (-0.001, 0.008)	0.17
Clinician Words	358.25 (124.80)	317.80 (91.76)	-40.45 (-82.17, 1.27)	0.17
Story Generation				
Number of Words	290.13 (132.30)	283.58 (131.61)	-6.55 (-86.00, 72.90)	
C-Units	27.53 (12.30)	25.15 (11.52)	-2.38 (-10.34, 5.59)	1.00
Type-Token Ratio	0.48 (0.09)	0.51 (0.07)	0.02 (-0.03, 0.08)	1.00
Mazes	0.019 (0.016)	0.020 (0.009)	0.001 (-0.004, 0.006)	1.00
Clinician Words	112.33 (40.43)	97.05 (25.75)	-15.28 (-39.70, 9.15)	0.83
Picture Description				
Number of Words	109.30 (41.09)	131.29 (88.18)	20.92 (-7.77, 49.62)	
C-Units	10.13 (4.51)	11.37 (7.88)	1.29 (-0.99, 3.57)	0.79
Type-Token Ratio	0.63 (0.07)	0.60 (0.12)	-0.02 (-0.07, 0.02)	0.79
Mazes	0.01 (0.011)	0.011 (0.008)	0.002 (-0.004, 0.007)	0.79
Clinician Words	39.90 (10.07)	45.11 (17.97)	5.40 (-3.05, 13.84)	0.79
Procedural Description				
Number of Words	218.95 (101.22)	215.30 (111.27)	-3.65 (-52.64, 45.34)	
C-Units	21.98 (9.03)	21.50 (8.72)	-0.48 (-4.73, 3.78)	1.00
Type-Token Ratio	0.51 (0.08)	0.51 (0.10)	0.01 (-0.03, 0.04)	1.00
Mazes	0.01 (0.009)	0.01 (0.008)	-0.001 (-0.004, 0.003)	1.00
Clinician Words	197.60 (56.49)	208.7 (60.00)	11.10 (-23.89, 46.09)	1.00

* Holm adjusted p-values (based on 4 tests within each task condition) from the paired differences T-tests.