RESEARCH

LISTENING EFFORT AND TELEHEALTH IN SPEECH, LANGUAGE AND HEARING SCIENCES: PRELIMINARY FINDINGS ON THE DEVELOPMENT OF THE LISTENING EFFORT SCREENING QUESTIONNAIRE

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SUMMARY

Objective: Remote therapy and rehabilitation procedures have become popular in recent years, but the effects of audio and video streaming quality (AVSQ) and the listening effort (LE) have been neglected. Since increased LE and reduced AVSQ may have a diminishing effect on the use of cognitive resources depending on the communication environment or auditory skills, it is especially important in interventions related to hearing and speech-language disorders. The aim of our study is present the preliminary development process of a simple listening effort screening questionnaire (LESQ) that can support professionals in remote interventions.

Material and Methods: 65 adult individuals with persistent developmental stuttering participated in this study. Participants filled out an 11-point Likert-type scale with 5 items related to LE and 3 items related to AVSQ. Participants attended three remote therapy sessions and filled out the LESQ. Average values obtained from three sessions were used for the analysis. Factor analysis and Cronbach's alpha coefficient analysis were conducted for internal consistency of the inventory and correlation coefficients between LE and AVSQ item averages were calculated for the assessment of construct validity.

Results: As a result of the reliability analysis, the last item in the LE subscale was removed from the final LESQ. Cronbach's alpha coefficient for the 7-item LESQ, LE subscale, and AVSQ subscale were 0.87, 0.85, and 0.83, respectively. The factor analysis confirmed a two-factor construct with AVSQ and LE which explain 66.5% of the total variance. There was a statistically significant correlation between the LE and AVSQ sub-scales (r = 0.57).

Conclusion: LESQ can be used as a screening tool for professionals planning to conduct remote therapies, especially for hearing and speech-language-related programs. Future studies that will include various disorders and therapy outcomes will be conducted.

Keywords: Listening effort, telehealth, remote therapy, speech and language therapy, aural rehabilitation

KONUŞMA, DİL VE İŞİTME BİLİMLERİNDE DİNLEME EFORU VE TELE SAĞLIK: DİNLEME EFORU TARAMA ANKETİNİN GELİŞTİRİLMESİNE İLİŞKİN ÖN BULGULAR

ÖZET

Amaç: Uzaktan terapi ve rehabilitasyon uygulamaları son yıllarda gittikçe popülerleşmekle birlikte ses ve video aktarım kalitesinin (SVAK) ve dinleme eforunun (DE) bu süreçlerdeki etkisi yeterince değerlendirilmemiştir. Artan DE ve azalan SVAK, iletişim ortamına veya işitsel becerilere bağlı olarak bilişsel kaynakların kullanımını azaltıcı bir etkiye sahip olabileceğinden, özellikle işitme ve konuşma-dil bozukluklarına yönelik müdahalelerde önem taşımaktadır. Çalışmamızın amacı, profesyonellere uzaktan müdahalelerde destek olabilecek basit bir dinleme eforu tarama anketinin (DETA) ön geliştirme sürecini sunmaktır.

Gereç ve Yöntemler: Çalışmaya kalıcı gelişimsel kekemeliği olan 65 yetişkin birey katılmıştır. Katılımcılar, DE ile ilgili 5 madde ve SVAK ile ilgili 3 maddeden oluşan ve 11 puanlık Likert tipi bir ölçeği doldurmuştur. Katılımcılar üç uzaktan terapi seansına katılmış ve her bir uygulamadan sonra DETA'yı tekrar doldurmuş ve analiz için bu üç seanstan elde edilen değerlerin ortalaması kullanılmıştır. Envanterin iç tutarlılığı için faktör analizi ve Cronbach alfa katsayısı analizi, yapı geçerliliğini değerlendirmek için ise DE ve SVAK alt ölçek madde ortalamaları arasındaki korelasyon katsayıları hesaplanmıştır.

Bulgular: Güvenilirlik analizi sonucunda DE alt ölçeğindeki son maddenin DETA'dan çıkartılmasına karar verilmiştir. 7 maddelik DETA, DE alt ölçeği ve SVAK alt ölçeği için Cronbach alfa katsayısı sırasıyla 0.87, 0.85 ve 0.83 olarak elde edilmiştir. Faktör analizi, toplam varyansın %66,5'ini açıklayan SVAK ve DE ile iki faktörlü bir yapıyı doğrulamıştır. DE ve SVAK alt ölçekleri arasında istatistiksel olarak anlamlı bir korelasyon elde edilmiştir (r = 0.57).

Sonuç: DETA, özellikle işitme ve konuşma-dil ile ilgili durumlarda uzaktan terapi yapmayı planlayan profesyoneller için bir tarama aracı olarak kullanılabilme açısından umut verici ön bulgular ortaya koymuştur. Gelecekte daha farklı bozuklukları ve müdahale programlarını içerecek daha büyük örneklemli çalışmalar planlanmaktadır.

Anahtar Sözcükler: Dinleme eforu, uzaktan terapi, dil ve konuşma terapisi, işitsel rehabilitasyon

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INTRODUCTION

Developments in telecommunication technologies in the last two decades paved the way for more accessible health services around the globe with the provision of health care remotely. However, real progress occurred during the COVID-19 pandemic and many professionals and healthcare providers were pressured to adopt telehealth solutions very quickly and often under-prepared. Although

there is substantial literature on the challenges and opportunities related to telehealth and ethical considerations, data management, service delivery, measurements systems, etc. (see reviews by Blandford et al.[1], Jaspreet et al.[2], and Mechanic et al.[3]) a critical aspect that so far neglected in the literature is the auditory aspects and listening effort in particular, especially in services that rely heavily on speech and hearing.

Telehealth for Speech & Hearing

The provision of speech, language and hearing therapy/rehabilitation remotely was an interesting topic way before the pandemic as a result of the shortage of speech and language and hearing professionals worldwide and the visual-auditory and perceptual aspects nature of these interventions[4]. Benefits and comparable outcomes with face-to-face therapies have been shown for various conditions including voice disorders[5-7], acquired neurological speech-language disorders[8-10], speech sound disorders[11-13], stuttering[14-16] and aural rehabilitation[17-19]. A common theme in these studies is that remote therapies can provide benefits with improved access to care, cost-effectiveness, and satisfaction that are comparable to face-to-face therapies but also there are technical requirements that should be met. Technical requirements in this context are particularly about the internet speed which affects both the person who receive the therapy[20] and also the professional who made perceptual decisions[21]. Thus, the audio and video streaming quality (AVSQ) should always be checked and controlled for the provision of speech, language, and hearing-related interventions. Unfortunately, although AVSQ is often mentioned in the literature, the effects of reduced AVSQ on the listening effort (LE) are disregarded.

Listening Effort

Listeners must keep their focus to receive and process the auditory input. Processing, however, can degrade if mental resources are not properly managed. Previous research on working memory and cognitive resources led to the conclusion that LE is related to the distribution of cognitive resources among different activities, depending on the difficulty of the task and the available cognitive resources.[22,23]. Pichora-Fuller et al.[24] defined effort as "the deliberate allocation of mental resources to overcome obstacles in goal pursuit when carrying out a task", with LE referring to the auditory task that requires attention in the scope of the current study. Considering the acoustic challenges that are introduced by low AVSQ or competing and/or poor-quality signals stemming from the participants' or professionals' acoustical environment, the LE can increase more in telehealth services. It is well-known that LE is negatively affected by the acoustical environment (e.g., reverberation, poor signal-to-noise ratio)[25-27] and hearing loss both in adults[28] and children[29]. Hence, it can be speculated that a LE can affect telehealth services regarding speech, language, and hearing disorders.

Measuring the LE and AVSQ

An important consideration regarding LE is the measurement method. There are three widely used methods in LE measurements: self-reports (e.g., questionnaires), physiological measures (e.g., pupillometry), and behavioral measures (e.g., dual-task paradigm). Few studies were conducted to check the reliability of these methods compared to each other. Strand et al.[30] compared self-report, behavioral reaction times, behavioral recall, pupillometry, cognitive tasks, and personality tests. Surprisingly, the most sensitive method to different signal-to-noise ratios in speech perception tests was self-report. Moreover, Giuliani et al.[31] compared different LE measurement methods and found that while pupillometry is the most sensitive method the self-report measures are also sensitive to LE. These studies suggested that although there is no "gold standard" to measure the LE, self-report questionnaires can be used reliably to report perceived LE. However, to the authors' knowledge, even though self-report measures of LE are reliable, and LE can affect the quality of telehealth services, no study incorporated self-report measures of LE to remote speech, language, and hearing-related interventions.

Assessment of AVSQ on the other hand is considered minimally before in telehealth research. The Telehealth Usability Questionnaire[32] and Telemedicine Satisfaction Questionnaire[33], the most widely used telemedicine questionnaires, include Likert-type items to rate the voice quality, visual quality, and ease to talk to and hear the clinician.

The Aim of the Study

Considering the impact of increased LE on cognitive capacity and consequently on speech, language, and hearing performance, we believe it would be beneficial to provide professionals with a quick-to-use questionnaire to check the presence of an increased LE in conjunction with AVSQ. Therefore, this study aims to develop a listening effort screening questionnaire (LESQ) that primarily can be used in remote speech, language, and hearing services.

MATERIAL and METHODS

Participants

Participants were selected according to the criterion-dependent sampling method among PDS who responded to the requests in professional e-mail groups and from a university clinic, as well as from self-help groups associated with the National Stuttering Association (NSA) in Turkey. Inclusion criteria for the present study were a) volunteering for participation, b) being literate, c) at least 18 years of age, d) the presence of stuttering confirmed by the participant, and the stuttering severity (%SS) score greater than 2% during oral reading or speaking with the second author of this study who is a licensed speech-language therapist. The study excluded participants who had co-occurring mental, neurological, sensory, or communication impairments, as well as those who had recently received psychiatric care or speech therapy. Additional requirements for inclusion include having access to the internet, a headset, and a microphone, having a working knowledge of computers, and being unable to attend in-person facilities because of academic or professional obligations.

The second author conducted telehealth sessions synchronously over the internet using Adobe Connect (Adobe Inc. CA, USA) software. A high-speed wired connection with a speed of 24 Mbps was used to ensure quick and stable internet access throughout the sessions. The Apple MacBook (Apple, CA, USA) laptop, which has a 1.3 GHz Intel Core i5 processor and 4 GB of 1600 MHz DDR3 memory, was used to conduct the telehealth sessions. JBL Tune 510BT (JBL, CA, USA) wireless on-ear headphones were also employed to improve the participants' voice quality and clarity for the therapist.

The therapy stage consisted of three sessions that employed a self-disclosure approach, which aims to reduce avoidance related to stuttering with supporting the participants in the exploration/identification of feelings, thoughts, and behaviors related to stuttering. Sessions were conducted once a week and each one lasted approximately 45 -60?min. Since the therapy itself and therapy outcomes were not among the main outcomes of this study, readers can find the details on the benefits of the self-disclosure approach to stuttering in the related literature[34-36].

Lokman Hekim University Ethics Committee (No: 2022/11-1; Date: 03/08/2022) approved the study and all participants were informed about and approved the consent form. The research was performed in accordance with the Helsinki declaration.

LESQ Items

Likert-type 11-point (0-10) LESQ items were created in two domains - the AVSQ and the LE. Since the aim was to develop a quick, easy-to-use screening tool, we aimed for simple questions. There were 3 items in the AVSQ sub-scale which are "How was the audio-streaming quality during the therapy?", "How was the video quality during the session?", and "How often did you experience audio/video drop-outs during the session?". 5 items in the LE sub-scale were influenced by LE and cognitive load-related questions in previous questionnaires such as The Speech, Spatial, and Qualities of Hearing Scale[37] and NASA-task load index[38], the definition of LE in the literature and discussions with hearing and speech-language professionals. As a result, the items were "Did it take a lot of effort to understand what your therapist was saying?", "Did you have to concentrate too much when talking to your therapist?", "Were you able to easily ignore other sounds while listening to your therapist?", "Did you make too much of an effort to follow up on the meeting and therapy?", "Consider background noise such as a fan or running water. Can you follow what your therapist is saying?". Responses were Likert type 11-point scale with endpoint anchors of 0 (increased effort - worst streaming quality) to 10 (no effort - best streaming quality), thus bigger values indicated a better listening environment and decreased LE.

Statistics

Descriptive statistics of the survey results and ratings of participants were graphically and quantitatively presented. Likert-style rankings were used for analysis. Cronbach's alpha coefficient was calculated for internal reliability. Then, a principal component analysis (PCA) was conducted on the questionnaire ratings to control factors. Pearson correlation analysis was run between 3 item average for AVSQ and 5 item average for LE sub-scales. All p values were considered significant if less than 0.05.

RESULTS

Sixty-five adults with PDS (age range = 19-32 years; mean age = 28 years; 44 males, 21 females) participated in this study. All participants finished three therapy sessions and filled out the questionnaire after each session. The average values of the three sessions were used for the analysis. The mean, median, standard deviation (SD), and range values for each item were presented in Table 1.

Internal Reliability and Correlation Coefficient

Cronbach's alpha (α) was $\alpha = 0.83$ for the AVSQ subscale, $\alpha = 0.78$ for the LE subscale, and $\alpha = 0.84$ for the total LESQ. Reliability analysis showed an increase both for the LE subscale and total LESQ when the last item in the scale was removed ("Consider background noise such as a fan or running water. Can you follow what your therapist is saying?"). Moreover, inter-item correlations were weakest for the same item, and it has the largest range and SD value. Therefore, we removed the last question from the analysis and obtained $\alpha = 0.85$ and $\alpha = 0.87$ for the LE subscale (4 items) and total LESQ (7 items), respectively.

Pearson's correlation coefficient was statistically significant for 4 items LE subscale and 3 items AVSQ subscale with $r = 0.57$, $p < 0.001$.

Factor Analysis

The suitability of PCA was assessed before analysis. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.80 with individual KMO measures all greater than 0.7, classifications of "middling" to "meritorious" according to Kaiser[39]. Bartlett's test of sphericity was statistically significant ($p < .001$), indicating that the data was likely factorizable.

PCA revealed two components that had eigenvalues greater than one, which explained 57.27% and 16.97% of the total variance, respectively. Visual inspection of the scree plot indicated that two components should be retained.

The two-component solution explained 74.2% of the total variance. A Varimax orthogonal rotation was employed to aid interpretability. The rotated solution exhibited a 'simple structure'[40]. Factor loadings for two factors with Varimax rotation with Kaiser normalization are presented in Table 3. Items with moderate loadings (>.50) for their respective factors are shown in boldface.

The first factor was named "LE" and received the highest loads from 5 items aimed to reflect the subjectively experienced listening effort. The second factor was named "AVSQ", and it received the highest loads from 3 items aimed to reflect the subjective rating of experienced audio-video streaming quality (Table 2).

Table 1. The mean, median, standard deviation, and range values for each item. SD = standard deviation.

	Mean	Median	SD	Range
How was the audio-streaming quality during the therapy?	8.69	9.00	0.99	7 - 10
How was the video quality during the session?	8.63	9.00	1.16	5 - 10
How often did you experience audio/video dropouts during the session?	8.00	8.00	1.64	4 - 10
Did you make too much of an effort to understand what your therapist saying?	9.00	9.00	1.15	5 - 10
Did you have to concentrate too much when talking to your therapist?	8.69	9.00	1.26	4 - 10
Were you able to easily ignore other sounds while listening to your therapist?	8.40	9.00	1.22	4 - 10
Did it take a lot of effort to understand what your therapist was saying?	8.79	9.00	1.15	5 - 10
Consider background noise such as a fan or running water. Can you follow what your therapist is saying?	7.40	8.00	1.89	2 - 10

Table 2. Factor loadings of LESQ items.

Rotated Component Matrix		
	Component	
	LE	AVSQ
AVSQ-1	0.34	**0.82**
AVSQ-2	0.04	**0.91**
AVSQ-3	0.41	**0.78**
LE-1	**0.65**	0.39
LE-2	**0.82**	0.29
LE-3	**0.82**	0.07
LE-4	**0.86**	0.25

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

DISCUSSION

The current study produced positive and encouraging preliminary data for the LESQ's use in the screening of LE and streaming quality in remote speech, language, and hearing-related services. Clearly, further psychometrics with larger participant numbers and different types of therapies / rehabilitative interventions is necessary, but the current study has provided preliminary evidence for the utility of the questionnaire. The results provide evidence that the LESQ features internally consistent items for evaluating LE and AVSQ domains that are relevant to telehealth settings and indicate that the LESQ has promise that justifies further investigation, research, and improvement.

The LESQ showed good internal consistency with Cronbach's alpha values above 0.80 in subscales and total scale points. Although there are various suggestions regarding the acceptable values of alpha, values between 0.80 - 0.95 are considered a good indicator of internal consistency[41]. Good internal consistency indicates that all the items in a questionnaire measure the same concept or construct, and it should be determined before any research is conducted to ensure validity. Although there is a recent questionnaire that aims to assess the LE for cochlear implant recipients that consisted of 21 items[42], the questionnaire is still in development and there is no Cronbach's alpha value reported. The only comparable questionnaire is the widely used Speech, Spatial, and Qualities of Hearing Scale[37] which includes other domains of hearing besides the LE. The qualities subscale includes LE-related items and alpha values reported for the qualities subscale were between 0.85-0.91[43] which indicated that our alpha values were comparable.

Considering the well-known relationship between degraded acoustic stimuli and increased LE[44], the significant correlation coefficient between the LE and AVSQ subscales can be considered a sign of construct validity. Picou et al.[45] state that improved auditory input combined with better working memory capacity, verbal processing speed, and lip-reading ability can reduce the LE. Poor streaming quality degrades acoustical stimuli and visual cues which can support lip-reading. Thus, a combination of poor audio and video streaming quality can easily affect LE negatively.

Although test-retest validity is an important consideration in questionnaire development, the nature of our measurement was not ideal for such an assessment. AVSQ may change even within the same session of web-based services, hence assessment of AVSQ in various sessions is prone to be different from each other.

Our plans include conducting additional research with larger samples to assess how the LESQ performs against other behavioral and physiological measures of LE, such as pupillometry and dual-task measures. Additionally, we will include objective measurements of streaming quality (e.g., internet speed, and ping measurements) to check for the relationship between subjective statements and objective quality measurements. Moreover, our plans include assessing the predictive validity of the LESQ in terms of therapy/rehabilitation success in participants with different diagnoses and needs and professionals from different healthcare services (audiology, psychology).

CONCLUSION

The preliminary data suggested that LESQ is a promising, quick, and easy-to-use scanning tool for the assessment of effortful listening which may impact verbal and aural therapies/services negatively. Professionals should consider including LESQ in their remote - online telehealth services to ensure quality. Future studies will be conducted with larger sample sizes and various patient groups and professionals to provide more detailed psychometrics.

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