Subjective Impact of Age-Related Hearing Loss Is Worse for Those Who Routinely Experience Boredom and Failures of Attention

Carolyn M.L. Crawford,[1] Kalisha Ramlackhan,[1] Gurjit Singh,[2,3,4] and Mark J. Fenske[1]

Objectives: Despite extensive evidence supporting the benefits of hearing treatments for individuals affected by hearing loss, many leave their hearing issues unaddressed. This underscores the need to better understand the individual factors influencing decision-making regarding hearing loss treatments. One consideration regarding the low uptake of treatment is the finding that the subjective impact of hearing loss is greater for some individuals than for others, yielding a significant discrepancy between subjective measures of hearing loss (e.g., self-report hearing-handicap scales) and objective audiometric assessments (e.g., audiograms). The current study seeks to elucidate some of the cognitive-affective factors that give rise to these individual differences in the subjective impact of hearing loss. Specifically, we hypothesized that a stronger trait tendency to experience boredom would be correlated with more intensely negative experiences of hearing-related issues, and that this relationship would be mediated by underlying attentional difficulties.

Methods: Through a partnership with hearing care clinics (Connect Hearing Canada), we recruited a large sample of older adults (n = 1840) through their network of hearing-care clinics. Audiometric thresholds provided an objective measure of hearing ability for each participant, while self-report questionnaires assessed individual differences in the subjective impact of hearing-related issues (hearing handicap), subjective strain experienced when listening (listening effort), tendency to experience boredom, tendency to experience difficulty maintaining task-focused attention (mind-wandering), and self-perceived level of cognitive functioning.

Results: The subjective impact of hearing loss—both in terms of hearing handicap and strain when listening—was found to be more intensely negative for those who are characteristically more susceptible to experiencing boredom, and this relationship was shown to be mediated by self-reported differences in the ability to maintain task-focused attention. This relationship between trait boredom proneness and the subjective impact of hearing-related issues was evident across all levels of objective hearing abilities. Moreover, there was no evidence that the subjective impact of hearing loss is worse for those who routinely experience boredom because of objectively-poorer hearing abilities in those individuals.

Conclusions: A greater trait susceptibility to experiencing boredom was associated with a more aversive subjective experience of hearing loss, and this relationship is mediated by attentional difficulties. This is a novel discovery regarding the cognitive-affective factors that are linked to individual differences in the effect that hearing loss has on individuals' daily functioning. These results may be helpful for better understanding the determinants of hearing-rehabilitation decisions and how to improve the uptake of treatments for hearing loss. The observational nature of the current study restricts us from drawing any definitive conclusions about the casual directions among the factors being investigated. Further research is therefore needed to establish how individual differences in the characteristic tendency to experience boredom are related to attentional-control difficulties and the experience of hearing-related issues. More research is also required to determine how all of these factors may influence decisions regarding hearing-loss treatments.

Key words: Age-related hearing loss, Attention, Audiometry, Boredom, Cognition, Mind-wandering, Proneness, Psychology, Self-reported Hearing loss.

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INTRODUCTION

Hearing loss is a prevalent chronic condition among older adults that is often accompanied by a myriad of negative impacts to one's health and wellbeing (Amieva et al. 2015), yet it remains untreated in the majority of affected individuals (Bisgaard & Ruf 2017; Chien & Lin 2012). One plausible reason why so few people pursue hearing rehabilitation is that the subjective experience of hearing loss, shaped by impaired abilities to perform everyday tasks, such as having conversations with friends and family or listening to the radio or television, is worse for some individuals than others. Indeed, studies have consistently demonstrated a discrepancy between the magnitude of the subjective, experiential impact of hearing loss and their objective, audiometrically assessed impairment (e.g., Nondahl et al. 1998; Saunders et al. 2004; Kiely et al. 2012), with the observation that measures of self-reported hearing loss are typically better predictors of hearing aid uptake than objective audiometric assessments of hearing ability (e.g., Tahden et al. 2018; Sawyer et al. 2019; for reviews, see Jenstad et al. 2011; Knudsen et al. 2010). While audiometric threshold assessments provide a general measure of an individual's physiological capacity for auditory sensation and perception, subjective measures, such as the Hearing Handicap Inventory for Adults-Screening (HHIA-S; Newman et al. 1990; Newman et al. 1991; Ventry & Weinstein 1983) investigate the impact of hearing loss on different aspects of an individual's psychosocial wellbeing. Thus, a given objective level of perceptual impairment detected by audiometric assessments may affect the day-to-day lives of some people more severely than it does for others.

Previous studies attempting to bridge the gap between objective measures of hearing loss and its subjective impact, as well as those investigating factors that influence decisions regarding hearing rehabilitation, have focused on understanding how factors such as age, self-reported health, social stigma, mental health, and personality traits may influence the experience of hearing loss (Wiley et al. 2000; Jang et al. 2002; Wallhagen 2010; Knudsen et al. 2010; McCormack & Fortnum 2013; Pronk et al. 2018). These findings provide some insight into the

[1]Department of Psychology, University of Guelph; [2]Phonak Canada, Mississauga, Canada; [3]Department of Speech-Language Pathology, University of Toronto, Toronto, Canada; and [4]Department of Psychology, Ryerson University, Toronto, Canada.

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discrepancy between objective hearing-loss assessments and self-reports of its effects, but do not address other potentially important cognitive-affective components that may influence one's subjective experience of hearing loss. The hypothesis tested here is that boredom—an aversive experience that arises when one wishes to but is unable to engage in a satisfying activity (Eastwood et al. 2012)—is a key factor that may help explain why the subjective impact of hearing loss may be worse for some people than for others. This possibility arises because, like the subjective negative impact of hearing loss, there are large individual differences in the frequency and intensity in which boredom is experienced, which we refer to as 'trait boredom proneness' and the 'characteristic tendency' or 'chronic tendency' to experience boredom (e.g., Tam et al. 2021; Hill and Perkins 1985; Vodanovich et al. 1991; Sommers & Vodanovich 2000). It should be noted here that trait boredom proneness and state boredom are two related but distinct concepts. Hearing loss hinders one's auditory perceptual ability, making it more challenging for the affected individual to engage in certain satisfying activities, such as social interactions (Laplante-Lévesque et al. 2012). Because state boredom is precipitated by the inability to engage in satisfying activities, and hearing loss hampers one's auditory ability to perceive and thereby engage in certain satisfying activities, people with a characteristic propensity to experience boredom may be impacted by hearing loss in a more intensely negative way than those who are less prone to boredom. We examined the possibility that differences in trait boredom proneness are linked to differences in individuals' experience of the subjective impact of hearing loss, while also considering the cognitive-affective mechanisms that may mediate this potential relation between trait boredom proneness and hearing loss.

State and Trait Boredom and Their Relations to the Experience of Hearing Loss

Psychologists and philosophers alike have attempted to explain boredom through a broad scope of perspectives and theories, yet definitions seem to share one commonality; boredom emerges when an individual attempts to engage in a task that aligns poorly with an individual's capabilities or interests (Eastwood et al. 2012; Csikszentmihalyi 1998; De Chenne 1988; Zuckerman 1979; Carriere et al. 2008). Cognitive perspectives on state boredom highlight the importance of the individual's response to their environment and seek to understand the factors that influence such responses, such as attentional control and self-regulatory abilities (Eastwood et al. 2012; Fisher 1993; Hamilton 1981; Harris 2000; Todman 2003; Isacescu et al. 2017). A growing body of literature focuses on the idea that state boredom is a functional cognitive-affective state that helps inform an individual that the current activity they are engaging in or attempting to engage in does not correspond well with their stimulatory needs or capabilities, thereby prompting the individual to alter their approach to the current task or to shift activities altogether (Bench & Lench 2013; Elpidorou 2014).

The wide range of explanations posited to conceptualize state boredom suggests that a chronic tendency to experience boredom manifests as a product of various intrinsic characteristics and situational contexts. Trait boredom proneness has been linked to difficulties maintaining self-control over impulses and urges, leading to detrimental behavioural effects, including pathological gambling, binge-eating, and abuse of drugs and alcohol (Stickney & Miltenberger 1999; Blaszczynski et al. 1990; Mercer & Eastwood 2010; Todman 2003; Lee et al. 2007; Wiesbeck et al. 1996; LePera 2011). In addition to impulsivity, the tendency to experience boredom has been associated with other personality traits such as impatience (Kass & Vodanovich 1990) and negative self-awareness (e.g., negative self judgements and evaluations; Seib & Vodanovich 1998). Many cognitive studies have found links between trait boredom proneness and attentional difficulties, including an increased susceptibility to attentional lapses, reduced performance on tasks demanding sustained attention, and higher rates of attention-related mistakes (Isacescu et al. 2017; Carriere et al. 2008; Cheyne et al. 2006). Further, the chronic tendency to experience boredom has been associated with reduced affect and even psychological issues such as depression and anxiety (e.g., Fahlman et al. 2009; Goldberg et al. 2011; Gordon et al. 1997; Sommers & Vodanovich 2000).

Of significance to the current study, a strong individual tendency to experience boredom has also been associated with more frequent self-reporting of both psychological and physical illnesses (Sommers & Vodanovich 2000). The higher symptom-reporting seen in individuals who are more prone to boredom may be attributable to findings that characteristically boredom-prone individuals have relatively higher levels of negative self-focused evaluations (e.g., Seib & Vodanovich 1998). This is further supported by research demonstrating an association between a greater characteristic tendency to experience boredom with narcissism, suggesting that the boredom-prone individual tends to focus on and ruminate about themselves (e.g., Wink & Donahue 1997). Eastwood et al. (2007) have also reported evidence that trait boredom proneness is linked to alexithymia, such that boredom-prone individuals have a relatively lower ability to label and understand their emotions and internal states. This inability to accurately label and understand emotions and internal states may also help to explain why those with alexithymia and trait boredom proneness are more likely to display somatization, in which psychological distress is experienced and communicated as negative physical symptoms (Lipsanen et al. 2004; Sommers & Vodanovich 2000).

Despite the inherent negative connotation of characteristics such as narcissism and alexithymia, and the common portrayal of the tendency to experience boredom as a deleterious characteristic, it is worth considering the potential advantages of trait boredom proneness. The heightened negative self-focus by the boredom-prone individual may translate to an enhanced ability to detect the onset of physical impairments, such as hearing loss, early on in their progression. Further, due to this increased likelihood of reporting uncomfortable experiences, individuals with trait boredom proneness may also be more motivated to seek treatments to reduce unpleasantness related to physical issues. This may be especially true for hearing loss, given that such an impairment may directly precipitate boredom by hindering one's ability to engage in meaningful activities such as having a conversation.

The phenomenon of loneliness is akin to boredom in the sense that both capture feelings of a lack of engagement and under-stimulation; state boredom may arise from a deficiency in various types of stimulation (e.g., mental, social, physical), while loneliness specifically captures a deficiency of social stimulation and human connection [see review by Bandari et al.

(2019)]. It could even be argued that loneliness itself is a form of boredom that encapsulates an individual's desire to engage with the world, specifically with other living beings. Thus, it is unsurprising that previous research has consistently demonstrated an association between both state and trait boredom with loneliness (Moore & Schultz 1983; Farmer & Sundberg 1986; Peng et al. 2020). It is well known that hearing loss can lead to social isolation and consequentially, loneliness [see review by Shukla et al. (2020)]. Thus, loneliness may be an underlying factor in the relationship between boredom proneness and the subjective experience of hearing loss.

Importantly, while hearing loss can be conceptualized as a sensory factor that disrupts one's ability to effectively engage with their surroundings, trait boredom proneness has been associated with intrinsic attentional difficulties that contribute to issues with engagement, such as higher rates of spontaneous mind-wandering (Malkovsky et al. 2012; Mercer & Eastwood 2010). Mind-wandering specifically refers to the cognitive phenomenon in which one's thought processes drift away from a current task. It is often conceptualized as a type of attentional lapse, particularly when it occurs spontaneously and unintentionally (Cheyne et al. 2006; Carriere et al. 2008; Danckert 2017). Thus, the tendency to experience spontaneous mind-wandering represents a dispositional difficulty in maintaining task-focused attention.

Although state boredom is not directly assessed in the current study, it is useful to consider how it may relate to the factors that were measured. Externally induced state boredom arises when engagement in a task demands high levels of self-sustained, effortful attention, because the activity is either overly simple, difficult, or generally uninteresting for an individual [see review by Eastwood et al. (2012)]. As a hearing impairment progresses, tasks that were once easy to engage in may gradually become increasingly challenging, or conversely, under-stimulating, increasing the likelihood that state boredom will arise. For example, the experience of playing an instrument or listening to music may become significantly less stimulating and interesting as an individual loses their hearing ability, transforming what was once a stimulating experience into a boring one. In contrast, as a hearing loss issue develops, maintaining a conversation demands increasing levels of effortful attention, making what was once a simple activity a challenging and potentially overstimulating one. For individuals who were already prone to experiencing boredom and attentional difficulties, when the attentional effort demands of common tasks are no longer congruent with an individual's needs and capabilities, they become even more susceptible to experiencing boredom, which they may ascribe to their hearing impairment.

It is important to note here that, given the fact that trait boredom proneness may intensify the impact that a hearing loss issue has on a person's day to day life, it is also likely that a hearing impairment causes the affected individual to experience boredom. Thus, the relationship between boredom proneness and the subjective experience of hearing loss is likely bidirectional whereby one factor perpetuates the other.

Current Study

The aim of the current study is to test the hypothesis that individual differences in the characteristic tendency to experience boredom are associated with the extent to which hearing loss—established objectively using clinical assessments of audiometric thresholds—has a negative subjective impact. We tested this in a large sample of older-adult first-time visitors at audiology clinics. In addition to receiving an objective hearing assessment—audiometric thresholds obtained by hearing-care professional—each participant completed a questionnaire assessing the subjective impact of any changes in their hearing, and their characteristic tendency to experience boredom. To assess the possibility that attentional difficulties may mediate the potential relation between trait boredom proneness and hearing-loss impact, participants also completed a self-report scale measuring their tendency to mind-wander during task-focused attention. Because individuals who are prone to boredom may already have a reduced capacity for attentional control, the development of normal age-related changes in hearing ability may make it even more challenging for such individuals to engage in satisfying interactions in noisy environments. Thus, we expect the subjective impact of age-related hearing loss to be more intensely negative as levels of trait boredom proneness increase, and that this will be linked to tendencies of attentional failures (i.e., mind-wandering).

MATERIALS AND METHODS

All materials, procedures, and other aspects of this research were approved by the University of Guelph Research Ethics Board (protocol #18-11-033).

Participants

A sample of 1840 adults, aged 50 years or older (M = 64.2 years, see Table 1 for additional demographic information), provided informed consent to participate in our study. Participants were given the opportunity to enter a draw to win $250 as compensation for their participation.

Given that data collection was carried out in person at each of 98 Connect Hearing clinics across Canada, we were aware that there would be a delay between the time of data collection and the time we received the paper-copy questionnaires and audiometric-threshold forms and were able to transcribe each

TABLE 1. The number of participants and their proportions within the total sample of each age group, level of hearing ability, and sex category

	No. Participants	Proportion of Total Sample
Age		
50–59 years	630	34.2%
60–69 years	687	37.3%
70–79 years	397	21.6%
80 years or older	110	6.0%
Chose not to report	16	0.90%
Hearing ability/loss level		
Normal hearing ability	605	32.9%
Minimal hearing loss	605	32.9%
Mild hearing loss	504	27.4%
Moderate+loss	99	5.4%
Missing audiogram data	27	1.5%
Sex		
Female	1059	57.6%
Male	773	42.0%
Other	0	0.0%
Chose not to report	8	0.43%

participant's data into a digital format that could be counted and collated with the rest of the sample. We therefore would not have precise control in stopping data collection at a given sample size. Thus, we requested that data collection be carried out over a certain timeframe, April 2019 to March 2020, as opposed to aiming for a specific number of participants. Thankfully, our final number of participants, n = 1840, was in line with prior large-sample investigations of the correlates of boredom proneness [e.g., Isacescu et al. (2017); n = 1928].

Materials and Apparatuses

Self-Report Measures • Participants completed a questionnaire that contained multiple self-report measures. These included demographic and general-information questions about participants' sex, age, education, overall hearing ability, and whether they had previously owned a hearing aid (see questions in Supplemental Digital Content 1A, PDF http://links.lww.com/EANDH/B49). Participants could select one of 5 options to indicate the highest level of education they received; *"less than high school (<12 years)*", "*High school (12 years)*", *"Some college/university (13-15 years)*", "*Bachelor's degree (16-17 years*)", or "*Master's/PhD/MD (18+ years*)". The characteristic tendency to experience boredom was assessed using the eight-item Short Boredom Proneness Scale (SBPS; Struk et al. 2017; see questions in Supplemental Digital Content 1b, PDF http://links.lww.com/EANDH/B49). The tendency to experience mind-wandering was assessed using the eight-item Mind-Wandering: Deliberate/Spontaneous Scale (MW-D/ MW-S; Carriere et al. 2013; see questions in Supplemental Digital Content 1c, PDF http://links.lww.com/EANDH/B49). The subjective impact of hearing-related issues was assessed using ten items from the Hearing Handicap Inventory for Adults-Screening (HHIA-S; Newman et al. 1990; Newman et al. 1991; Ventry & Weinstein 1983; see questions in Supplemental Digital Content 1d, PDF http://links.lww.com/EANDH/B49), as well as four items we developed for this study to measure the level of subjective strain experienced during listening (i.e., Listening Effort, see questions in Supplemental Digital Content 1e, PDF http://links.lww.com/EANDH/B49). Three of the items can be seen as modified versions of a question from Gatehouse & Noble's (2004) Speech, Spatial and Qualities of Hearing Scale (i.e., Qualities-item #18 regarding the experience of listening effort during conversation), with variations in wording to tap into different aspects of the experience and consequences of the strain associated with listening effort, including the tendency to avoid situations altogether due to the *expected* level of listening effort. Twelve items from the PROMIS® Cognitive Function and Abilities Scale-Short were used to evaluate self-reported levels of cognitive function (PROMIS; Cella et al. 2007; see questions in Supplemental Digital Content 1f, PDF http://links.lww.com/EANDH/B49).

Education was coded in such a way that increasing levels of education corresponded with an increasing number of points, wherein the lowest level of education, "*less than high school (<12 years)",* corresponded with 1 point; while the highest level of education, "*Master's/PhD/MD (18+ years)*", corresponded with 5 points. All questionnaire scores were computed according to the original scale creators' guidelines. Higher score sums in the SBPS component indicate greater propensities to experience boredom. Greater scores in both MW-S and MW-D represent stronger individual tendencies to spontaneously and deliberately mind-wander, respectively. Higher scores in HHIA-S reflect more aversive subjective experiences of hearing loss. The item that asked participants to rate their overall hearing ability on a scale of one to ten, was reverse coded to align with the representation of HHIA-S, meaning that higher scores indicate greater levels of hearing issues. Six items in the PROMIS functions and abilities scale were reverse coded to ensure that higher scores indicated participants' perception of having higher levels of cognitive function. Last, higher levels in listening effort scores reflect participants' perception that they need to exert greater levels of effort to be able to hear properly in a given situation. If responses to items were ambiguous or absent, their total score on that section was excluded from analysis.

Participants' scale scores were only calculated and included in the analysis if they responded to every item within a scale. In total, there were missing data from 105 participants in the SBPS scale, 67 participants in the MW-D scale, 88 participants in the MW-S scale, 116 participants in the HHIA-S survey, 110 participants in the overall hearing ability item, 149 people in the PROMIS scale, and 114 participants in the Listening Effort scale. The pairwise deletion method was then used for all comparative analyses. Pearson correlation analyses were conducted using the R package apaTables.

During analysis, we specifically excluded MW-D items in our measure of attentional control because prior research has suggested that deliberate mind-wandering represents an intentional, creative type of mental activity that can serve as an escape from boredom caused by the current activity an individual is engaging in (e.g., daydreaming; Martarelli et al. 2021; Weibel et al. 2018; Marcusson-Clavertz & Kjell 2019; Fox et al. 2014; see review by Mooneyham & Schooler 2013). In contrast, spontaneous mind-wandering encompasses an uncontrolled transfer of mental focus from the task at hand to unrelated mental activity, representing a type of attentional lapse (e.g., Carriere et al. 2013; Marcusson-Clavertz & Kjell 2019; Seli et al. 2014; Isacescu et al. 2017). Further, spontaneous mind-wandering is more strongly associated with attentional difficulties, distraction, and even attention-deficit hyperactivity disorder symptomatology than deliberate mind-wandering (Marcusson-Clavertz & Kjell 2019; Seli et al. 2015). Accordingly, research has also demonstrated that boredom proneness is more strongly related to spontaneous than deliberate mind-wandering (Martarelli et al. 2021; Isacescu et al. 2017).

Audiometric Threshold Assessments • Objective hearing ability was assessed by calculating the pure tone audiometric threshold in the better ear ($4PTA_{BE}$), which includes frequencies within the speech-frequency range (500, 1000, 2000, and 4000 Hz). We then classified participants as having normal hearing ability ($4PTA_{BE}$ < 16 dB HL), minimal hearing loss (25 dB HL ≥ $4PTA_{BE}$ ≥ 16 dB HL), mild hearing loss (40 dB HL ≥ $4PTA_{BE}$ > 25 dB HL), or moderate or worse hearing loss ($4PTA_{BE}$ > 40 dB HL). Table 1 provides a breakdown of the number of participants identified as belonging to each of the hearing-ability categories.

Procedure

Data collection from 98 Connect Hearing Canada clinics across Canada began April 2019 and was completed in March 2020. Study materials were assembled into individual study packs for each participant and sent via post to each clinic.

Each study package contained consent and debriefing forms, the 47 questionnaire items, and a sheet for the clinician to fill out with audiometric thresholds. As first-time visitors to a clinic, participants were asked if they were interested in participating in the study. Those who chose to participate were given a study pack by clinic staff, which they completed in the waiting room. Participants provided informed consent, filled out the questionnaire, and then proceeded to have their left and right ear audiometric thresholds measured by a clinician. Questionnaire forms and audiometric-threshold records were later delivered by courier to the University of Guelph for analysis. Individuals who stated that they had previously used a hearing aid before participating in our study were excluded from the analysis (n = 14).

RESULTS

Boredom Proneness and the Subjective Impact of Hearing-Related Issues

Our main hypothesis was that individual differences in the long-term tendency to experience boredom are related to the severity of the subjective impact of age-related hearing loss. To test this, we first examined whether individual differences in trait boredom proneness (SBPS scores) were linked to differences in the subjective impact of hearing loss (HHIA-S scores) and the subjective strain experienced when trying to hear (Listening-Effort scores). This analysis revealed significant positive correlations whereby higher levels of trait boredom-proneness scores were associated with higher levels in our measure of the subjective impact of hearing loss ($r = 0.25$, $p < 0.001$; $df = 1627$) and level of perceived effort when trying to hear ($r = 0.35$, $p < 0.001$; $df = 1633$). The severity of the subjective impact of hearing-related issues and subjective strain experienced while listening are plotted as a function of trait boredom proneness separately in Figure 1 for each level of objective hearing ability. To assess whether the strength of these links between trait boredom proneness and the subjective experience of hearing loss vary with the severity of the objective hearing loss, we used separate linear regression models that included objective-hearing level ($4PTA_{BE}$ scores) as a factor. This confirmed trait boredom proneness is related to both the subjective impact of hearing loss ($\beta = 0.13$, $p < 0.001$; $df = 1627$) and the strain of trying to hear ($\beta = 0.12$, $p < 0.001$; $df = 1633$). Moderation analyses were used to assess whether the strength of the relationship between trait boredom proneness and the subjective measures of hearing-related issues varied across levels of objective hearing ability. There was no evidence of an interaction between trait boredom proneness and objective hearing ability on the HHIA-S measure of the subjective impact of hearing loss ($p = 0.21$; $df = 1600$; see left side of Figure 1). There was, however, support for an interaction between trait boredom proneness and objective hearing ability on listening effort ($\beta = 0.0015$, $p = 0.047$; $df = 1607$; see right side of Figure 1), with trait boredom proneness being more strongly related to listening effort at higher levels of objective hearing loss ($\beta = 0.14$, $p < 0.001$) than at lower levels of objective hearing loss ($\beta = 0.11$, $p < 0.001$).

A power analysis was conducted for our main relationship of interest, the correlation between trait boredom proneness and the subjective impact of hearing loss, revealing the current study has very high power (n = 1627, r = 0.25, $p < 0.001$, power = 0.98).

Spontaneous Mind-Wandering as a Mediator Between Boredom Proneness and Subjective Hearing Loss

To assess our additional hypothesis that any relationship between trait boredom proneness and the subjective experience of hearing loss would be mediated by attentional difficulties, we performed a mediation analysis with SBPS scores as the predictor, MW-S scores as a mediator, and HHIA-S scores as the outcome. This analysis suggested that the total predictive effect of trait boredom proneness on the subjective impact of hearing loss was $\beta = 0.13$ ($p < 0.001$), 17.4% of which could be accounted for by spontaneous mind-wandering ($\beta = 0.022$, $p < 0.01$; $df = 1555$; see Table 2). It was also determined that 19.9% of the total predictive effect that trait boredom proneness had on listening effort ($\beta = 0.13$, $p < 0.001$) was accounted for by spontaneous mind-wandering ($\beta = 0.025$, $p < 0.001$; $df = 1563$; see Table 3).

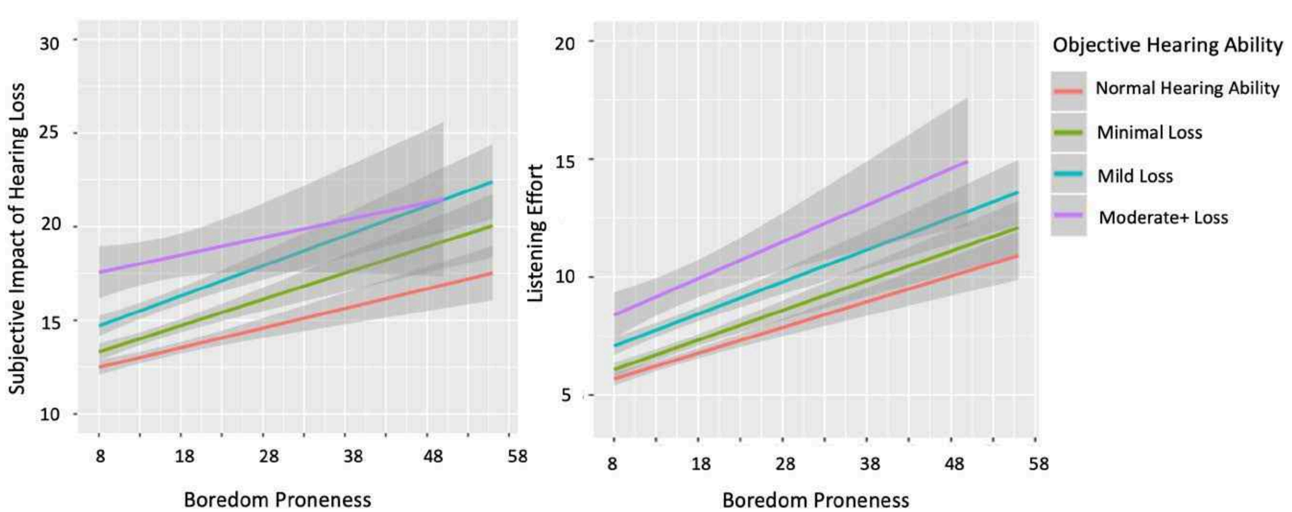

FIG. 1. Individual differences in the subjective impact of hearing loss [Hearing Handicap Inventory for Adults-Screening (HHIA-S)] and subjective strain while listening (Listening Effort) plotted as a function of boredom proneness [Short Boredom Proneness Scale (SBPS)] for each level of objective hearing ability (audiometric thresholds). 95% confidence interval bands are shown in gray.

TABLE 2. Mediation analysis in which SBPS scores represent the predictor, HHIA scores represent the outcome, and MW-S represents the mediator

	Coefficient Estimate (β)	95% CI
SBPS scores' direct predictive effect on HHIA scores	0.11*	(0.076–0.14)
SBPS scores' indirect predictive effect on HHIA scores (accounted for by MW-S)	0.022†	(0.0082–0.040)
Total predictive effect of SBPS scores on HHIA scores	0.13*	(0.10–0.16)

*p < 0.001.
†p < 0.01.
HHIA, Hearing Handicap Inventory for Adults-Screening; SBPS, Short Boredom Proneness Scale.

TABLE 3. Mediation analysis in which SBPS scores represent the predictor, listening effort scores represent the outcome, and MW-S represents the mediator

	Coefficient Estimate (β)	95% CI
SBPS scores' direct predictive effect on listening effort scores	0.10*	(0.079–0.12)
SBPS scores' indirect predictive effect on listening effort scores (accounted for by MW-S)	0.025*	(0.014–0.040)
Total predictive effect of SBPS scores on listening effort scores	0.13*	(0.11–0.15)

*p < 0.001.
SBPS, Short Boredom Proneness Scale.

General Trends and Observations

To gain a general understanding of the relationship among various questionnaire factors and hearing threshold, we examined patterns of correlations among key factors in the study (see Table 4).

The results were consistent with our prediction for our main question of interest; the characteristic tendency to experience boredom influenced how people subjectively experienced their hearing ability or loss. Meanwhile, there was no evidence supporting a significant relationship between trait boredom proneness and objective hearing loss ($r = -0.014$, $p = 0.56$).

Based on prior research, we expected that levels of mind-wandering would decrease with age (see review by Maillet & Rajah 2014). Our results confirmed this, as we found that both deliberate and spontaneous mind-wandering were indeed negatively correlated with age ($r = -0.19$, $p < 0.001$; $r = -0.21$, $p < 0.001$). Levels of trait boredom proneness were also lower in older participants ($r = -0.17$, $p < 0.001$).

Results from cognitive-affective studies investigating the links between boredom and spontaneous thought processes have shown that spontaneous mind-wandering is more strongly related to boredom proneness than deliberate mind-wandering (Isacescu et al. 2017; Martarelli et al. 2021). Using the Decoster method, we replicated the finding that the relationship between boredom proneness and spontaneous mind-wandering is indeed stronger than that between boredom proneness and deliberate mind-wandering ($z = -9.68$, $p < 0.001$).

Clinical pure tone audiometric thresholds were positively correlated with the subjective impact of hearing loss ($r = 0.33$, $p < 0.001$) and perceived effort exerted to hear ($r = -0.28$, $p < 0.001$).

Objective Audiometric Results and Boredom Proneness

It was also important to investigate the possibility that the relationship between trait boredom proneness and people's subjective experiences of hearing loss was not simply attributable to an underlying link between boredom and objective levels of hearing loss. Such a relationship may have emerged, for example, if people who are more chronically prone to boredom were at greater risk for inducing damage to their ears (i.e., due to riskier behaviour such as listening to music at excessively loud volumes). To test whether trait boredom proneness was related to objective, audiometric hearing loss, a linear regression model was created, which demonstrated no evidence in support of a statistically significant relationship between trait boredom proneness and objective hearing loss ($\beta = -0.017$, $p = 0.56$).

Secondary Exploratory Analyses

The negative subjective experience of hearing loss was less pronounced in older participants ($r = -0.11$, $p < 0.001$), despite the fact that objective hearing ability ($4PTA_{BE}$) was poorer in older participants ($r = 0.45$, $p < 0.001$). This finding is consistent with previous research (e.g., Gordon-Salant et al. 1994; Kamil et al. 2015; Nondahl et al. 1998; Wiley et al. 2000; see review by Pronk et al 2018). Nondahl and colleagues (1998) posit several suggestions to explain why this may happen. For example, individuals may develop stronger coping strategies to manage their impairment over time. Day-to-day tasks that depend on intact hearing may also become less frequent or demanding with increasing age, therefore making hearing loss a less salient issue. Finally, older adults may be more accepting of their hearing loss because they consider it an inevitable and even expected product of age. All of these considerations may affect the way that older adults report their subjective experience of hearing loss.

Greater levels of trait boredom proneness were linked with lower levels of self-reported cognitive functioning ($r = -0.48$, $p < 0.001$). Both types of mind-wandering were also related to declines in self-reported cognitive functioning, but again, the relationship was stronger for spontaneous mind-wandering than deliberate mind-wandering ($r = -0.46$, $p < 0.001$; $r = -0.21$, $p < 0.001$, respectively).

Our finding that higher levels of education were associated with better objective hearing ability was unsurprising ($r = -0.19$. $p < 0.001$), given the consistent body of evidence supporting the relationship between a greater number of years in education and a reduced risk of developing hearing impairments, as well as other health issues in general (Dalton et al. 2020; Cruickshanks et al. 2003, 2010, 2015; Hahn 2015; Kaplan 2015).

DISCUSSION

The significantly low proportion of individuals with hearing loss that choose to pursue hearing rehabilitation treatment (i.e., hearing aids), taken in conjunction with the finding that self-reported hearing loss is a stronger predictor of treatment uptake than objective measures of hearing loss, warrants investigation into the psychological factors influencing the impact

TABLE 4. Correlation matrix, with means (M) and SD for key cognitive-affective and hearing-related measures

	M	SD	SBPS	MW-D	MW-S	HHIA	Cognitive	Effort	Objective	Age
SBPS	15.3	8.7								
MW-D	11.5	5.6	0.32*							
MW-S	10.2	5.6	0.50*	0.63*						
HHIA	14.6	4.5	0.25*	0.11*	0.20*					
Cognitive	50.2	8.6	−0.48*	−0.21*	−0.46*	−0.34*				
Effort	7.3	3.2	0.35*	0.17*	0.27*	0.69*	−0.53*			
Objective	21.6	10.6	−0.01	−0.09*	−0.09*	0.33*	−0.02	0.28*		
Age	64.2	8.9	−0.17*	−0.19*	−0.21*	−0.11*	0.07*	−0.02	0.45*	
Education	3.6	1.0	−0.16*	0.11*	0.03	−0.19*	0.15*	−0.22*	−0.19*	−0.05†

SBPS = boredom proneness, cognitive = PROMIS self-reported cognitive functions and abilities, effort = subjective strain of listening, objective = audiometric assessment of hearing ability.
$*p < 0.01$.
$†p < 0.05$.
HHIA, Hearing Handicap Inventory for Adults; MW-D, deliberate mind-wandering; MW-S, spontaneous mind-wandering; SBPS, Short Boredom Proneness Scale; SD, standard deviation.

that hearing loss has on affected individuals' day-to-day lives. A growing body of research demonstrating the functions, causes, and consequences of boredom led to our hypothesis that an increased long-term propensity to experience boredom may make people's experiences of hearing loss more intensely negative. For example, when an individual who already has a tendency to experience boredom cannot engage in a stimulating conversation due to a hearing loss issue, they may experience this lack of stimulation as more aversive than less boredom-prone individuals. We also expected, if such a relationship was indeed evident, that attentional mechanisms may underly this link. In alignment with our original prediction, we found that more intensely negative subjective experiences of hearing losses were associated with greater levels of trait boredom proneness. No evidence was found in support of a significant relationship between trait boredom proneness and objective hearing loss, thereby suggesting that a long-term susceptibility to boredom does not act as a risk factor for the development of a hearing impairment, for example, through increased behaviour that could be harmful to one's hearing ability, such as listening to music at excessively loud volumes. Similarly to how individuals exhibit different pain tolerances, it is reasonable to suggest that there is variation in the subjective, experiential impacts of hearing loss across individuals with highly similar objective hearing abilities.

An individual who struggles with pre-existing issues in attentional control and capacity is typically more prone to boredom due to an inherent inability to maintain focus on environmental stimuli (Carriere et al. 2008). When an individual predisposed to low attentional control is presented with a hearing loss issue, the difficulty they experience in effectively engaging with their surroundings may be further exasperated, possibly making them even more susceptible to experiencing state boredom. Our results are in support of this hypothesis, as trait boredom proneness was found to be a mediator in the relationship between spontaneous mind-wandering and the subjective experience of hearing loss. This suggests that attentional control difficulties intensify the aversity of a hearing loss experience indirectly, by promoting the negative feelings associated with boredom.

The importance of elucidating the role that attentional control plays in the relationship between trait boredom proneness and the subjective impact of hearing loss is underscored by the fact that untreated hearing loss is associated with reduced cognitive functioning, which has been shown to decrease attentional abilities (Amieva et al. 2015; see review by Luo & Craik 2008). With attentional control attenuating as a result of the cognitive decline onset by untreated hearing loss, an individual's hearing loss experience will become even more aversive, strengthening the interplay between these individual factors.

Theoretically, the heightened levels of boredom and subsequent decreased affect observed in people with hearing loss (e.g., Watt & Davis 1991) may occur across a variety of attentional capacities. Reduced affect may then precipitate disengagement, which can manifest in spontaneous mind-wandering and further reduced affect. Thus, although we have portrayed spontaneous mind-wandering as a mediator between trait boredom proneness and the subjective experience of hearing loss in this study, the interplay between these variables may be cyclical in their nature, with each factor perpetuating the effects of the other.

Strengths, Limitations, and Future Research Directions

The SBPS scale specifically has been criticized for its inability to determine whether high responses truly reflect trait boredom proneness or, instead, represent poor abilities to respond to and cope with boredom (Danckert et al. 2018). Arguably, higher levels of chronic boredom proneness may be caused by weak boredom-coping mechanisms, possibly due to underlying attentional difficulties. Thus, this critique of SBPS may be irrelevant, at least to our study.

However, the challenge of determining whether individual scores on the SBPS scale represent a long-term propensity to experience boredom or a more recently developed tendency to experience boredom, solely attributable to a hearing impairment, still prevails. In either case, a hearing impairment should theoretically lead to increases in SBPS scores. Therefore, individuals who are more susceptible to experiencing boredom before the onset of a hearing loss will find it even more challenging to maintain focus when they are faced with this new sensory obstruction that facilitates further boredom and its negative cognitive-affective and performance consequences.

One potential way to distinguish whether a participant is chronically prone to boredom would be to reassess cognitive-affective factors in future studies prior to conducting a within-subjects analysis between results from initial and secondary testing sessions. In individuals who experienced heightened levels of boredom proneness solely due to the hearing impairment, it is plausible their SBPS, MW-S, and PROMIS scores may exhibit a significant decrease in the second assessment, in cases in which they have adopted hearing aids. Meanwhile, one would expect that for individuals who demonstrate boredom proneness as more of a long-term, static trait, if they adopt a hearing aid, the mean differences between SBPS, MW-S and PROMIS scores from the primary to secondary trial would only be mild or moderate (i.e., the hearing aid only decreases boredom and its associated cognitive-affective factors by a mild-moderate proportion).

It is worth addressing the possibility that depression acted as a confounding variable in the relationship between boredom proneness and the subjective experience of hearing loss. A study conducted by Choi and colleagues (2019) found that depression was associated with overestimated hearing impairment, meaning that individuals demonstrating higher levels of depression reported having more severe hearing loss than what was objectively determined through clinical audiometric threshold assessments. A link between trait boredom proneness and depression has also been found in a multitude of studies (e.g., Vodanovich et al. 1991; Farmer & Sundberg 1986; Blaszczynski et al. 1990), which is unsurprising given that depression and boredom share some common causes and indicators, including an altered state of arousal (Cohen 2008; Goldberg et al. 2011), a tendency to experience attentional failures (Carriere et al. 2008), and most evidently, reduced affect (Ahmed 1990; Farmer & Sundberg 1986; Gordon et al. 1997; Seib & Vodanovich 1998; Vodanovich et al. 1991). While there are certainly overlapping features between depression and boredom, one study that used structural equation modelling found that boredom proneness is a distinct construct from depression, apathy, and anhedonia (Goldberg et al. 2011). van Tilburg and Igou (2012) argue that state boredom arises when an individual attempts to engage with an activity that is insufficiently challenging or meaningful and motivates an individual to seek more fulfilling activities. In contrast, anhedonia, a characteristic feature of depression, causes a disrupted ability to find and experience pleasurable experiences (e.g., Ho & Sommers 2013). Therefore, perhaps considering how boredom and depression vary in terms of their motivational components offers insight on the difference between the two constructs; while boredom captures a desire to seek out and engage in more rewarding behaviour, depression may hamper an individual's ability to experience the motivation required to seek out meaningful activities, as well as their capacity to enjoy them.

One major pitfall of the present study is its observational nature, preventing us from being able to establish any conclusions about the causal directions of the relationships between these variables. This is further complicated by the perpetual, cyclic interactions between these cognitive-affective factors. For example, does poor cognitive functioning lead to more frequent bouts of boredom for an individual, or do frequent attentional lapses, which underly high a propensity to experience boredom, result in poorer cognitive functioning?

However, the current dataset is vast and provides a rich opportunity for correlational analyses involving variables that could be investigated in greater depth in the future. Our sample size is also strikingly large and demographically diverse, which strengthens our extrapolations to the general population. Further, after conducting a follow-up study in the future, it is hoped that we will be able to provide some insight on the causal directions of these links.

Further, another common limitation among studies in the audiology-cognitive field is the fact that they frequently only evaluate hearing loss by measuring its subjective impact, despite the lack of correspondence between objective measures of hearing loss and measures of the subjective impact of hearing loss (e.g., Kiely et al. 2012; Nondahl et al. 1998; Saunders et al. 2004). To the best of our knowledge, this is the first study to identify the potential role of boredom proneness in explaining in part the discrepancy between objective hearing loss and the subjective experience of hearing handicap.

Implications

The results of this study provide novel insights about the psychological factors that shape an individual's experience of their hearing loss, which in turn may influence decisions regarding treatment. Elucidating such factors is important, given that many people who discover they have hearing loss choose not to pursue treatment, despite evidence that untreated hearing loss may be linked to negative outcomes, such as social isolation (Bisgaard & Ruf 2017; Chien & Lin 2012; Shukla et al. 2020). Our results suggest that individual differences in various cognitive-affective factors, including attentional control and trait boredom proneness, influence individuals' subjective hearing loss experiences. Given the array of acute and long-term benefits associated with hearing aid use, if those who are more prone to boredom experience a hearing loss as more aversive, they are potentially at an increased likelihood of adopting a hearing aid, and therefore at a lower risk in developing some of the negative outcomes of hearing loss, including depression and dementia (Amieva et al. 2015).

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Address for correspondence: Mark J. Fenske, Department of Psychology, University of Guelph, Guelph, Ontario, Canada N1G 2W. Email: mfenske@uoguelph.ca

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