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Listening Effort Outcome Measures in Adult Populations

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Abstract

Listening effort is being considered clinically as an important indicator of patient success with amplification. Listening effort refers to “the mental exertion required to attend to, and understand, an auditory message”. (McGarrigle et al., 2014) Cognitive ability, age, and degree of hearing impairment all must considered when measuring the effort one is exerting on a specific task. Listening effort can be measured using subjective tools, electrophysiologic measures, or with a dual-task paradigm. Subjective tools include self-reports and questionnaires. Electrophysiologic measures can consist of measuring pupil dilation, heart rate variability, and skin conductance. A dual-task paradigm is set-up with two tasks performed by a person simultaneously. The amount of decline on the secondary task compared to when that task is completed in isolation, indicates the amount of effort that was exerted on the task. Each method has its strengths as well as its limitations. This paper discusses the current research on the various methods to measuring listening effort and provides clinical applications for these outcome measures.

Introduction

Listening effort is a critical aspect for audiologists to consider when providing services. Hearing impaired individuals report an increased effort is required to fully hear and understand speech in their day-to-day activities. (Johnson et al., 2015) A goal of clinicians is to assist in resolving communicative issues related to hearing impairment. Clinicians performed audiologic evaluations and provide intervention to address the communication and listening challenges faced by many people with hearing impairment. (Johnson et al., 2015) To achieve this, it is important to address an individual's listening effort. Speech understanding is important in evaluating hearing ability, but this does not capture the cognitive resources and processing ability necessary to understand words. (Mackersie & Calderon-Moultrie, 2016) Over 50 years ago, researchers discussed the need for a multi-criterion assessment to evaluate communication ability beyond word recognition testing. (Gosselin & Gagne, 2010) Listening effort refers to "the mental exertion required to attend to, and understand, an auditory message". (McGarrigle et al., 2014) McGarrigle (2014) also explains that effort for listening increases when there is a degraded signal, interference of the signal, and limitations of the listener. This third category would include listeners with hearing impairment. People with hearing loss are likely to utilize more mental resources than people with normal hearing. Listening and understanding speech involved the peripheral auditory system as well as structures in the brain involved with higher level ordering and cognitive processes. (Johnson et al., 2015) The effort a person must exert to listen can be taxing. Audiologists must be aware of the energy spent by their patients with hearing loss when they are trying to hear, listen, and ultimately follow conversations. For this review, we will use the terminology as defined by Pichora-Fuller and Singh (2006) for hearing and listening. Hearing is a passive function that provides access to the auditory world via the perception of sound. Listening is the process of hearing, however it consists of the intention and attention that demand cognitive effort. Listening effort is the attention and cognitive resources required to understand speech and language (Gosselin & Gagne, 2011). It is important to recognize the impact that listening effort can have on a patient. Similar to how each person produces a different audiogram, and each person perceives their hearing difficulties, the amount of energy each person uses to listen successfully varies as well. Understanding the role that listening effort has can help a clinician better meet their hearing-impaired patient's needs.

How is listening effort measured?

Listening effort can be measured subjectively or objectively; in other words, with physiologic responses or the patient's perception of how much effort they are exerting to listen. There are assumptions that are made about each method. It is assumed for subjective measures, that the listening effort will be accurately documented. It is assumed for objective measures that mental exertion during listening is caused by limited available resources and that this exertion will produce poorer outcomes on the secondary task. (McGarrigle et al., 2014) Subjective tests would include questionnaires answered by the person about how much effort they feel they exerted on a certain test or exercise. Objective tests could include a wide range of cognitive tests or listening in noise tests that clinicians can analyze and identify where the participants' weaknesses lay. McGarrigle et al (2014) found that there is weak to no relationship between self-reports and objective dual task measures. They explain further that there are limitations in differentiating the correlation between self-report and difficulty of the task. Seeman and Sims (2015) also discovered that subjective measures were not correlated with listening effort. An example of the difference between performance and perception of a task is present in the study performed by Bologna et al (2013). They utilized irregular rhythm detection as an objective measure. This task consists of detecting an irregular temporal pattern within a repetitive sequence of tones. This study presented the irregular rhythm detection task to one ear and either running speech, steady-state noise, or no signal to the contralateral ear. Participants then filled out the NASA Task Load Index which is a subjective measure. Analysis focused on the Task Difficulty domain and the Performance domain of the questionnaire. Results revealed participants perceived the speech signal to be the most difficult and effortful competing signal while performing the irregular-rhythm detection task. Behavioral thresholds were found to be unaffected by the differing stimuli, meaning that results were not significantly different between each stimulus. The authors indicate perceived listening effort may be associated with suppression of task-irrelevant information.

Subjective Measures of Listening Effort

As previously noted, listening effort can be measured using subjective methods where the feelings or opinions of the participant are analyzed. A common tool used as a subjective measure is a questionnaire. Currently, in the clinic, hearing handicaps are taken into consideration and measured using patient's self-reports. (Gosselin & Gagne, 2010) A person will have the ability to rate their ease of listening with these questionnaires and the clinician will be able to assess whether a treatment or recommendation has been benefitting the patient. McGarrigle et al (2014) discusses the Speech, Spatial, and Qualities (SSQ) hearing scale by Gatehouse and Noble. The SSQ requires patients to rate their perceived communication difficulties in real-world situations. Reportedly, first time hearing aid users indicate decreased listening effort after three months of hearing aid use. (McGarrigle et al., 2014) Hearing impaired subjects give higher ratings of listening effort than their normal hearing counterparts. Self-report measures are a quick, easy-toadminister tool that can provide an insight into how the person perceives their hearing difficulty and listening effort.

According to Gosselin and Gagne (2010), the Acceptable Noise Level Test (ANL) is another form of subjective measurement to assess listening effort. This test is reportedly "one's willingness to tolerate background noise" and is used as a predictor for hearing aid success. (Gosselin & Gagne, 2010) To obtain a patient's ANL, a recorded voice recites a story that is adjusted to the patient's most comfortable listening volume. Background noise is then presented while the patient listens to the story at a comfortable level. The background noise is increased to a level that is the loudest a person can tolerate while still understanding the original story. The ANL is the calculated difference between the loudest, tolerated background noise level and the most comfortable listening level. This is considered a subjective measure as it uses the person's perception of what they can tolerate.

Dual-Task Paradigm

Researchers often utilize an objective method known as a dual-task paradigm which consists of two tasks the participant must partake in at the same time. Dual task paradigms ask participants to perform two tasks separately and then again concurrently. These tasks assume that the cognitive system has a limited amount of resources to use to process information. One task is the primary and the other is the secondary. The tasks are typically presented under three conditions: (a) primary task independently; (b) secondary task independently; and (c) primary task and secondary task simultaneously. Listening effort is then measured as the difference between the secondary task independently and the secondary task when it is presented with the primary task. (Gagne, 2017) The primary task utilizes a certain amount of mental capacity and the secondary task uses up whatever is available after. When discussing listening effort, many studies have an auditory task as the primary and a tactile or cognitive task as the secondary. When the two tasks are performed simultaneously, one of the tasks' results decline. This decline in the secondary task is interpreted as having increased listening effort. (Gosselin & Gagne, 2010) There are researchers who have demonstrated that performing two tasks simultaneously can result in poor results in both tasks, even if one task is prioritized. It is important to assess the accuracy of each task when presenting them simultaneously. (Johnson et al., 2015)

Akeroyd (2008) indicates measures of working memory are more effective than measures of general ability. For instance, performing a reading span assessment will provide the clinician with more information than evaluating their IQ. Gosselin and Gagne (2011) had a primary task involving closed set sentence recognition presented orally, which means it was an auditory only task. The sentences were read at 60 decibels (dB) with speech babble presented in the background at 72 dB. Their secondary task was a tactile task involving vibration patterns that the participant would feel in their hand (Gosselin and Gagne, 2011). This ultimately taxes the entire auditory system and allows for the necessary effort to be measured.

Response times can correspond with processing and suggest that a slower speech processing rate can impede communication and increase listening effort. (McGarrigle et al., 2014) This is an important consideration as everyday spoken language is produced at an increased rate. Houben et al (2013) performed a study which measured participants' response times on a task in varying levels of background noise. The authors indicated that measuring response times of a task taxed the system and allowed for the measuring of listening effort. The identification tasks involved repeating back the final digit in a series of three numbers. The arithmetic task involved calculating the sum of the initial and final digits of the three-digit series. These were presented with varying levels of background noise which affected the signal-to-noise ratios (SNR). The 12 participants had normal hearing. They found when the SNR was worse (the background noise was closer in volume level to the target signal), the subjects' response time was lengthened on each task. Their response time was poorer on the arithmetic task than the identification task. Houben et al (2013) explained that the tasks resemble dual-task methods as they are given a task in addition to speech recognition, but that it differs due to the absence of a simultaneous task.

Johnson et al (2015) created a dual task measure study. This study involved 30 adult participants performing the Revised Speech Perception in Noise Test (R-SPIN) where the participant listened to sentences and repeated the last word of each sentence. Each target word is produced in a high-context and a low-context sentence and a multi-talker babble stimulus is produced simultaneously. Each participant also rated the listening effort required for each sentence. Each outcome measure was sensitive to the change in difficulty to the task. Less words were recalled with high SNRs and lower context sentences. Self-reported scores were also reflective of this change.

Howard et al (2010) measured listening effort as a means to assess the effort required for children to listen in the classroom. Their study was a dual task measure where school-aged children were asked to perform two tasks simultaneously in varying levels of background noise. The background noise used was multi-talker babble. The first task required the participants to repeat monosyllabic words. The second task required them to recite sets of five digits. Results revealed that performance decreased on the secondary task. Performance deteriorated further with decreased SNRs. These SNRs are comparable to the SNRs found the typical classrooms. These findings suggest that there is considerable effort required for children to listen in the classroom setting. This information is applicable to adult populations as well as they are in difficult listening environments in their work setting and their listening demands at work should be considered.

Another form dual task measurement of listening effort was presented by Sin Tung et al (2016). They performed a study using eight normal hearing older adults and eight bilateral hearing aid using older adults. The older adults were asked to listen to competing sentences while crossing a street in a simulator with a treadmill. The participants were asked to repeat the color and number they heard in each target sentence. The older adults in the hearing loss group performed worse on the word recognition task than the normal hearing group, even with their binaural hearing aids on during the test. All subjects performed better when there was an 100% probability the target would be at the expected location rather than 60% probability. There were no differences noted between groups in the kinematic measures. This study allowed the participants to be measured in a more realistic, complex environment.

Physiologic Responses to Task Load

There is also research available consisting of the participants' physiologic responses to different tasks. An increase in cognitive effort can result in neural, endocrine, and immune responses in the body. Changes in the body related to increased cognitive load include arousal of the sympathetic nervous system and decrease in activity of the parasympathetic nervous system. This increase in sympathetic nervous system activity can be assessed by measuring cardiovascular responses, pupil dilation, or electrodermal activity. (Mackersie & Calderon-Moultrie, 2016) Heart rate variability is "the natural fluctuation in interbeat intervals that occurs over time." (Mackersie & Calderon-Moultire, 2016) An increase in task load results in decreased heart rate variability. This method has been utilized for tasks involving memory, attention, and response inhibition. Skin conductance is an electrodermal measure where surface electrodes are attached to the palm or finger and the skin's ability to conduct an electrical current is measured. (McGarrigle et al., 2014) Increased task load results in increased skin conductance. These measures have been utilized with tasks involving arithmetic, memory, and Stroop interference. *S*tudies have suggested that heart rate variability is more sensitive to changes in SNR than skin conductance measures. (Mackersie & Calderon-Moultire, 2016)

Mackersie and Calderon-Moultrie (2016) performed a study to assess the effects of speech rate on heart rate variability and skin conductance where word repetition accuracy was equated for participants. Twenty-six adult subjects were asked to repeat words that were produced at varying rates in the presence of four-talker babble. The SNRs were determined by equating the mean word repetition accuracy for each condition. The authors used 80% accuracy to equate the SNRs. On average, there was a 3dB increase in SNR required for the fast talker to match the performance obtained at the normal rate. The heart rate variability and skin conductance were measured simultaneously. The average scores for the fast and normal rates were not statistically significant. Skin conductance increased and heart rate variability decreased during the word repetition tasks. The faster rate speech results in greater skin conductance than for that of the normal speech rate. Heart rate variability was also greater when the rate was faster than with the normal rate. The author's did control for respiration of the participants. Mackersie and Calderon-Moultrie (2016) concluded that there is evidence supporting the nervous system responded to increased auditory task load, even when performance remains unchanged.

Similarly, Seeman and Sims (2015) utilized heart rate variability and skin conductance in response to listening effort. Their participants were divided into three groups of 15 to 16 normal hearing adults. Each group performed a different task. Three diotic-dichotic tasks were utilized; a diotic single digit, a dichotic single digit, and a dichotic double digit. Speech-in-Noise (SIN) testing was utilized as well with noises presented at 70 dB SPL, 65 dB SPL, 60 dB SPL, and 55 dB SPL. The primary task was the +5 and +15 SNR SIN tasks while heart rate variability was monitored. The secondary task was the visual letter-identification task where the participant was asked to push a button each time a target letter was displayed. The NASA Task Load Index was completed by each participant at the end of every listening condition. They found that heart rate increased with increased complexity of a task as well as poorer signal-to-noise ratios. It was shown to be sensitive to the diotic-dichotic listening tasks and the SNR changes for the SIN tasks. Skin conductance elevated when a task increased complexity, but not when the SNR was poorer. Heart rate variability was not significantly correlated to self-report measures.

McGarrigle et al (2014) discussed the use of pupillometry to measure the body's response to tasks that vary in difficulty. Pupillometry consists of measuring the pupil size in response to changes in the environment or mental task load. McGarrigle et al (2014) reports findings from Zekveld et al (2011) where older and hearing-impaired adults revealed less of a decrease in pupil size between difficult and easy tasks compared to their younger, normal hearing counterpart. This suggests that there is less release from effort in the older and hearing-impaired participants. It has been shown that older adults have smaller absolute pupil size and this could affect results to some degree. Studies must be well controlled to account for differences in absolute pupil size among various populations. (McGarrigle et al., 2014)

Table 1. Listening effort studies published 2010-2016 with various designs.

Study	Design	N	Tasks	Findings
Bologna et. al. 2013	Subjective and ehavioral	20 normal hearing adults	a) Irregular rhythm detection b)NASA task load index	Behavioral thresholds unaffected by contralateral stimulus type; perceived effort was not correlated with behavioral results
Houben et. al. 2013	Dual task	12 normal hearing adults	a) Identify the final digit in a triplet b) Calculate the sum of the initiial and the final digits in a triplet	Increased SNR results in longer response times; response of arithmetic task more effected than the identification task
Howard et. al. 2010	Dual task	31 normal hearing children	a) Repeat monosyllabic words presented in background noise b) Rehearse sets of 5 digits for recall	Performance decreased on secondary task; worse performance when SNRs were more difficult; considerable listening effort is required at SNRs comparable to classroom levels
Johnson et. al. 2015	Dual task	30 normal hearing adults	Speech intelligibility at 4 SNRs by using keywords in high- and low-context sentences	Self report demonstrated greater sensitivity to changes in SNR; self-report method preferred
Mackersie & Calderon-Moultrie 2016	Electrophysiologic	26 normal hearing adults	a) Skin conductance b) Heart rate variability c) Speaking rate	Performance was the same with normal and fast rate speech; HRV was greater with fast rate; skin conductance increased with speech rate
Seeman and Simms 2015	Dual task and electrophysiologic	46 normal hearing adults	a) Heart rate variabilty b) Skin conductance c) Letter indentification task	HRV was greater for increased task difficulty and poorer SNRs; listening effort increased with poorer SNRs; skin conductance was greater for difficult tasks but not for poorer SNRs
Sin Tung et. al. 2016	Dual task	8 older adults with bilateral hearing loss and 8 normal hearing older adults	a) Word recogntion b) Kinematic parameters	Normal hearing had better word rec accuracy; no difference between groups in kinematic measures; both groups performed better when they had 100% probability of where the target was

Applications of Listening Effort Measurements

Clinically, there is rare to no use of dual task measures to assess listening effort. Clinicians typically utilize subjective measures to analyze listening effort. Many of the studies discussed have shown discrepancies between performance and self-reported effort. The information gathered from these studies can assist clinicians in their counseling strategies as well as improve their fitting methods. Studies have shown that hearing aid use is greater in individuals that are less able to compensate themselves for the hearing loss (Pichora-Fuller, 2006). However, if there is a pathology or decline further in the auditory pathway, a hearing aid may not be able to compensate. Although many hearing aid manufacturers are trying to make digital hearing aids that can do the listening for the person as well as amplify the stimuli, it does not exist at this time. People need to be able to process the sound with their brains after it is encoded in the auditory system. According to Gosselin and Gagne (2010), other researchers in the field have utilized dual-task paradigms to assess effectiveness of various noise reduction algorithms in hearing aids. The results of these studies indicated that noise reduction strategies incorporated in hearing aids reduce listening effort and allow the cognitive resources to be used for other tasks. Sarampalis et al (2009) performed a study assessing noise reduction features in hearing aids. They found that the noise reduction features do reduce listening effort and free up cognitive resources for other tasks. Noise reduction features did not influence the speech recognition thresholds of the participants, but they found that they did have a quicker response in visual response times. Kalluri and Humes (2012) suggest more research is needed on long term effects of amplification on older adults and cognition. The authors indicate there is not enough evidence to support that hearing aid use will have a positive effect on cognition.

Younger adults vs. Older adults

Many listening effort studies have shown that there are differences in older and younger adults. A study by Pichora-Fuller and Singh (2006) shows some of the differences seen between younger and older adults. Their study presented voices which are referred to as “speakers”. These speakers were presented through a physical speaker which is referred to as “a box”. At first, each person was presented a monologue from a single speaker in a room. The two age groups were found to have performed similarly. However, when they added two speakers each from a different box in different parts of the room, the older adults had a harder time following along in the conversation. When two different speakers were presented from the same box, the older and younger adults performed equally again. In the same article, Pichora-Fuller and Singh (2006), they measured the speed of processing of older adults versus younger adults and found that in conditions where phonological information was degraded, older adults had difficulty understanding speech whereas the younger adults did not. These conditions were such that every *n*th amplitude was eliminated in the SPIN-R test as well as eliminating every third segment of a speech signal divided into 10msec segments. In both of those conditions, phonological information was disrupted as well as had the frequency shifted. However, when pauses and vowel durations were reduced only, there was no difference in the performance between older and younger adults. This study suggests that older adults cannot process information as well as younger adults when phonological information is distorted. It takes their brain a longer time to understand what is being said. This study proposes that listening effort is greater for older adults. A literature review by Gagne (2017) revealed there was an age effect when older adults with normal hearing were compared to younger normal hearing peers. The studies he reviewed found that older adults expend a greater amount of effort in speech in noise tasks than younger adults. These results were true when the test conditions were the same as well as when performance levels were equated with SNR levels.

Humes (2015) reviewed his previous studies and reports that performance in middle age is significantly better than that of older adults while it is also significantly worse than younger adults. This suggests that throughout the life span, cognitive processing declines. This also proposes that sensory and cognitive declines are gradual across the adult life span and do not emerge suddenly when entering old age.

Audibility

It can also be important to measure the audibility of a person to know whether or not they have a hearing deficit and if so, the amount of an average speech signal that is being heard by that individual. Many older adults have hearing loss in the high frequencies which indicates that the high frequency sounds are inaudible to them. These sounds include speech stimuli such as fricatives and other voiceless consonants. These patients often report other speakers “mumble” or “do not annunciate”. A hearing loss due to aging is referred to as presbycusis. There are two different types of presbycusis, which are often overlooked. There is sensory loss which is damage to the hair cells and neural loss which is damage to the ganglion cells. Hair cells are the sensory receptors located in the cochlea, which are more peripheral. Ganglion cells are located on the spiral ganglion, which are more neural in nature. Neither type of cell damage can be repaired; however, having a sensory versus neural loss can affect their available cognitive resources. There are also central losses that occur further into the central auditory system which can affect additional cognitive abilities. These differences in location need to be sorted out to perform tests because results will differ in terms of listening effort. A person with a more neural or central pathology may require more listening effort than a person with a sensory loss because it impacts brain structures that deal with higher functioning.

One way is to take people without a cochlear pathology and restrict their audibility via masking or filtering to imitate a hearing loss. This method would suggest that cochlear pathologies do not cause inaudibility. The other method is to restore audibility in people who did have a cochlear pathology. Once the audibility issues were fixed, the cognitive issues were more apparent. (Humes, 2007) To restore audibility Humes (2007) utilized three methods. One method was equivalent to fitting a hearing aid in the clinic which involved raising the gain of the device to above their threshold through 4000 Hz. This method did not work well because the high frequencies continued to be inaudible. A second method was to raise the overall threshold, as well as, spectrally shape the signal. This created high suprathreshold levels in the low frequencies with less gain in the higher frequencies. However, this method could provide too much gain in the low frequencies for some people which can lead to complications with occlusion. It could exceed their uncomfortable loudness level (UCL) or make the sounds so loud that they are intolerable. The last method is to spectrally shape the signal to 15dB above the threshold through 4000 Hz. This is the ideal way to ensure speech is audible, comfortable, and tolerable. It follows the curve of the hearing loss and gives sufficient audibility at each frequency. (Humes, 2007)

To compensate for the hearing loss and cognition problems, there is a criterion that needs to be met for participants. Some studies use normal hearing subjects only while others compare both normal hearing and hearing impaired subjects. These studies have a strict criterion for the configuration and degree of the hearing loss. In addition to Humes' methods to restoring inaudibility are what other researchers refer to as equated speech. In many studies, the young adults perform better on the tasks then the older adults. This general result may be due to the presbycusis noted in a portion of the older adult population. However, if speech is equated for both groups to compensate for hearing loss, a difference in performance level still exists. This finding suggests that there is more listening effort exerted in older adults than younger adults. For example, in Gosselin and Gagne (2011), the signal-to-noise ratio (SNR) for the older adults was raised so that they were performed at 80% or better because the younger adults were performing in the 80%-100% range. When the environments were set equal for everyone, hearing loss was no longer the confounder. The individual's cognitive resources were being evaluated. In this same study, the response times for older adults were longer than younger adults even with the equated speech. There is a greater listening effort for older adults to perform as well as the younger adults.

Conclusion/Discussion:

The results were consistent in all studies that even when hearing loss differences were eliminated, there were still cognitive differences between the young and older adult groups. This suggests that as we age, our cognitive abilities change and we require more effort to do tasks. Dual task paradigms assess speech recognition performance with a more realistic approach as majority of people are listening while performing other tasks. (Gosselin & Gagne, 2010) The dual task paradigm will also allow the clinician to obtain objective information about how the patient will perform while considering their cognitive abilities. Patients with the same audiogram and word recognition scores can perform differently with amplification depending on their cognitive abilities and what they can do with the acoustic information. (Gosselin & Gagne, 2010) Majority of the studies suggest that there is a lack of consensus regarding the definition of listening effort and a lack of a clinical standard to measure listening effort.

Limitations & Considerations

Subjects were poor judges of how much effort was involved in performing the task. For subjective measurements, this could skew results. Gosselin and Gagne (2010) report that there have been studies indicating there are more discrepancies with self-reporting compared to objective results in the older adult population. It had been found that older adults overestimate their capabilities and underestimate their degree of impairment. There may also be limitations to a person’s definition of effort. Subjects may use task difficulty or performance accuracy rather than the amount of exertion to rate their listening effort. (McGarrigle et al., 2014) A limitation to the ANL test is that there is no measure of comprehension. A person may have a high tolerance to background noise while being unable to hear or comprehend the target stimuli.

For dual task paradigms, Downs and Crum (1978) and Feuerstein (1992) found that performance of the secondary task was not correlated with the subjective ease of the listening measure. The primary task had a positive correlation between ease of listening and performance accuracy. (Gosselin & Gagne, 2010) In studies using background noise, the signal used as the competing signal can play a role in the outcomes. Multi-talker babble may create a more difficult listening environment than white or pink noise. (Howard et al., 2010) Another consideration is that many of the studies utilized normal hearing listeners as their participants. It is important to note the type of subject pool in each study. According to Mackersie and Calderson-Moultrie (2016), Richter discussed if a task is too difficult for an individual they may withdraw from exerting effort on the task and the relationship between task demand and listening effort will break down. The relationship between the response to a stimulus and the auditory effort exerted to comprehend the stimulus is unclear at this time. There is no measure to rule out attention as a factor. (McGarrigle et al., 2014)

Gagne (2017) explains that the variability in secondary tasks across studies needs to be considered. He also goes on to inquire about how participants would perform should the SNR decrease or become more challenging. It is unknown whether simultaneous or concurrent dual-task paradigms are more sensitive or reliable in measuring listening effort. Further research is necessary to explore these current limitations. All in all, more research is needed to identify a reliable and sensitive task or protocol to measure listening effort in the clinic.

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