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A pilot study of telehealth and face-to-face consultations in diagnostic audiology

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This paper reports quasi-experimental telehealth data, where older adults (n=15) received instructions and carried out otoacoustic emmisions testing in face-to-face and video conditions. Participant-experimenter interaction was video recorded and the time taken in giving instructions and to complete the measurement was calculated. This revealed a trend whereby participants were faster in performing measurements in the video condition. Regression analysis showed that the number of measurement trials that participants made had a significant effect on the time taken to complete a measurement, while the number of probe tips used and the communicative responses of test subjects were not significant factors. These results support the position that telehealth consultations can provide accurate and efficient diagnostic measurements. We discuss this within the framework of media richness theory, which may prove useful in evaluating correspondence between procedure complexity and the applicability of telehealth solutions.

Key words: Telehealth, Video communication, diagnostic audiology, otoacoustic emmissions

Introduction

There are demographic, technological and economic grounds for adopting telehealth solutions for diagnosis, monitoring and rehabilitation within the public healthcare sector. For instance, in Denmark, by the year 2040, it is anticipated that the number of children and also people of an age suitable for the workforce will have stagnated, while the population of over 70 year olds will have increased by 84% (Digitaliseringsstyrelsen, 2014). This indicates that there will be an imbalance between the target population requiring assistance and the demographic that are able to provide this. This situation could be expected to place a strain on the resources required to provide adequate medical and allied health services (The Danish Government, Local Government Denmark, & Danish Regions, 2012). Utilizing telehealth applications that can effectively support clinician-patient communication may help in redressing this situation.

Telemedicine is when a patient is examined, monitored or treated remotely, by means of digital media (The Danish Government, Local Government Denmark, & Danish Regions, 2013). Experience with the deployment of telehealth services is limited (O'Keefe 2008), and lacks detailed analysis of success factors that contribute to positive outcomes, benefits and also usability by patients and carers (Celler et al. 2014). While telehealth is currently being used in Denmark, there is potential to improve the penetration rate of telemedical solutions (Digitaliseringsstyrelsen, 2015). Telehealth research projects typically deal with two types of data: (a) administrative and clinical data and non clinical data created as part of the research project, and (b) administrative and clinical data created as part of the normal care provided to patients, including historical data (Nepal et al. 2013), but not video documented interaction. In this paper we present a study where transient-evoked otoacoustic emission (OAE) testing was carried out in face-to-face (FTF) and video communication (VC) conditions, in order to compare the validity and reliability of a diagnostic measurement performed in both. We analyzed video recordings from both conditions with particular consideration given to the time taken to perform the consultation prior to the actual performance of OAE testing.

OAEs are an objective clinical measure that are commonly used in neonatal hearing screening and ototoxicity monitoring (Kemp et al, 1990; Lichtenstein & Stappels, 1996). They are not commonly used to monitor the hearing status of older adults or senior citizens as emission amplitudes decrease with age (Bonfils, 1989). Our rationale for using OAEs in this study was that they are procedurally simple. Performing an OAE measurement is a two-stage process. The first stage involves the selection of a probe tip that will ideally form an acoustic seal with the outer ear. If the selected probe tip is too large a smaller tip must be chosen, and vice versa, until an adequate fit has been found. In the second stage, the quality of the in-situ probe fit must be evaluated in the ear canal with a test stimulus. Our hypothesis was that receiving instructions and performing this measurement over video communication would challenge a group of older adults that included senior citizens, and that they would have difficulties in carrying out OAE measurements in this experimental condition.

Methods

Participants

Fifteen adults (mean age 65, SD 9) who were acquaintances of the first author volunteered to participate in this study. All participants resided in the south of Sjaelland and typically had career backgrounds in personal care, industrial or rural sectors, except for one participant who had been the head of an IT department. This cohort was chosen as we deemed them to be representative of a group of individuals who were in the transition into retirement, and may therefore be potential candidates to utilize telehealth applications.

	Group 1 (n=8)	**Group 2 (n=7)**
Age mean	65	64
Age SD	11	9
Gender	4F/4M	3F/4M
First measurement condition	VC	FTF
Second measurement condition	FTF	VC
Third measurement condition	control	control

Table 1. Specifics of both experimental groups and the sequence in which testing was carried out.

Instrumentation

The diagnostic instruments used in this study were the Madsen Capella[2] OAE system from GN Otometrics. This was connected to the computer that was also used in the VC condition to present and relay video (see figure 1). The video connection was to another computer controlled by the experimenter. This station also ran a deviceware server connection from RemotEar that was used to control the OAE system while also providing the video communication channel. An external digital video camera was placed to the side of the participants and recorded their interaction with the instruments and the experimenter.

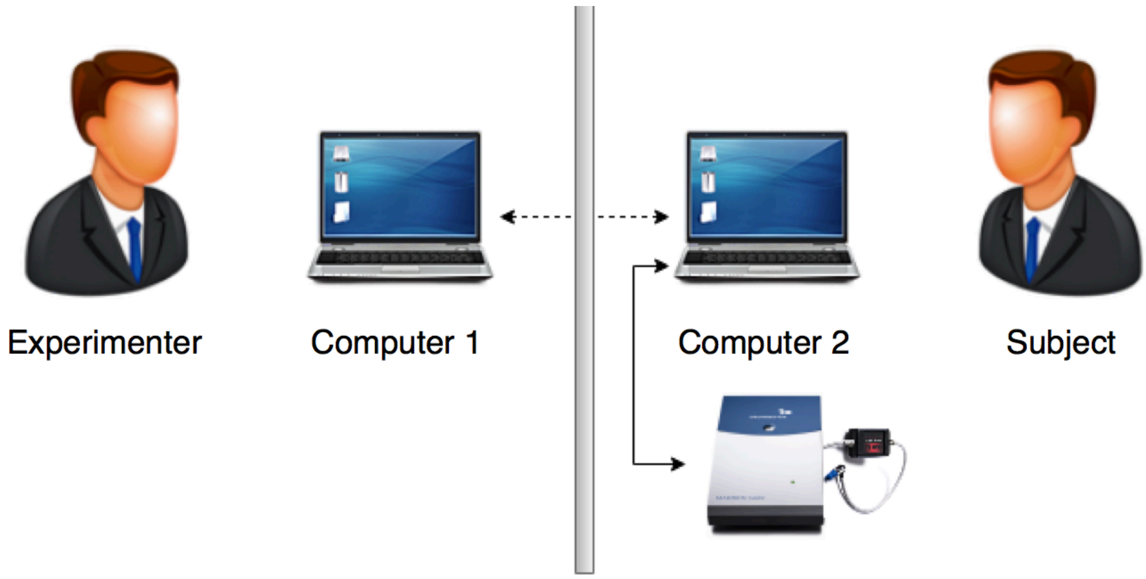

Figure 1. Schematic of the equipment connections used during the VC condition.

Testing was carried out in a domestic living room with noise sources typical of this environment, for example, a clock and a heating unit. Participants were tested individually and were initially only informed that they would be involved in making two ipsilateral measurements a number of times. The groups performed testing in the sequence outlined in table 1. During the VC condition, the experimenter, who assumed the role of a proxy clinician, sat in an adjacent room and the participant was alone in the living room. Sound levels across the video channel were checked and then instructions were given according to the manuscript (see appendix). Tympannometry was also performed in the FTF condition, but this data is not reported in the current paper.

OAE recording

As this study is concerned with the relative differences between VC and FTF communication in a clinical setting, the OAE results were not analyzed. Instead, the time taken to complete the measurement including instruction time was our primary dependent variable. We deemed an OAE measurement to be complete when 512 transient-evoked OAE sweeps were recorded, at which time the instrument was programmed to automatically terminate testing. This takes approximately 30 seconds in noise-free recording situations. Accurate measurement of transient-evoked OAEs require that the ear canal is acoustically sealed in a way so that stimuli do not reverberate. The acoustic response of the stimuli is evident when plotted in the time domain and is commonly called the 'probe fit'. We used the chirp stimuli as implemented in the Madsen Capella[2] device, and stored probe fittings from each participant.

The probe fit has a bearing on the quality of the measurement, and is therefore a precondition for recording. The left panel of figure 2 shows an ideal probe fit, which yielded a measurement that was made in 27 seconds with 45 rejected sweeps. It can be seen from the probe fit that there is little reverberation in the ear canal, and the response falls within the grey area designated as the 'acceptable range'. The right panel of figure 2 shows a probe fit that is sub-optimal and indicates reverberation in the ear canal which is outside the acceptable range. The measurement made subsequent to this probe fit took more than 3 minutes in which time 3754 sweeps were rejected.

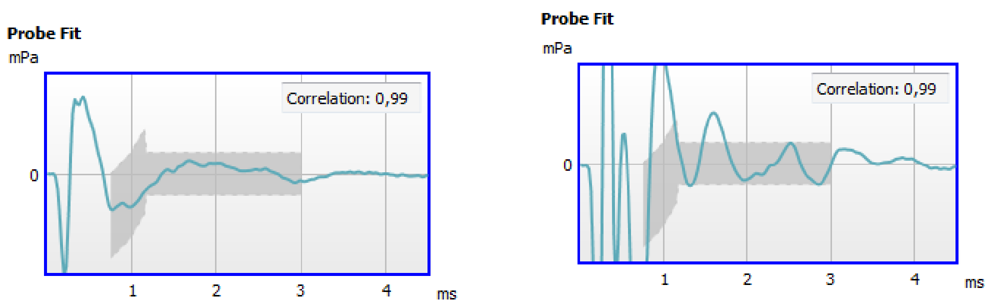

Figure 2. Examples of good (left panel) and poor (right panel) probe fits.

Results

Twelve OAE measurements were completed in the FTF condition and 11 in the VC condition. We examined video recordings from both conditions and annotated the time at which instruction giving started, and when measurements were started, manually stopped or automatically terminated. The mean overall test session times were 197 secs (SD 96) for the FTF and 147 secs (SD 84) for the VC conditions. From the time series data, we calculated the measurement times, that is, time segments where OAE acoustic stimulation was being presented, and which may have varied with other factors like the ambient noise in the test environment. Measurement time segments were subtracted from the individual overall session times to yield time segments during which experimenter-participant interaction took place and these are given in table 2. Pairwise comparison of the times in each condition showed a significant difference between VC and FTF conditions, $t(19,97)= 2.45$, $p<0.05$.

	mean	SD	Min	Max
OAE FTF	120	54	41	198
OAE VC	72	39	38	157

Table 2. Details of the time per condition for the completed measurements in seconds. The time taken to perform the measurement was removed prior to calculation of these values.

The mean completed measurement times were z-transformed in order to facilitate comparison between conditions (see figure 3). The benefit of using this transform is that it shows a standard score according to the number of participants on a scale where negative values indicate longer times. This showed a tendency whereby 5 out of 12 participants were longer than the median in the FTF condition, while only 2 out of 11 participants were longer than the median in the VC condition.

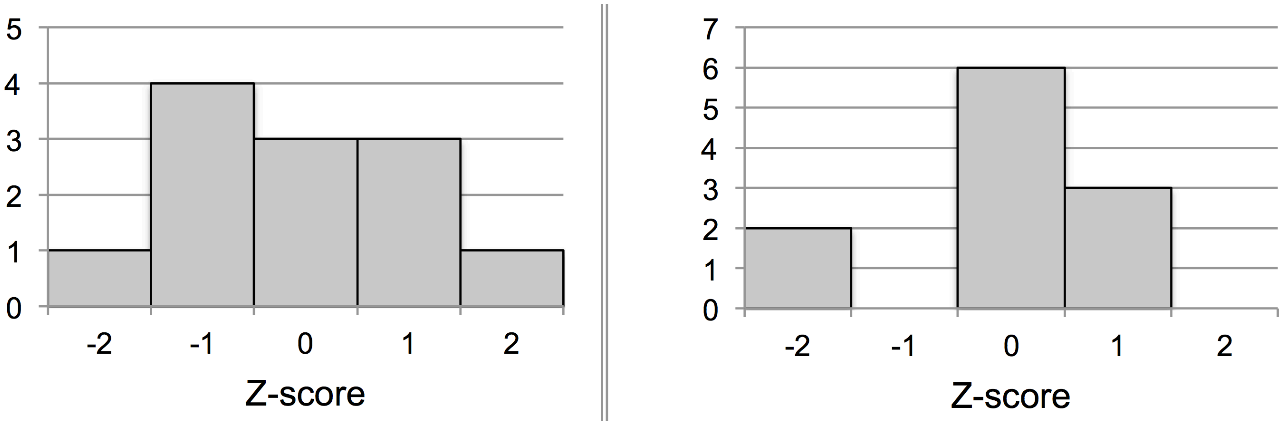

Figure 3. Z-distributions of the test times from the FTF (left panel) and VC (right panel) conditions.

To understand why this tendency was evident, we categorized the communicative responses from all participants into 3 classes: minimal responses, questions and comments. Minimal responses were those that occurred over a short time course, for instance, ‘okay’, ‘mm’ or a nod of the head, and typically were continuers (Schegloff 1982; Boden 1994). Utterances classified as questions were posed by the participant and were treated by the experimenter as such (compare Schegloff 1984). Comments were typically longer utterances that may or may not have had an influence on the clinical direction of the dyad. The classification results across all participants are provided in table 3. It can be seen that more minimal responses were given during the VC condition whereas more questions and comments arose during the FTF condition.

Utterance type	FTF	VC
Minimal response	10	14
Question	13	5
Comment	34	7

Table 3. Classification of utterance type in both conditions.

The video data showed probe tip selection and probe trialing in the ear canal were discrete sequences so we tallied, both the number of probe tips used, and the number of trials attempted in both conditions. Mean values of these were 2 probe tips (range 1-5), and 3 trials (range 1-8) in the FTF condition, and 1 probe tip (range 1-2) and 2 trials (range 1-6) in the VC condition.

The individual times taken to complete the measurement were submitted to hierarchical regression with candidate models which included the variables number of trial, number of probe tips used and number of unsolicited utterances, which were the questions and comments, as shown in table 3. This analysis showed that 61% of the variation in participants' measurement times was due to the variable trial. This indicates that the number of times that participants aborted the measurement, repositioned the probe and commenced a new measurement was the most time-consuming sequence.

Candidate models	r^2	ΔF
Trial	0.61	32.34**
Trial + probe tip	0.61	0.02
Trial + probe tip + unsolicited utterances	0.61	0.12

Table 4. Specifics of the 3 candidate regression models, where the variables probe tip (number of tips used) and unsolicited utterances (number) where added to trial (number of repositioning of the probe and re-commencement of measurement).

Discussion

Our hypothesis, that a group of older adults would face difficulty in performing a diagnostic procedure with video communication, was not borne out. We found that amongst the same cohort, and with the same experimenter in the role of proxy clinician, approximately the same number of participants could complete the measurement in both conditions. We also report a trend whereby in the VC condition, participants were faster in completing the measurement and produced fewer unsolicited comments and questions. These tendencies suggest that VC, in the performance of a simple diagnostic task, may facilitate efficiency, as it does not invite unsolicited talk. The regression analysis showed that there was a relationship between the overall test time and the number of trials that a participant took to perform the measurement. This result suggests that if OAEs, or a similar diagnostic procedure, were to be used in monitoring a patients hearing status, the focus of an initial face-to-face consultation could be to introduce and drill a prospective patient in the practicalities of performing the routine that would later be performed over VC. In the case of OAEs this would include selecting the appropriate probe tip and positioning the probe in the ear canal.

In the present study we assumed that a simple diagnostic measure, like OAEs, would only require a limited degree of media richness in order to support performance of the task. Media richness theory states that nuanced interpersonal interaction is best supported with rich media, while lean interaction requires only simple media (Daft, 1986). The media richness required for various healthcare communication settings may be simple for screening procedures and more complex for advanced diagnostic and rehabilitation routines. The results of the present study support the position that the media richness of VC settings is not only sufficient for diagnostic measures, like OAEs, but it also promotes efficiency as seen in the mean overall times and the number of comments made by participants in the VC condition. This is an interesting result since VC encounters are considered less rich, and therefore less effective, than FTF encounters. Further assessment of the suitability of telehealth applications may involve comparative work with more advanced clinical routines that are encountered in hearing healthcare and rehabilitation, like continuous discourse tracking or counseling.

There are methodological limitations to subjecting diagnostic consultations to experimental analysis as we report in this paper. Namely, it was impractical for the experimenter (who was the first author) to be blind to the purpose of this study. Additionally, an analysis of the type reported in this paper, does not explore potential positive attributes that would be a part of FTF interaction. For these reasons, this paper is only an initial foray into experimental telehealth application in hearing rehabilitation. It supports the premise that video communication is suitable and perhaps favorable for routine tasks that do not require high-levels of media richness, a finding which may have implications for the further implementation of video communication in healthcare. Moreover, it shows that video recording of experimental studies of communication can yield useful observations of novel forms of interaction in modern healthcare provision.

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Declaration of Interests

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Appendix – Script used for both conditions

Forklaring

- Jeg vil nu instruere dig at måle emissioner.
- Du skal først gå i gang når jeg beder dig om det.
- Du skal bruge måleapparatet der ligger på bordet.
- På måleapparatet er der en ledning.
- For enden af ledningen sidder en probe.
- Proben sender klik-lyde ind i dit øre.
- Når proben sidder rigtigt i øregangen, starter jeg målingen.
- Målingen tager ca. 30 sekunder
- Du skal sidde stille og ikke tale før målingen er færdig
- (Start probe fit)
- Kig på skærmen. Der er to bokse. I boksen til højre er et mørkegråt felt. Om lidt når du sætter proben i øret, kan du se i det mørkegrå felt om proben sidder rigtigt. Proben sidder rigtigt når den sorte streg er helt indenfor det mørkegrå felt. Instruktion
- Nu skal du trække ledningen om bag nakken, så den hviler på begge dine skuldre.
- Du skal sætte en af de farvede propper fast på proben.
- Prøv at tage den blå prop.
- Tryk den godt fast.
- (Start probe fit)
- Nu skal du sætte proben fast i øregangen, så den bliver siddende når du giver slip

Proben sidder forkert:

- Tag proben ud og sæt den bedre fast.
- Prøv at vælge en ny farvet prop, der passer bedre til dit øre.
- Du kan vælge enten en større eller end mindre prop

Proben sidder rigtigt:

- Målingen er færdig.
- Du må gerne tage proben ud af øret.