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ORIGINAL ARTICLE

Understanding Listening-Related Fatigue: Perspectives of Adults with Hearing Loss

Hilary Davis[a], David Schlundt[b], Kemberlee Bonnet[b], Stephen Camarata[a], Fred H. Bess[a] and Benjamin Hornsby[a]

[a]Department of Hearing and Speech Sciences, Vanderbilt Bill Wilkerson Center, Vanderbilt University School of Medicine, Nashville, TN, USA; [b]Department of Psychology, Vanderbilt University, Nashville, TN, USA

ABSTRACT

Objective: Adults with hearing loss (AHL) often report feeling fatigued after being in situations that require prolonged listening, an experience referred to as listening-related fatigue. We conducted focus groups to identify key domains and constructs of listening-related fatigue. Our goal was to create a theoretical framework for understanding listening-related fatigue that could guide the development of a reliable and valid assessment tool.

Design: Eight focus group discussions were conducted using a moderator's guide. Discussions were recorded, transcribed, coded, and analysed to identify common themes related to listening-related fatigue. A hierarchical coding manual was developed iteratively as new themes and subcategories were identified during the analysis process.

Study Sample: Forty-three adults (11 males; aged 20 to 77 years) with varying degrees of hearing loss participated in the focus groups. Participants included primarily hearing aid users ($n = 34$), hearing aid candidates ($n = 6$), and a small group of cochlear implant users ($n = 3$).

Results: Qualitative analyses revealed the multidimensional nature of listening-related fatigue for AHL, including physical, mental, emotional, and social domains. These varied experiences were influenced by the external (acoustic/environmental) characteristics of the listening situation, the internal state of the listener (cognitive/motivational), and coping strategies implemented to modify the listening experience. The use of amplification had both positive and negative effects on listening-related fatigue.

Conclusions: For some AHL, the consequences of listening-related fatigue can be significant, negatively impacting their quality of life. Data from these focus groups provides a framework for understanding the experience of listening-related fatigue among AHL. This is a critical first step in the development of a tool for measuring listening-related fatigue in this at-risk group.

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Introduction

Fatigue is commonplace in our lives and is characterised, subjectively, by feelings of weariness, tiredness, and a lack of energy (O'Connor 2004; Tiesinga, Dassen, and Halfens 1996). Mild feelings of fatigue are common, even in a healthy population, and expected when associated with sustained and demanding physical or mental work. This kind of fatigue is generally transient in nature, fading quickly with a short rest or break, and having only minimal effects on the individual. In contrast, for a subset of the population, particularly those with severe chronic health conditions, (e.g. cancer, diabetes, multiple sclerosis) feelings of fatigue can be more severe and sustained over time. Severe fatigue can result from simple everyday physical (e.g. general household chores) and mental (e.g. maintaining attention and focus) activities, resulting in significant negative effects on quality of life (Curt et al. 2000; Evans and Wickstrom 1999; Flechtner and Bottomley 2003; Hardy and Studenski 2010). For example, adults suffering from severe fatigue are more likely to have difficulty maintaining their attention and concentration (Bryant, Chiaravalloti, and DeLuca 2004; DeLuca 2005; van der Linden, Frese, and Meijman 2003). These deficits can impair speed of processing and degrade decision-making abilities in working adults, making them less productive and more likely to be involved in workplace accidents (Ricci et al. 2007). Likewise, older adults experiencing high levels of fatigue tend to be less active and more socially isolated. This population is less able to care for their own needs and more prone to depression than non-fatigued adults (Amato et al. 2001; Eddy and Cruz 2007).

Although many factors contribute to its onset, fatigue is often associated with the sustained application of physical and/or mental effort (Hockey 2013; Hornsby, Naylor, and Bess 2016). Relevant to this paper, research suggests that in some conditions (e.g. in noisy conditions), the seemingly simple act of attentive listening can be cognitively challenging and require *substantial* mental effort to complete. Mental effort refers to the active use of cognitive resources to complete a task. "Listening effort" refers to situations where mental effort is applied to a listening task (Pichora-Fuller et al. 2016). Importantly, compared to those without hearing loss, people with hearing loss frequently need to exert more mental effort towards listening tasks (Baldwin and Ash 2011; Hornsby et al. 2013; McCoy et al. 2005; Picou, Ricketts, and Hornsby 2011; Pichora-Fuller et al. 2016). Under some conditions, the sustained application of high levels of listening effort can result in feelings of "listening-related" fatigue (Key et al. 2017; McGarrigle et al. 2017; Moore et al. 2017).

CONTACT Hilary Davis hilary.davis@vumc.org Department of Hearing and Speech Sciences, Vanderbilt Bill Wilkerson Center, Vanderbilt University School of Medicine, 1215 21st Avenue South, MCE South Tower, Room 6414, Nashville, Tennessee, 37232-8718, USA

Thus, listening-related fatigue may be a significant concern for adults and children with hearing loss. This assumption is supported by research showing that the additional attention, concentration, and effort needed to overcome auditory deficits can be significant, resulting in reports of increased stress and fatigue for adults with hearing loss (AHL). When an individual with hearing loss experiences substantial listening-related fatigue, negative impacts on work performance and quality of life are common. AHL experiencing significant fatigue are more prone to workplace accidents and are more likely to take sick leave for "burnout" compared to their colleagues without hearing loss (Dinges et al. 1997; Hetu et al. 1988; Nachtegaal et al. 2009).

Researchers have used a variety of subjective, behavioural, and physiologic methods to assess fatigue in general, and listening-related fatigue specifically; however, a goldstandard for measuring listening-related fatigue does not exist (see Hornsby, Naylor, and Bess 2016 for review). One way to learn about an individual's perceptions of their fatigue is by using patient-reported outcome measures (PROMs). PROMs are subjective measures that can be used to assess an individual's health status, well-being, satisfaction with treatment, disease symptoms, and/or functioning (Meadows 2011). There are several standardised, valid, and reliable PROMs for assessing subjective fatigue (Christodoulou 2007; Thayer 1986; McNair, Lorr, and Droppleman 1971). Some measures are generic in nature and assess fatigue as part of a more global assessment of mood, health, or life quality (e.g. Thayer 1986; McNair, Lorr, and Droppleman 1971). In contrast, others were designed to assess disease-specific fatigue issues (e.g. cancer-related fatigue; see Dittner, Wessely, and Brown 2004 and Whitehead 2009 for reviews). Importantly, to date there are no standardised, valid PROMs for measuring listening-related fatigue (Hornsby, Naylor, and Bess 2016).

A few studies, however, have used existing PROMs to assess fatigue and vigour in adults and children with hearing loss (Dwyer et al. 2019; Hornsby and Kipp 2016; Hornsby et al. 2017; Alhanbali et al. 2017). A general, but not universal, finding from these studies is that adults and children with hearing loss are more likely to report more fatigue and less vigour (energy) than age-matched controls without hearing loss. In some cases, differences between groups are large; while in other cases, the differences are small and not statistically significant – raising concerns about the sensitivity of generic fatigue measures that are not designed to assess listening-related fatigue.

For example, Hornsby and Kipp (2016) had older adults who were seeking help for hearing difficulties ($n = 116$; 55–94 years old) complete the fatigue and vigour subscales of the Profile of Mood States (POMS), a well-validated, generic, instrument with good psychometric properties (McNair, Lorr, and Droppleman 1971; McNair and Heuchert 2010). Results revealed that, compared to normative ratings, vigour was significantly decreased (less energy) in AHL. In contrast, fatigue ratings were slightly higher for the adults with hearing difficulties, but the difference was small and not statistically significant. However, in a secondary analysis, Hornsby and Kipp (2016) found large between-group differences in the prevalence of "severe" fatigue and vigour deficits. "Severe" was defined as ratings that were more than 1.5 standard deviations above/below age-matched normative ratings. Compared to normative data, older adults with hearing difficulties were more than twice as likely to report severe fatigue and more than 4.5 times as likely to report a severe vigour deficit.

Dwyer et al. (2019) also examined the effects of hearing loss on subjective fatigue and vigour using the POMS. Participants were a small group ($n = 8$) of college-age adults with severe hearing loss (most used cochlear implants) and an age-matched group of peers with no hearing loss ($n = 8$). Consistent with Hornsby and Kipp, they found no difference in POMS fatigue ratings between groups. There were also no differences in mean vigour ratings or in the prevalence of "severe" fatigue or vigour deficits. However, Dwyer et al. (2019) also queried participants specifically about "listening-related" fatigue using an unvalidated, three question, disease-specific survey that was created for the study (e.g. "Difficulty listening causes me to become physically or emotionally tired"). Contrasting with the results from the POMS, responses to *specific listening-related fatigue questions* revealed large and statistically significant between-group differences.

Thus, we find fatigue can be common for many AHL and the impact of such fatigue can negatively affect work performance and quality of life. Furthermore, based on the extant literature, it appears that current generic fatigue measures may not be optimal for detecting listening-related fatigue in individuals with hearing loss (Dwyer et al. 2019; Hornsby and Kipp 2016). Importantly, a review of the broader fatigue literature revealed that valid, reliable, standardised methods for assessing listening-related fatigue do not exist (Bess and Hornsby 2014; Hornsby, Naylor, and Bess 2016).

The need for a PROM specifically designed to quantify listening-related fatigue in AHL led us to undertake a systematic process to develop and psychometrically validate such a scale. In this paper we describe a first step in this process. Focus groups were used to identify the key domains and constructs of listening-related fatigue from the perspective of AHL. Our goal is to use the information from focus group participants 1) to provide a theoretical framework for understanding the relationship between hearing loss, its psychosocial consequences, and listening-related fatigue and 2) to guide the later development of test items for a subjective tool, the Vanderbilt Fatigue Scale for Adults (VFS-A).

Materials and methods

Focus group participants were recruited from the clinical population seen at Vanderbilt Bill Wilkerson Centre Audiology clinics via stratified purposeful sampling. Individuals with other conditions, or medication use, that could potentially affect their feelings of fatigue were excluded from participation. Exclusion criteria included: 1) documented or self-reported sleep disorder; 2) regular use of prescribed or over-the-counter medications that may increase (e.g. Valium), or decrease (e.g. Ritalin) susceptibility to fatigue, and 3) diagnosis or self-report of untreated major depressive disorder; and 4) self-reported major health concerns associated with chronic fatigue (e.g. Parkinson's disease, undergoing active cancer treatment, chronic fatigue syndrome).

Forty-three adults (11 males), ranging from 20 to 77 years of age, (mean/standard deviation = 53.5/16.2 years) participated. Participants included hearing aid users and candidates ($n = 40$) and a small group of cochlear implant (CI) users ($n = 3$). All non-CI participants had bilateral hearing loss, ranging from mild to severe in degree (mean pure-tone average (PTA) at 500, 1000 and 2000 Hz of 42.4 dB HL in their better hearing ear; range 23–80 dB HL). Approximately 88% (35/40) of these participants had sensorineural hearing loss; the remaining five participants had long-standing conductive or mixed hearing loss. Most participants (85%; 34/40 individuals) utilised at least one hearing aid. Of the three CI participants, two were bimodal and one was

Table 1. Audiologic and demographic characteristics of focus group participants.

Group	*N*	Mean age and range (years)	Gender (F/M)	Employment status	Amplification use
Younger HL	22	43 years (20–55 years)	17/5	• 11 full-time • 1 part-time • 5 college students • 4 not employed outside the home • 1 did not disclose	16 HA users • 7 unilateral • 9 bilateral 6 non-users
Older HL	18	68 years (59–77 years)	13/5	• 10 retired • 8 full-time	18 HA users • 6 unilateral • 12 bilateral
CI Users	3	43 years (25–70 years)	2/1	• 2 full-time • 1 college student	3 CI users • 2 Bimodal • 1 Bilateral
Total	43	53.5 years (20–77 years)	32/11		

N: Number of focus group participants; HL: Hearing loss; F/M: Number of Female/Male participants; HA: Hearing Aid; CI: Cochlear Implant.

bilaterally implanted. Although language was not an exclusionary factor, all participants were proficient English speakers and communicated in an auditory-oral mode (i.e., sign language was not their preferred communication choice). No participants withdrew from participation during the duration of the study.

To facilitate dialogue within a focus group, hearing aid candidates/users were placed into one of two groups based on their age, based on the hypothesis that individuals in different life stages may have divergent listening experiences and varying perspectives about listening-related fatigue. This resulted in seven focus groups of adults with mild-to-severe hearing loss- four "younger" groups (20–55 years) and three "older" (59–77 years) groups. An eighth focus group consisted of the three individuals with CIs. The number of participants in each focus group ranged from three to eight (median = 5/group). Participants were financially compensated for their time and provided with a meal or snack during the meeting. Participant characteristics are shown in Table 1.

Focus group methodology

Focus groups were led by D. Schlundt, PhD; the Director of the Vanderbilt University Qualitative Research Core (VU-QRC), using a written moderator's guide. He had no prior relationship with any of the focus group participants. An initial version of the guide was developed using information from a literature review of related research in the areas of fatigue, stress, and effort, and the clinical experiences and expert opinion of our research team (academic researchers, clinical audiologists, and AHL). The guide was created using an iterative inductive/deductive approach (Fereday and Muir-Cochrane 2006; Tjora 2019; Azungah 2018) and was refined using well-established moderator procedures commonly used in qualitative research (Edmunds 1999; Morrison-Beedy, Côté-Arsenault, and Feinstein 2001; Merriam and Tisdale 2016). We initiated discussion by introducing the topic of listening-related fatigue, using targeted open ended questions and survey-type questions and prompts, and allowed participant responses to guide and focus additional discussion. The moderator was present to provide initial guidance for the discussion and to keep participants on task.

Exemplar questions/prompts included:

1. Does difficulty listening cause you to become physically, emotionally, or mentally tired?
2. What kinds of listening situations cause you to feel physically or emotionally tired due to difficulty listening?
3. How often do you feel physically or emotionally tired due to difficulty listening?
4. What are some of the things you do to cope with your hearing loss that cause you to get tired? To keep from getting tired or to help you recover from getting tired?

Focus groups were held at a meeting table in a quiet room which allowed for good acoustics and access to visual cues. In addition to the moderator, a second staff member of the laboratory team was present to observe the focus groups and take notes on the themes that were discussed. Meetings lasted approximately eighty minutes (70–95 min range) and were audio recorded. The focus group discussions were discontinued by the moderator when no new information was presented by the group participants for further discussion; however, the participants were encouraged to bring forth any additional comments before closing the session. Study procedures were reviewed and approved by the Vanderbilt Institutional Review Board in compliance with the Office of Human Resource Protection requirements.

Data analysis

Approximately 13 hours of focus group recordings were orthographically transcribed. All recordings were transcribed verbatim (using the professional transcription service www.rev.com). Participant comments and any mention of specific providers or clinics were de-identified. Prior to qualitative analysis, two members of the research team reviewed the transcripts for missing or unclear transcription. They then listened to the audio recordings, as needed, to edit the written transcript for accuracy and completeness.

Qualitative data coding and analysis was managed by the VU-QRC, led by a PhD-level psychologist (author Schlundt, core director). Here we report our methods following COREQ (Consolidated criteria for Reporting Qualitative studies) guidelines (Booth et al. 2014; Tong, Sainsbury, and Craig 2007). A hierarchical coding system with initial general themes was developed and iteratively refined using the interview guide and a preliminary review of the first four focus group transcripts. For example, an initial version of the coding system included the general theme "Physical characteristics of listening situations that trigger fatigue". The authors then completed thematic analysis of the initial focus group transcripts, reviewing the data for patterns to ascertain emerging listening-related fatigue themes (Fereday and Muir-Cochrane 2006). As these transcripts were reviewed, sub themes, such as "background noise", "number of people involved in communication", "lighting", were inductively generated and added to the coding strategy under the broad theme initially stated. Themes and sub-themes were added to the coding strategy if mentioned by more than one participant. This

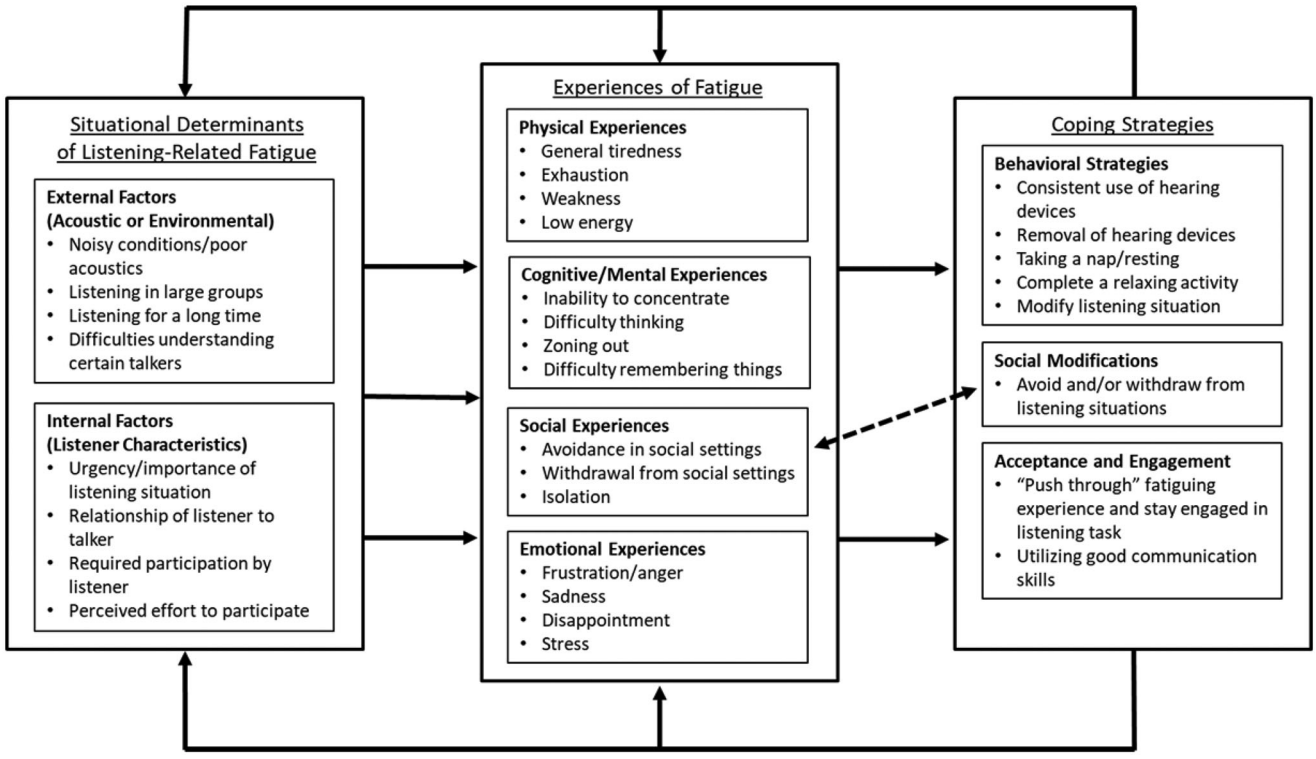

Figure 1. A dynamic process model of listening-related fatigue.

iterative process was replicated as additional focus group transcripts were obtained to further refine the coding strategy. As the result, the final coding system consisted of seven primary fatigue-related themes and multiple sub-categories definitions and rules created by the team. A copy of the coding system can be viewed at: https://healthbehavior.psy.vanderbilt.edu/Hornsby/CodingSystem_Hornsby.pdf.

Once the coding strategy was developed, trained coders reviewed each transcript for mention of the themes and subthemes by the participants. Each transcript was systematically coded by two individuals on a line-by-line basis. Each participant statement was treated as a separate quote and could be assigned up to five different codes based on its content. For example, a quote could be coded with both a qualities of fatigue code (Cateogry 1) and a listener motivation code (Category 3). Participant comments were combined in a single document and sorted by code. An iterative inductive and deductive approach was used to analyse our focus group data (Azungah 2018; Tjora 2019). The study authors individually reviewed the coded quotes and identifying higher-order themes using an iterative inductive-deductive approach (Azungah 2018; Fereday and Muir-Cochrane 2006; Tjora 2019). The team then met to discuss the identified themes and their relations to develop a theoretical framework of listening-related fatigue. Deductively, the analysis was guided by social cognitive theory (Bandura 2018; Usher and Schunk 2018), our literature review, and by clinical experience. Inductively, the codes and quotes from the focus group participants were used to fill in the details of the theoretical framework as described below.

Results

Theoretical framework

Our theoretical framework for understanding listening-related fatigue (see Figure 1) suggests that the listening-related fatigue is dynamic, having physical, cognitive, social, and emotional components (see Experiences of Fatigue section). These experiences are modified by important individual situational factors, including: 1) the characteristics of listening situations (i.e., External Factors section) and 2) an individual's responses to and perceptions of that situation (i.e., Internal Factors section) and 3) in some cases, by the coping strategies used to reduce the negative effects of listening-related fatigue (i.e., Coping Strategies section). In general, participant reports of listening-related fatigue were related to the difficulty experienced in a specific listening situation and by how motivated the listener was to effortfully engage within that context.

Our framework additionally illustrates how individuals may attempt to reduce or limit the development of listening-related fatigue by using coping strategies to modify the demands of the listening situation or their response to that situation. This process is highlighted by the overlap between certain social experiences and various coping mechanisms used to ameliorate the impact of listening-related fatigue- both of which involve avoiding or withdrawing from social settings (see dashed bidirectional arrow in Figure 1). Likewise, a feedback loop shows how coping strategies can influence other experiences of listening-related fatigue (cognitive, physical, emotional, and social) as well how situational determinants may affect fatigue development. This process may be repeated throughout the day, depending on the individual's lifestyle and listening demands. In the following sections, we describe each component of the framework and provide quotes to illustrate how each element relates to the perceptions of AHL.

Situational determinants of listening-related fatigue

External factors: challenging listening situations. Challenging listening situations, described as those which required effortful listening, were often perceived as fatiguing by focus group

participants. This was especially true when the listening demands were intentional and sustained over an extended period, such as a long day of work meetings or an extended social outing. Many participants reported that trying to listen and understand multiple talkers (e.g, when in a large group) was especially effortful and increased the likelihood of developing listening-related fatigue. One participant stated, "If there's just one person then that's the person you're going to focus on, I have no problem with that. I do become physically and emotionally tired when there are [many] talkers … ."

In addition, the vocal characteristics of the speaker and the listener's familiarity with them also contributed to their fatigue. One participant noted that trying to attend to someone who spoke quickly and/or softly would mean that "sooner or later" she would get tired from listening. Others noted it was fatiguing to try and communicate with others when they were far away or when the talker was not facing them—all situations which could be challenging for those with hearing loss. Similarly, some participants reported they were more likely to develop fatigue when trying to communicate with someone who was not aware of their hearing loss and thus did not adjust their speech patterns to aid the listener.

Internal factors: context of, and motivation in, the listening situation. Although challenging acoustics appears to increase the risk for listening-related fatigue, it was not a universal finding. For example, one participant noted "no problems", even when in difficult listening situations. He reported simply asking his wife to "fill him in" if he missed things during conversation. When asked to respond to the query "Fatigue and low energy due to listening are major problems in my life" 10% of participants reported, "Not a problem at all", while another 35% reported "Only a little problem". In contrast, 13% reported fatigue was "Quite a bit of a problem" (10%) or "An extremely major problem" (2.5%). Most respondents (42.5%), however, fell between the extremes, reporting listening-related fatigue was "Somewhat of a problem" in their lives. This distribution suggests that internal factors play an important role in how an individual perceives and responds to a challenging listening situation.

Comments from focus group participants support the idea that a listener's perception of, and response to, a situation influences their development of listening-related fatigue. For instance, the motivation to hear and understand in a given situation appeared to play a role. One participant noted that in their work setting, where competency in listening skills is expected, – "I find the more I have to focus on a situation, to try to hear, that's when I get drained … . If I'm in a situation where you have to capture every single moment … and if you get way too far behind, and you can't catch up? Then you come out of that meeting … completely drained." This effect can also be seen in personal relationships. One participant spoke of the fatigue experienced after engaging in conversation with his girlfriend. "I would take her out to dinner at 7 and by the time I'd drop her off, I'd be completely gone … we just spent four hours draining me because I was trying to pay attention and care." A key theme here is that a strong motivation to be actively engaged in the listening event over an extended time increased risk for developing listening-related fatigue.

Along these lines, some participants reported that the need to consistently monitor their acoustic environment required substantial, sustained effort, resulting in fatigue. For example, a full-time working AHL spoke of the stress and strain from trying to follow dialogue during workplace meetings. "I'll help lead meetings and I'm the one who writes on the board. Then the whole meeting I'm hyper-vigilant making sure I'm getting people's suggestions and things like that. That can be a stressful period of time where the whole time I'm trying to catch everything everyone is saying."

Experiences of listening-related fatigue

Physical experiences. Physical manifestations of listening-related fatigue, including reports of exhaustion, low energy, sluggishness, and tiredness, were common among participants. Although listening is not generally considered a physical task, participants agreed that demanding listening could be physically draining. The phrase "Listening is exhausting" was used by multiple respondents. One participant stated, "[Listening] situations are exhausting, unless I'm listening to mellow music or something like that. I get more exhausted from situations that other people enjoy and come away from more refreshed than I do … I'm exhausted most of the time." Another participant reported that "[listening] in social settings is tiring, as much as I love them. Shows and [plays] and things like that are exhausting … because I try really hard. It's tiring."

Other physical manifestations, such as headaches or a need for sleep or rest, following a difficult listening task were also commonly reported. For example, a working adult noted " … at the end of a night [where I've had difficulty hearing], I am just so unbelievably exhausted … I drive home and go to sleep because it's just worn me out."

Cognitive/mental experiences. Cognitive consequences of listening-related fatigue were pervasive and diverse. A common complaint was fatigue-related difficulties as a consequence of trying to think quickly and clearly, especially in demanding listening situations. For example, a graduate student with bilateral hearing loss stated: "I think the mental fatigue comes from not only trying to keep up [with what is being said in class] and just do the basics but it's also from all these extra things we have to do as people with hearing impairments … You suddenly realise I've spent so much energy on all these little things that no one else spends it on!"

Another participant highlighted the cognitive fatigue associated with trying to follow multi-talker conversations over time. "When someone says something and you're catching up, four seconds later trying to [process] what they said, but someone's already moved on … you're just playing catch up. That is a mentally exhausting task." These kinds of experiences were often repeated throughout the day and reportedly left participants feeling "mentally drained" and like their "brain was out of power".

Social experiences. For some participants, listening-related fatigue had a substantial negative impact on their ability, or desire, to engage in social activities. Some AHL reported avoiding challenging listening situations all together or reducing the amount of time spent in those situations, resulting in decreased interactions with others. One participant reported "I am a very social person. [But] I avoid going to really loud places like a bar … - things I would have done if I didn't have the hearing issues. Now I find myself really not engaging, so I come home. I don't really like to go there. It's too loud – I'm not going to be fine – and it's too much." While effective at minimising fatigue, this strategy has the obvious negative effect of potentially increasing self-induced isolation and withdrawal from social settings. Another cited listening-related fatigue as the reason she was no

longer as active after work: "I used to be social, more social than I am now. But it takes everything [energy wise] just to get through the day." Disengagement from social activities as a coping strategy to ameliorate the experience of fatigue is discussed in more detail later in the coping strategies section.

Emotional experiences. Struggling to hear and understand others was associated with a wide range of negative emotions, such as, depression, anxiety, sadness, anger, and frustration- all of which appeared to increase susceptibility to listening-related fatigue. Participants reported embarrassment when mishearing or not understanding and feeling left out in conversations. Some felt incompetent, annoyed and angry when accused of volitional "selective hearing" in the workplace. Participants reported that experiencing negative emotions as the result of hearing difficulties was, in itself, fatiguing. As noted above in the "social experiences" section, this often leads to a cascade of negative consequences, such as avoiding challenging social situations that may be stressful and fatiguing. As an example, one participant described her thought processes as she considered calling a friend on the telephone: "I get worn out, I get *anxious*. Before, during, and after speaking with her [on the phone] because I'm not hearing what she's saying and I know that I might say in the course of a conversation– 'Oh, I didn't hear that' or one of the million ways to say 'Could you repeat that?' I already feel *anxious* without even calling her, knowing that it's going to be *exhausting*." (emphasis added). Likewise, a college student reported feeling frustrated when he experienced difficulties listening. "If I've already blown through my patience with my hearing [difficulties] at 10 AM, I got the rest of the day in front of me … yeah, I'll be fatigued. And I'm more than likely gonna hit the 'off' switch and just not care … or be short tempered in that way."

Coping strategies for preventing and/or reducing listening-related fatigue

To prevent or reduce listening-related fatigue, participants reported a wide variety of proactive and reactive coping strategies. In fact, almost a third (29%) of participant comments were related to the prevention and remediation of listening-related fatigue.

Hearing device usage. Some focus group participants felt using their hearing devices (e.g. hearing aids and cochlear implants) actually *increased* their risk for developing fatigue. These individuals reported turning down or removing their hearing devices to take a break from listening to avoid reaching a fatigued state. For example, one participant reported, "I find the hearing aids very fatiguing because you pick up on so much more sound that before you just filtered out because you couldn't hear it. I found that I almost have to give my ears a break, [a] hearing break." Others agreed, reporting "taking the hearing aids out" for relief as soon as possible after a difficult day of listening.

Conversely, others reported that consistent use of their hearing device was critical for *limiting* listening-related fatigue. Some participants said that being without their device, due to forgetting it at home or it being broken was a stressful and fatiguing experience. For example, one participant reported: "I don't get as tired when I'm wearing my hearing aid … without them in, I'm really stressed. I'm tired." The reasons for these stark individual differences are unknown and highlight the need for additional research in this area.

Sleep and rest/listening breaks. Some participants reported fatigue, due to the stress and strain of active listening, that was so severe that it resulted in them taking naps or going to bed early. Others consciously structured their day to include breaks from listening, such as not scheduling back-to-back meetings, in an attempt to prevent or reduce listening-related fatigue. As an example, a working adult reported that " … instead of going to lunch with people [during the work day], a lot of times I'll go find a quiet spot in the shop and get a quick cat nap." Another noted that after listening intently to an event speaker she was " … so tired by the time I got home, I just say good night to my husband; and it ends at 8 o'clock, by 8:30 I'm in bed."

In contrast, others took a more proactive approach to avoid listening-related fatigue. A young adult noted, "If I'm going out with friends, I relax for a moment, re-energize, and then go. That's how I prepare. I don't do anything for like an hour before I do something [requiring listening]." Other participants reported that taking an active listening break, by finding a quiet space to rest and recover during the day, was a helpful coping strategy. A participant described her process for knowing when she needed to "recharge" after difficult listening. "[Listening] is like using a muscle. It's like this muscle needs to rest now for a little while. I can recharge and then I can go again but after a while, for me, I just reach a point of 'I'm tired now'." A college student reported, "A break helps. You know, if you've had a really stressful morning and your hearing's just not clicking, you can eat lunch by yourself and not have to listen to anyone. That's usually pretty good for recovery."

Passive and active avoidance/disengagement. As discussed earlier, for some AHL their listening-related fatigue was so severe they were hesitant or unwilling to engage in social activities. In addition, avoidance or physical withdrawal from difficult listening situations was also a commonly reported as a *passive* coping strategy to avoid developing, or to reduce existing, listening-related fatigue. For example, one participant explained "I don't go out a lot … I'd rather not go to places [with lots of noise]. Avoidance is the best technique. There are some times when I have to be there, then I just suck it up and know that I'm going to miss a lot of conversations and I'm going to be really tired at the end of it."

Likewise, even after attempting to engage in a difficult listening situation, some participants reported mentally tuning/zoning out (i.e., no longer maintaining focussed attention on the listening task or even turning off their hearing devices) after a time as an *active* coping strategy for reducing or limiting the development of listening-related fatigue. For example, when attending a large lecture, one participant reported "At some point during the lecture, I might just shut off … then at the end, when everybody is participating in the discussion, you can't really keep up because you missed out on 60 or 80% of the lecture." Other participants reported being "anxious to leave" noisy listening situations they found fatiguing, and leaving large gatherings, such as wedding receptions and parties, earlier than others.

Proactive engagement. Participants also reported that self advocacy strategies, commonly discussed in the clinical setting, were helpful for reducing or limiting listening-related fatigue. Tactics included informing a communication partner about their hearing loss, asking them to speak clearly and face them while speaking, and meeting in quieter, less busy areas. To maximise communication and minimise fatigue, some focus group participants were "selective" in where they would meet with groups, choosing to

move to a better (quieter, more ambient light) location in the room or communicating with a smaller group of individuals rather than the larger group. One participant reported "strategically placing myself in the room to be able to see the speaker" to avoid getting worn out during work meetings while another reported trying to "talk one-on-one with somebody" when at parties.

At the same time, some participants reported that the continued need to advocate for themselves was, in itself, fatiguing. One participant explained, "I feel mentally and emotionally worn out because of listening. Because it's taxing on, you know, I'm trying real hard … and I even prep people. I say, 'Look, I have to be in front of you. I need to be able to see your lips.' And if it's a noisy environment, I say, 'I've got to, we've got to move out,' and that's kind of more mentally taxing for me. And then the emotional part is the one where I just get frustrated." Thus, one person's method for reducing listening-related fatigue may result in an increase in fatigue if used by another individual. Improving our understanding of the factors that contribute to these individual differences will be a critical first step for developing interventions to mitigate the problem of listening-related fatigue in AHL.

Discussion

This paper describes our initial step towards developing a PROM for quantifying listening-related fatigue in adults using focus group methods. We present information from focus groups to describe the key characteristics of listening-related fatigue from the perspective of AHL. This is a critical step to ensure that any future PROM developed from these data will be relevant for the target population. Although this study focused on AHL, we hypothesise the resultant measure could be appropriate for other populations that struggle to listen and understand, such as individuals with tinnitus, auditory processing disorders, language impairment, and second language learners.

Focus groups provided us with rich, insightful information concerning the experience of listening-related fatigue among AHL and the coping strategies used to mitigate their negative experiences. Simply put, participants reported encountering a variety of difficult listening situations in daily life. For many, the process of actively listening and engaging in these situations led to diverse feelings of physical, cognitive, social, and emotional fatigue. For some AHL, the fatigue experiences were so distressing they led to disengagement or avoidance of certain social settings. This outcome, whether due to a fatigue-related reluctance to engage or as a coping strategy to reduce the development of fatigue, can create a cascade of side-effects that negatively affect quality of life.

The finding that high levels of effort (listening effort in our case) were associated with a diverse range of fatigue experiences (i.e. physical, emotional, cognitive and social) is consistent with broader fatigue literature. In fact, while not a universally held belief, researchers often describe the subjective experience of fatigue as a multidimensional construct (e.g. Michielsen et al. 2004; Hornsby, Naylor, and Bess 2016). Several commonly identified domains from the broader fatigue literature (see Whitehead 2009 for review) overlap with the experiences described by AHL. For example, the Multidimensional Fatigue Symptom Inventory- Short Form (MFSI-SF; Stein et al. 2004), developed to quantify fatigue in adult cancer patients, queries respondents about four dimensions of fatigue- general, physical, emotional, mental fatigue, and the related construct of vigour. In contrast, other researchers argue that at its core, fatigue is a unidimensional construct and that the various expressions reported in the literature are driven by a single, underlying latent construct (e.g. Michielsen et al. 2004). It is possible that using probe questions which asked about various types of fatigue experiences may have influenced our respondents. Whether the diverse physical, cognitive, social, and emotional experiences reported by our participants 1) represent unique components of a multidimensional construct or 2) are simply a reflection of an underlying unidimensional construct, remains an open research question. We plan to examine this question in the future by developing test items for a scale (the VFS) to assesses these potential dimensions of listening-related fatigue in a sample of adults with and without hearing loss.

In addition, the data derived from our focus groups and the extant literature served as a foundation for the development of a process model for understanding the multi-faceted issues associated with listening-related fatigue in AHL. Our framework suggests the subjective experience of listening-related fatigue is driven by two broad factors: 1) situational determinants- the characteristics of, and motivation to listen in, a given listening situation and 2) coping strategies- the individual responses to these listening situations. This finding is consistent with the "motivation control theory of fatigue" proposed by Hockey (2013) which highlights the importance of task characteristics and motivation on the development of fatigue.

Motivational control theory of fatigue and listening-related fatigue in AHL

In his model, Hockey (2013) argues that feelings of fatigue serve an adaptive, goal-directed function by modulating our motivation as we try to achieve a goal (e.g. successfully communicate with others). In this sense, his model shares the long-held view of fatigue as a protective mechanism (e.g. Mosso (1906) as cited in Hockey 2013). Hockey's model is based on the premise that, under certain conditions (e.g. low control, challenging conditions, and imposed goals), fatigue is a consequence of the sustained application of effort. Some goals are self-selected and require minimal effort to achieve (e.g. watch a favourite TV show). Other goals may require substantial effort to accomplish, be imposed by an external source, and/or be undesirable for the individual (e.g. complete a required, long and difficult, maths exam). In some cases, the desired goal may not be attained regardless of the effort applied (e.g. we may not be able to understand perfectly in a very noisy setting). The risk for fatigue varies across these different scenarios.

Hockey suggests that when attempting to achieve a goal we will allocate a certain amount of resources (cognitive and physical) to that goal – a budgeted effort. The amount of effort budgeted will depend on the importance of the goal. However, the decision to strive towards a goal is based not only on **its** importance to the individual but also on how much effort it takes to achieve the goal. To maintain effort towards a goal the "reward" (i.e., the perceived benefit from achieving the goal) must be high relative to the effort required to achieve it. Hockey suggests that as we work towards a goal there is an ongoing, unconscious, analysis of this "effort-reward" relationship. For example, consider the goal of communicating effectively in a noisy situation. Hockey suggests we would "budget" a certain amount of resources (effort) towards that goal. The amount of effort budgeted depends on the task demands (e.g. quiet or noisy environment) and the goals importance to the individual. If we can achieve the

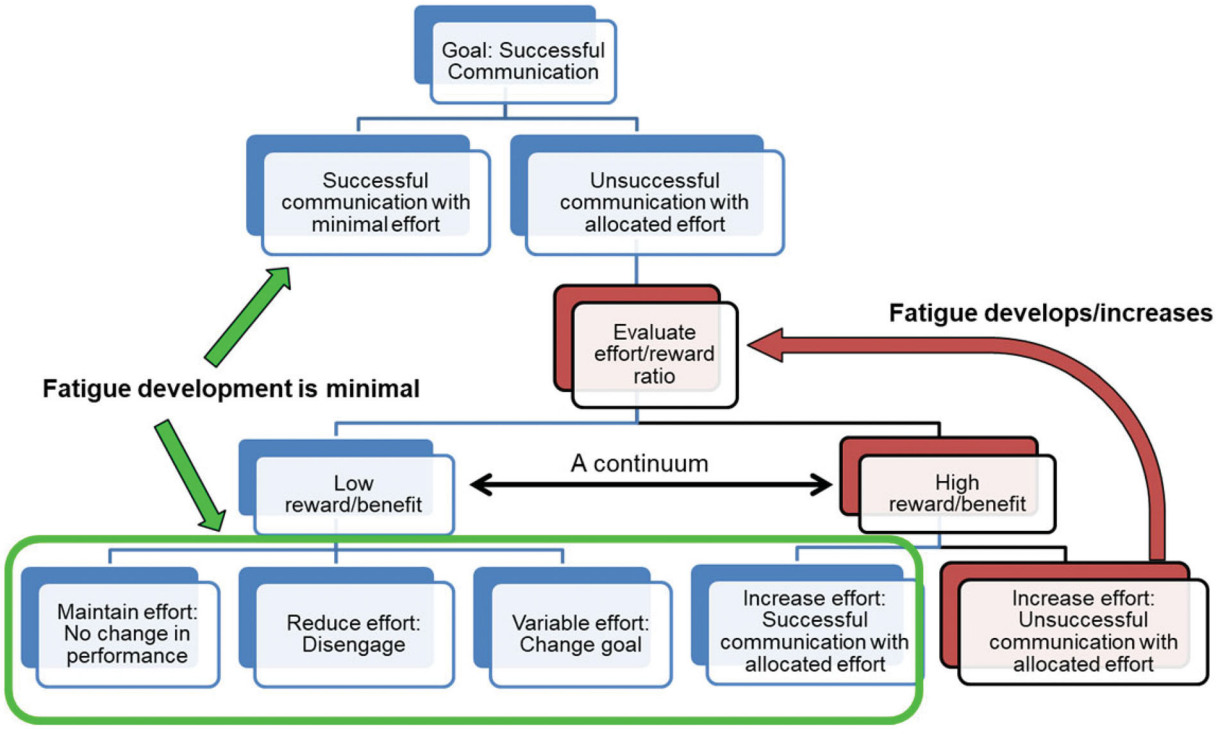

Figure 2. A simple block diagram, based on Hockey's (2013) motivation control theory of fatigue, highlighting processes by which listening-related fatigue may, or may not, develop.

goal with current level of budgeted effort there is a perceived reward and fatigue is unlikely to develop. This would especially be the case if communicating in that situation (the goal) was personally important to the listener.

In contrast, if we were unsuccessful achieving the goal- i.e., we applied our budgeted effort but continued to struggle to understand and could not communicate effectively; fatigue may begin to develop. In such cases, fatigue acts as a trigger. It encourages us to re-evaluate our current goal and the effort applied to achieve that goal. If achieving the desired goal were of *high* importance, we may ignore the fatigue and *increase* our effort (e.g. pay more attention to the speaker) in an attempt to enhance our communication. If this is successful, the fatigue may be reduced or remain stable, at least for a period of time. If, however, the increase in effort does not help, (e.g. we still can't communicate effectively), feelings of fatigue will likely increase in frequency and magnitude- triggering a recurring review of the effort-reward relationship until the goal is achieved or changed.

Alternatively, if communicating well in a given situation (the desired goal) is *not* of high importance, the reward for achieving that goal may be low and the individual may adopt a different strategy. They may decide to 1) *maintain* their effort and accept the current level of performance (e.g. accept only understanding half of what was said), 2) *reduce* their effort and disengage from the task (e.g. stop listening attentively), or 3) *change their goal* and, potentially, the effort applied towards the new goal. In these cases, fatigue is also *unlikely* to develop because the revised goal (e.g. understand only half of the conversation or disengage from the conversation) is more likely to be achievable with the applied effort.

Our focus group data suggests the experiences of listening-related fatigue described by AHL are consistent with expectations based on Hockey's model. Assuming the desired goal of successful communication in a noisy environment is self-selected and thus important to the individual, our focus group participants and other AHL report they must allocate high levels of effort to communicate in those situations (Alhanbali et al. 2017; Holman et al. 2019). Despite the application of high levels of effort, many focus group participants reported continued difficulty understanding (i.e., they were unsuccessful in achieving the goal), putting them at high risk for developing listening-related fatigue. Depending on the importance of understanding for the individual, they may increase their effort and persevere with the task or disengage/withdraw from the task, essentially changing their goal. Figure 2 shows a simple block diagram highlighting how Hockey's model could apply to the listening-related fatigue experienced by AHL.

Results of Hughes and colleagues (2018) also support this interpretation. They conducted focus groups to examine the experience of listening effort in a group of adults with severe-profound hearing loss who use CIs. Based on CI user comments, researchers identified a "core category" which described listening effort as a process of seeking "social connectedness"- a sense of belonging or being in touch with one's social world. Social connectedness, or the lack thereof, was an inherent extension of the CI users' ability/inability to communicate effectively with others. Hughes et al. (2018) suggest that CI users experience an "effort-reward imbalance". Prior to obtaining their CIs, adults with severe-profound hearing loss reported that despite high effort and motivation to connect and communicate effectively, they were often unsuccessful (limited reward). As a result, and consistent with Hockey's model, many chose to "disconnect" from the social setting (e.g. reduce their effort and/or revise their goal)- despite the negative consequences on quality of life. Upon receiving their CI, participants noted that the need for high levels of effort was somewhat reduced, but not eliminated. Also consistent with Hockey's model- the decrease in effort, coupled with other auditory improvements associated with the CI,

reduced the effort-reward imbalance enough to allow many CI users to maintain their effort and engage more effectively in social settings (i.e., achieve their goal).

An interesting prediction based on Hockey's model is that fatigue may actually *increase* for new CI users, particularly initially after implantation. As noted in Hughes et al. (2018) and by our own focus group participants, in challenging listening situations (e.g. a potential effort-reward imbalance) some AHL may disengage/withdraw from the situation, thus avoiding development of fatigue. However, with use of a CI, some adults with severe-profound hearing loss, who may have previously withdrawn from the situation, may be able to more successfully engage in the same setting- at least with the application of high levels of listening effort. Hockey's model predicts the sustained high levels of effort required for success in that setting would *increase* risk for fatigue (i.e., trigger evaluation of the effort-reward relationship). Comments from a subset of our own focus group participants support this hypothesis (see Hearing Device Usage section above).

In contrast, Holman et al. (2019) reported hearing aid use had a small, but *positive*, effect on listening-related fatigue. They conducted one-on-one interviews with adults with mild-to-severe hearing loss. As part of the interview, they asked participants who wore hearing aids ($n = 10$) about the impact of their aids on listening-related fatigue. Although none volunteered information about the benefit of hearing aids for reducing fatigue, once prompted, all reported some beneficial effects. The reasons for the divergent findings are unclear but may be related to differences in study samples (e.g. mild-to-moderately severe versus severe-to-profound losses), their baseline performance abilities, and the relative benefit in performance an individual receives from their CI or hearing aid. For example, in contrast to our example above, assume an adult hearing aid user with severe-profound hearing loss is able to converse adequately in quiet, but only with substantial effort. Assuming understanding was important to the individual, the sustained effort would increase this individual's risk for fatigue even when communicating in quiet. However, if upon receiving their CI their performance improves enough that they can effectively communicate in quiet with minimal effort, the risk for fatigue in that setting is expected to be substantially reduced. Further work is needed to better understand the many factors that may modulate listening-related fatigue in AHL (e.g. device type, settings, use time and experience, speech processing abilities, general and auditory-specific cognitive factors).

Limitations

While our study provided new information regarding the construct of listening-related fatigue in AHL, it does have limitations. For example, our decision to recruit participants with a wide range of ages, degree of hearing losses and device use patterns allowed us to gain insights from AHL with a variety of perspectives. However, the resultant sample size within any one age or hearing loss group was relatively small. Thus, consistent with other qualitative studies, our results are limited to our selected sample. As noted earlier, our methodological approach of querying participants about various dimensions of listening-related fatigue may have unduly influenced participant responses. Finally, our analysis method involved an iterative evaluation by research team members, individually and as a group, of relationships between focus group comments, identified themes and our theoretical framework, all of which are driven by the unique perspectives of the study sample and the research team. Additional work is needed to replicate and validate the framework developed in this study. Future work should include data collection from a broader population, obtaining information about the participants' geographic location, language, socioeconomic status, education level, and other factors that may impact and contribute to the experience of listening-related fatigue.

Conclusions

In summary, our findings are consistent with prior work suggesting that listening-related fatigue may be a significant problem for some AHL, especially when listening in adverse conditions; and, that such fatigue can negatively impact performance and quality of life (Dwyer et al. 2019; Hetu et al. 1988; Hornsby and Kipp 2016; Kramer, Kapteyn, and Houtgast 2006). Results suggest that listening-related fatigue in AHL can be diverse, encompassing physical, mental, emotional and social experiences.

Moreover, we learned that listening-related fatigue arises from a dynamic process of a person's interaction with their environment. Not only are the characteristics of the listening situation important, but so are the individualised proactive and reactive strategies that people use to avoid and/or minimise listening-related fatigue. When adults with hearing loss are highly motivated to engage in challenging listening situations, they are at increased risk for listening-related fatigue, and subsequently, they may experience a range of negative emotions. Responses of AHL range from feeling overwhelmed by the listening-related fatigue to becoming very skilled at minimising and avoiding it. Some coping strategies, such as "checking out" or avoiding situations, can have negative vocational impacts and adverse social consequences. From a broader perspective, the development of listening-related fatigue in AHL in our sample appears to be well modelled by a Motivation Control Theory of Fatigue (Hockey 2013).

Although there is mounting evidence that AHL are at increased risk for listening-related fatigue, and its negative sequelae; currently no measures of listening-related fatigue exist. Our long-term goal is to fill this gap by developing and validating a measure of listening-related fatigue relevant to the experiences of AHL. To best identify those struggling with listening-related fatigue, a validated measure is needed. With such a tool audiologists could identify those at most risk and advise them on strategies to minimise and avoid its negative effects. Practical counselling about fatigue and potential mitigating factors–such as taking a break, consistently using and/or taking a break from hearing assistive devices, or limiting time in difficult listening environments–is of paramount importance for those patients who report ongoing and severe listening-related fatigue. The next steps of this study will aim to create such a scale for clinical and research use.

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