Research Article

The Effects of Amplification on Listening Self-Efficacy in Adults With Sensorineural Hearing Loss

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Objectives: The aim of this study was to evaluate listening self-efficacy ratings between aided and unaided conditions in different communication environments and to determine what patient- and device-centered variables were associated with individual differences.

Method: An observational, cross-sectional study design was used to evaluate 165 older adults with mild to moderately severe sensorineural hearing loss who wore hearing aids at least 8 hr per week. Listening self-efficacy for both unaided and aided listening was measured using the Listening Self-Efficacy Questionnaire (LSEQ; Smith, Pichora-Fuller, Watts, & La More, 2011), consisting of a global score and subscales of Dialogue in Quiet, Directed Listening, and Complex Listening. Metrics to explain variability in the degree of improvement in LSEQ ratings with aided listening included patient-centered variables of age, pure-tone average, and personality and device-centered variables of hearing aid use, speech intelligibility index, directionality, and noise reduction. The NEO Five-Factor

Inventory (Costa & McCrae, 1985) was used to measure 5 personality traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness). Associations were evaluated between LSEQ ratings and patient- and device-centered variables using a linear mixed-model analysis.

Results: Statistically significant improvements in LSEQ ratings were found for aided conditions (relative to unaided conditions), easier listening environments, lower pure-tone averages, and lower levels of neuroticism. Furthermore, the improvement in listening self-efficacy with hearing aids did not depend on the listening environment but did alter with severity of hearing loss, length of hearing aid use, and levels of conscientiousness.

Conclusions: Results of this study suggest that wearing hearing aids is associated with improved listening self-efficacy in a variety of communication environments. Aural rehabilitation and counseling may focus on improving listening self-efficacy to address the challenges of consistent hearing aid use and reduced quality of life related to hearing loss.

The use of hearing aids can lead to improvements in the quality of life for adults with hearing loss (Chisolm et al., 2007); however, many adults who could potentially benefit from hearing aids either do not have them or do not use them regularly (Chien & Lin, 2012; Hartley, Rochtchina, Newall, Golding, & Mitchell, 2010; World Health Organization, 2018). Even when people have current technology fit appropriately for their hearing loss, hearing aid usage and benefit are not guaranteed.

There is more to the treatment of hearing loss than audiometric results, prescriptive formulas, and technology—nonaudiologic factors can affect the success of interventions. These factors include perceived severity of hearing loss, perceived benefit of hearing aids, and the support of significant others. For example, studies show that external cues to action (e.g., family support) and internal attitudinal beliefs (e.g., perceived disability) are influential in help-seeking behavior and the uptake of hearing aids (Meyer, Hickson, & Fletcher, 2014; Meyer, Hickson, Lovelock, Lampert, & Khan, 2014). Another factor that is known to influence improved hearing aid outcomes is self-efficacy (Hickson, Meyer, Lovelock, Lampert, & Khan, 2014; Meyer, Hickson, & Fletcher, 2014). The relationship between self-efficacy and positive patient outcomes has not been extensively studied within the field of audiology.

Self-efficacy is defined as the confidence in one's ability to successfully undertake behaviors to achieve specific goals (Lee, Hwang, Hawkins, & Pingree, 2008; Marks,

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Editor-in-Chief: Sumitrajit Dhar

Editor: Ryan McCreery

Received July 26, 2018

Revision received November 20, 2018

Accepted April 3, 2019

https://doi.org/10.1044/2019_AJA-18-0120

Disclosure: The authors have declared that no competing interests existed at the time of publication.

Allegrante, & Lorig, 2005). It is different from outcome expectancy, which is the estimation that a certain behavior will result in the target outcome. Expectations based on self-efficacy can influence behavior modification because they are linked to the internal conviction that one can achieve the outcome expected with their own skills. There are four major sources that affect a person's self-efficacy: past experience, physical and emotional reactions prior to an attempt, observations of others performing a task, and level of encouragement received from others (Bandura, 1977). Moderation of self-efficacy is of interest because it has been thought to be a factor in the successful management of a number of health conditions (e.g., Bandura, 1977, 1992; Kelly-Campbell & McMillan, 2015; Yoo, Kim, Jang, & You, 2011). It is a predictor of health management behavior for certain activities and conditions (e.g., sun safety, motivation to exercise, diabetes management, heart disease management), and clinicians have made use of self-efficacy improvement intervention strategies to encourage adherence to their treatment program and promote better patient outcomes (e.g., Allen, Fain, Braun, & Chipkin, 2008; Clark & Dodge, 1999; King et al., 2010). For example, a diabetes self-management study by King et al. (2010) found that behavior-specific support from friends, family, and community resources is associated with behavior-specific self-efficacy, which is also connected to self-management behaviors, such as healthy eating and physical activity. In theory, incorporating strategies that focus on the sources of self-efficacy (e.g., external support system, skill-building programs) will increase the likelihood of patient compliance to prescribed treatment. It is important to note that the general consensus is that the predictive ability of self-efficacy is dependent on the targeted behavior change. For example, a person can have high self-efficacy for quitting smoking, but not follow through in the end because of an inhibitor such as addiction. Additionally, the positive effects of high self-efficacy can plateau or diminish over time. If the target behavior was to increase healthy behaviors such as regular exercise, feelings of self-efficacy may predict positive behavioral changes initially that gradually diminish. Measurement of initial self-efficacy is not always a good indicator of outcomes over time in some instances, and it is imperative to interpret the impact of self-efficacy on a case-by-case level (Clark & Dodge, 1999).

Listeners with acquired hearing loss are faced with the same communication environments as their normal hearing peers, but often with the added challenge of using new communication strategies, the need to advocate for oneself, and/or learning skills related to hearing aid use. As previously stated, the study of the effect of self-efficacy on patient outcomes is relatively new in the field of audiology. Of the available research, hearing aid self-efficacy studies are the most common. Hearing aid self-efficacy involves belief in one's ability to perform the skills needed to successfully utilize hearing aids (i.e., handling of devices, acclimatization to sounds, aided listening). The general trend exhibited is that higher levels of hearing aid self-efficacy are associated with higher levels of satisfaction

and hearing aid wear (e.g., Kelly-Campbell & McMillan, 2015; Meyer, Hickson, & Fletcher, 2014; Meyer, Hickson, Lovelock, et al., 2014), although this trend is not universal (e.g., Ferguson, Woolley, & Munro, 2016). For example, older adults who wore their hearing aids daily and attained at least moderate benefit based on the International Outcome Inventory for Hearing Aids (Cox & Alexander, 2002) were significantly more likely to report higher hearing aid self-efficacy, particularly in their ability to adjust to a hearing aid and benefit in different listening situations (Meyer, Hickson, & Fletcher, 2014). Based on the relationship of hearing aid self-efficacy with positive hearing aid outcomes, we wanted to explore the extent to which other types of self-efficacy could be applicable to clinical practice in audiology. There is a paucity of research focusing on listening self-efficacy, which is defined as the belief listeners have in their ability to plan and perform actions necessary to understand speech in different listening situations. It is worth studying for its possible value to audiologic rehabilitation—listening self-efficacy may influence speech understanding and listening behavior modifications (Smith, Pichora-Fuller, Watts, & La More, 2011). Should listening self-efficacy be found a predictor of improvement in any of those areas, rehabilitation models and techniques could be developed to specifically increase self-efficacy.

The primary focus of this study was the effect of amplification on listening self-efficacy. Our first hypothesis (H1) was that aided listening self-efficacy would be greater than unaided listening self-efficacy due to improving audibility through hearing aids. Since many studies show that hearing aid users perform better in quiet or simple environments than they do in noisy environments (Cox & Alexander, 1992; Humes, Ahlstrom, Bratt, & Peek, 2009; Kochkin, 2005), we also hypothesized (H2) that the effect of hearing aids on listening self-efficacy ratings would be greatest in situations involving one-on-one conversation in quiet and focused attention on a single speech source, with less improvement when listening in complex auditory scenes with multiple talkers and background noise.

Like any type of self-efficacy, listening self-efficacy is but one of many possible predictors of successful hearing aid outcomes—its effects alone or in combination with other factors may contribute to the results. Therefore, the current study included both patient- and device-centered variables that may explain individual variability in the effect of hearing aids on listening self-efficacy, and several secondary hypotheses were tested. Sources of variability may include degree of hearing loss, audibility achieved by amplification, hearing aid processing, experience with hearing aids, and personality (Knudsen, Öberg, Nielsen, Naylor, & Kramer, 2010). Although hearing aids are unable to overcome all deficits experienced with sensorineural hearing loss, listeners with more severe loss present with lower unaided listening self-efficacy than individuals with more mild losses (Smith et al., 2011), and therefore, we hypothesized (H3) that the effect of hearing aids on listening self-efficacy would be greater for those with more severe hearing losses. We further hypothesized (H4) that individuals

with greater aided audibility, achieved either through hearing aid gain or directionality, would experience greater improvements in listening self-efficacy with hearing aids. Finally, individuals with longer experience wearing hearing aids, either in their daily use or over a lifetime, have more practice listening with their hearing aids and therefore were predicted to demonstrate a greater aided effect on listening self-efficacy (H5).

Finally, the role that personality plays in any self-report measure cannot be overlooked. Researchers have demonstrated that personality explains 5%–20% of the variance in self-reported hearing aid outcomes (Cox, Alexander, & Xu, 2014; Gatehouse, 1991). Across five dimensions recognized by psychologists as the major domains of personality, individuals who reported poorer hearing aid outcomes tend to have higher neuroticism scores, while those who score higher in extraversion, openness, and agreeableness are more likely to report better outcomes (Cox, Alexander, & Gray, 2007; Wu et al., 2017). Since self-efficacy involves one's belief and is assessed using self-reports, we expect that there will be a significant association between personality and listening self-efficacy, and we hypothesized (H6) that individuals who scored higher in neuroticism would demonstrate a lower aided effect on listening self-efficacy, whereas those who scored higher in extraversion, openness, and agreeableness would demonstrate a greater aided effect on listening self-efficacy.

Method

Participants

One hundred seventy participants were recruited as part of a larger study on hearing aid outcomes through volunteer databases and community advertisements at the University of Washington ($n = 90$) and the University of Iowa ($n = 80$). The purpose of the larger study was on variables affecting hearing aid outcomes; therefore, all subjects owned hearing aids bilaterally with self-reported wear time of at least 8 hr per week over the last 6 months, and the hearing aids had at least 5 dB of American National Standards Institute (ANSI, 2003) high-frequency gain. Participants included native English-speaking adults (self-reported) between the ages 21 and 79 years with bilateral, sensorineural hearing loss (defined later). The Montréal Cognitive Assessment (Nasreddine et al., 2005) was used to screen patients for the possibility of severe cognitive impairment, which could affect test results. A score of 26 has been used by other studies to screen for dementia, but according to a recent Cochrane Review, reduction of the cutoff score produced results with similar sensitivity yet with fewer false positives (Davis et al., 2015). Several studies have suggested a cutoff score of 23 (Carson, Leach, & Murphy, 2018; Luis, Keegan, & Mullan, 2008), which was also the criteria used in the current study. Participants were excluded if they had possible conductive components indicated by air–bone gaps of 15 dB or greater at any frequency with a one-frequency exception; thresholds worse

than 70 dB HL for either ear at any frequency in the range of 0.25–4 kHz; otologic disorders or head, neck, or ear injuries; or diagnoses of neurological disorders that affect cognition and/or memory. According to a power analysis performed with G-Power (Version 3.1.9.3; Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007) for the current study, 72 people were needed to detect a medium effect ($\eta_p^2 = .01$) using a repeated-measures analysis of variance with an α level of .05 and a power of .80. Of the 170 subjects recruited to the current study, data were missing on five subjects due to experimenter or equipment error.

Materials and Procedure

Participants gave their consent to participate in the study, which was approved by the Human Subjects Review Committee at the University of Washington and the University of Iowa. Each participant was compensated for his or her time and given an explanation of the possible risks, including time commitment and stress. Testing took place during two separate visits. Visit 1 consisted of audiometric and cognitive screening tests described above and measures of hearing aid status. Visit 2 consisted of self-reported measures collected in paper-and-pencil format, which included measures of self-efficacy, personality, and hearing aid use.

Audiometry

Otoscopy was performed to determine if canals were clear for testing. Pure-tone air- and bone-conduction audiometry was performed on a Grason-Stradler GSI 61 audiometer with supra-aural Telephonics Dynamic Headphones in current calibration. Pure-tone air-conduction thresholds were obtained at 0.25–8 kHz with interoctave thresholds at 0.75 and/or 1.5 kHz if there was a difference greater than 15 dB between the adjacent thresholds. Pure-tone bone-conduction thresholds were obtained at 0.5, 1, 2, and 4 kHz (ANSI, 2009). Thresholds were obtained using the modified Hughson-Westlake procedure (Carhart & Jerger, 1959). The pure-tone average (PTA) at 0.5, 1, and 2 kHz for the better ear was used as the metric for hearing loss severity. For the statistical analysis, scores were standardized with a mean of 0 and an *SD* of 1 to allow for easier interpretation of interactions with categorical variables.

Hearing Aid Status

Participant hearing aids were evaluated to quantify the integrity of the fitting of their current hearing aids. Real-ear measurements were taken in response to a 65-dB SPL standard speech signal to quantify audibility of the hearing aids with respect to the NAL-NL2 prescriptive strategy and the aided speech intelligibility index (SII; ANSI, 2003) using the Audioscan Verifit (v1). The output averaged across all frequencies was calculated, and the better ear value was used in subsequent analysis. Additionally, we measured the noise reduction and directionality

of each hearing aid in the test box to determine if signal processing significantly contributes to the changes in listening self-efficacy. Noise reduction was measured in decibels of gain reduction, and testing was performed in the test box using the “air conditioning” stimulus at 70 dB SPL. Directionality was measured as the difference in decibels between hearing aid responses for the front and back speakers in the test box. The stimulus was set at 70 dB SPL, and the signal-to-noise ratio used was 0 dB. The difference in output responses was averaged across 0.25–4 kHz.

Listening Self-Efficacy Assessment

The Listening Self-Efficacy Questionnaire (LSEQ; Smith et al., 2011) was used because it targets confidence in listening ability and it quantifies listening self-efficacy in situations where the listener’s goal is speech understanding. Existing outcome questionnaires assess hearing aid benefit and self-reported difficulty in a variety of listening situations (e.g., Abbreviated Profile of Hearing Aid Benefit [APHAB]; Cox & Alexander, 1995), but none specifically addresses the individual’s confidence in his or her abilities to listen in any of those situations. Rather than assessing self-rated ability by asking questions like “how much” or “how often,” a person experiences a certain problem, the LSEQ seeks to measure confidence by asking “how certain are you?” or “how confident are you?” In fact, a principle components factor analysis of responses on the LSEQ and APHAB indicates that ratings on each questionnaire load onto different factors and thus are relatively independent of each other—they assess different constructs (Smith et al., 2011). The items of the LSEQ analyze the listener’s beliefs in their listening abilities in three subscales: One-on-One Conversation in Quiet, Focused Attention on a Single Speech Source, and Complex Auditory Scenes (e.g., competing noise or distance while listening to a speaker). Ratings in each of these subscales can help a clinician identify areas where a patient has low listening self-efficacy. These ratings can be used as points of comparison when the goal is to evaluate listening self-efficacy in relation to an intervention such as aided and unaided conditions (Smith et al., 2011). Participants completed the LSEQ twice in the same session to consider how they would answer if they did not wear hearing aids (unaided condition) and how they would answer with their hearing aids (aided condition). The LSEQ assesses the self-report of confidence in listening ability in 18 different situations that are grouped into subscales of Dialogue in Quiet (DQ), Directed Listening (DL), and Complex Listening (CL). A global score (self-efficacy [SE]) is also computed as the average across all items. Participants are to answer the question “How certain are you that you can do this right now?” as a set percentage (0%–100% in increments of 10%) in respect to the given listening situation (0% = *cannot do this at all*; 100% = *I am certain I can do this*). The subscales and overall ratings are calculated by taking the average of item responses, with higher ratings being indicative of greater listening self-efficacy.

Hearing Aid Use

Hearing aid experience was quantified using self-reported daily use and lifetime hearing aid experience from the Satisfaction With Amplification in Daily Life Questionnaire (SADL; Cox & Alexander, 1999). Items 16 and 17 measure experience with current hearing aids and cumulative hearing aid experience over their lifetime, and Item 18 measures daily hearing aid use. Each response option for Items 16, 17, and 18 was treated as a categorical variable for analysis (current and lifetime experience of 1 = *less than 6 weeks*, 2 = *6 weeks to 11 months*, 3 = *1–10 years*, 4 = *over 10 years*; daily experience of 1 = *none*, 2 = *less than 1 hr per day*, 3 = *1–4 hr per day*, 4 = *4–8 hr per day*, 5 = *8–15 hr per day*).

Personality

A comprehensive approach was taken to evaluate whether variations in normal personality can affect listening self-efficacy by using the NEO Five-Factor Inventory (NEO-FFI; Costa & McCrae, 1985), which has been used in several large-scale studies on hearing aid outcomes (Bentler, Wu, Kettel, & Hurtig, 2008; Cox, Alexander, & Gray, 2005; Cox et al., 2007). Participants completed the NEO-FFI (Costa & McCrae, 1985, 1989) to quantify personality traits within five domains: neuroticism, extraversion, openness, agreeableness, and conscientiousness. The survey is composed of 60 items with 12 items per trait, and each trait is scored individually with no global score. Greater numbers indicate greater degrees of the specified personality trait or greater frequency for experiencing certain feelings (e.g., neuroticism = anger, anxiety, and impulsivity; extraversion = enthusiasm, talkativeness, and action; openness = curiosity, interest, and insightfulness; agreeableness = appreciation, trust, and compliance; conscientiousness = efficiency, reliability, and thoroughness). For the statistical analysis, personality scores were standardized with a mean of 0 and an *SD* of 1 to allow for easier interpretation of interactions with categorical variables.

Data Analysis

A linear mixed model was fitted to the LSEQ data with hearing aid status (unaided, aided) and subscale (DQ, DL, CL, SE) as within-subject factors. Between-subjects factors included variables that were patient centered (age, gender, PTA, personality) and device centered (lifetime/current/daily hearing aid use, SII, directionality, noise reduction). Interactions were included initially but were removed from the model if nonsignificant. Only complete data sets were included in the analysis ($n = 165$).

Results

Table 1 displays demographic, hearing aid, personality, and LSEQ data across all participants (57% male, 43% female), and Table 2 shows Pearson correlations between all variables in the study. Figure 1 shows mean global and subscale LSEQ ratings for both aided and unaided conditions.

Table 1. Demographic, hearing aid, personality, and self-efficacy data across all participants ($n = 165$).

Variable	<i>M</i>	<i>SD</i>	Minimum	Maximum
Age (years)	67.07	10.87	21.00	79.00
PTA (better ear)	40.53	11.51	12.50	70.00
SII (better ear)	60.78	14.34	22.50	90.00
DIR (binaural average)	5.94	4.86	-2.32	20.44
NR (binaural average)	3.68	2.77	-0.62	19.34
Current aid use (SADL Item 16)	2.91	0.48	1.00	4.00
Lifetime aid use (SADL Item 17)	3.25	0.57	2.00	4.00
Daily aid use (SADL Item 18)	4.58	0.72	1.00	5.00
NEO-FFI Neuroticism	16.37	8.75	0.00	44.00
NEO-FFI Extraversion	28.65	6.27	10.00	45.00
NEO-FFI Openness	33.06	6.05	18.00	47.00
NEO-FFI Agreeableness	36.08	5.04	24.00	47.00
NEO-FFI Conscientiousness	34.28	6.44	17.00	47.00
LSEQ DQ: unaided	56.90	26.16	0.00	100
LSEQ DL: unaided	53.92	23.19	0.00	95.00
LSEQ CL: unaided	26.32	19.79	0.00	81.25
LSEQ SE: unaided	41.99	20.65	0.00	87.78
LSEQ DQ: aided	85.18	14.24	35.00	100.00
LSEQ DL: aided	82.92	13.41	23.75	100.00
LSEQ CL: aided	54.04	22.43	0.00	90.00
LSEQ SE: aided	70.38	16.02	15.00	93.89

Note. PTA = pure-tone average; SII = speech intelligibility index; DIR = directionality; NR = noise reduction; SADL = Satisfaction With Amplification in Daily Life; NEO-FFI = NEO Five-Factor Inventory; LSEQ = Listening Self-Efficacy Questionnaire; DQ = Dialogue in Quiet; DL = Directed Listening; CL = Complex Listening; SE = Self-Efficacy global score.

As a reminder, the primary hypotheses were that aided LSEQ ratings would be greater than unaided LSEQ ratings and that these effects would be greater in more simple listening environments than complex listening environments. The overall effect of hearing aid status was significant, $F(1, 156) = 119.44, p < .0001$, with higher self-efficacy ratings reported for aided compared to unaided listening. Across LSEQ subscales, ratings were 27.63 points better under aided listening conditions. The significant main effect of subscale, $F(3, 492) = 598.61, p < .0001$, revealed that LSEQ ratings varied based on listening environment (see Table 1 for values; all paired comparisons between subscales were significant at $p < .0001$); however, the interaction between hearing aid status and LSEQ subscale was not significant ($p > .05$). These results suggest that the effect of wearing hearing aids on LSEQ ratings was consistent across all subscales.

Secondary hypotheses involved factors associated with the degree of improvement in LSEQ ratings with hearing aids; therefore, the interactions between hearing aid status (i.e., aided/unaided) and associated patient- and device-centered variables were evaluated. The interaction between hearing aid status and device-centered effects of SII, noise reduction, and directionality on LSEQ were not significant ($p > .05$), suggesting that the effect of wearing hearing aids on LSEQ ratings did not change with greater degrees of audibility, noise reduction, or directionality. Significant interactions between hearing aid status and other variables

included PTA, conscientiousness, and experience using hearing aids. The significant interaction between hearing aid status and PTA, $F(1, 1141) = 111.24, p < .0001$, supported the observation that the effect of wearing hearing aids on LSEQ ratings increased at a rate of 6.99 points for every 1 *SD* increase in PTA. The Pearson correlation between PTA and the LSEQ SE rating was $-0.489 (p < .0001)$ for the unaided data and $-0.21 (p = .006)$ for the aided data (see Figure 2 and Table 2). The main effect of conscientiousness on LSEQ was not significant, but the interaction with hearing aid status was significant, $F(1, 1141) = 9.14, p = .0026$, showing that for every 1 *SD* increase in conscientiousness, the effect of wearing hearing aids on LSEQ ratings increased by 1.80 points (data not shown). The association between LSEQ and conscientiousness was slightly stronger under aided listening conditions ($r = .07, p = .358$) than unaided listening conditions ($r = -.01, p = .859$); however, neither effect was significant independently (see Table 2).

There were also significant interactions between hearing aid status and all measures of experience using hearing aids: daily hearing aid use, $F(3, 156) = 5.88, p = .0008$ (see Figure 3); current hearing aid experience, $F(3, 156) = 8.29, p < .0001$ (data not shown); and lifetime of hearing aid experience, $F(2, 156) = 4.68, p = .01$ (see Figure 4). Relative to the group reporting the most daily wear time, 8–15 hr a day ($n = 115$), the effect of wearing hearing aids on LSEQ ratings across subscales decreased by 2.55 points for the group wearing hearing aids 4–8 hr a day ($n = 32, p = .09$), 6.98 points for the group wearing hearing aids 1–4 hr a day ($n = 16, p = .0007$), and 12.69 points for the two individuals wearing hearing aids less than 1 hr a day ($n = 2, p = .02$). Relative to the group reporting the most experience with their current set of hearing aids, greater than 10 years ($n = 11$), the effect of wearing hearing aids on LSEQ ratings increased by 11.16 points for the group wearing hearing aids for 1–10 years ($n = 130, p < .0001$) and 8.92 points for the group wearing hearing aids for 6 weeks to 11 months ($n = 24, p = .01$). Relative to the group reporting the most experience with hearing aids over their lifetime, greater than 10 years ($n = 53$), the effect of wearing hearing aids on LSEQ ratings decreased by 3.05 points for those wearing hearing aids for 1–10 years ($n = 102, p = .04$) and increased by 4.35 points for those wearing hearing aids for 6 weeks to 11 months ($n = 11, p = .19$). Note that smaller sample sizes in some groups led to greater error around the mean, which is accounted for in the linear mixed model; hence, the significance of effects may be due to variability around the mean and not to the size of the mean difference between groups. For example, both Figures 3 and 4 show a trend in the median data of greater benefit with hearing aids on LSEQ ratings as experience level increases (measured either daily or over a lifetime). Group sizes differ significantly in the reference groups used for comparisons (e.g., $n = 115$ in the daily use group of 8–15 hr/day; $n = 53$ in the lifetime group of 10+ years), leading to greater variability around the reference

Table 2. Pearson correlations between all variables in the study.

Variable	Predictors												
	Age	PTA	SII	DIR	NR	Experience			NEO-FFI				
						Current	Life	Daily	N	E	O	A	C
Predictors													
Age	—	-.22**	.13	.02	.03	-.13	-.1	.01	-.24**	-.06	-.08	-.03	0
PTA		—	-.71**	-.15	-.06	.13	.43**	.17*	.09	-.06	-.18*	.05	-.02
SII			—	.27**	.18*	-.11	-.26**	.02	-.07	.09	.08	.07	.12
DIR				—	.22**	.11	.03	-.04	-.02	0	.08	.18*	.11
NR					—	.08	.04	0	.07	-.12	.09	-.04	-.02
Experience													
Current						—	.46**	.01	.05	-.02	-.11	0	-.01
Life							—	.17*	-.01	.12	-.06	.22**	.13
Daily								—	-.01	.09	.09	.21**	.03
NEO-FFI													
N									—	-.36**	.07	-.27**	-.42**
E										—	.20**	.28**	.32**
O											—	.24**	.01
A												—	.24**
C													—
Outcomes													
Unaided													
DQ	.02	-.45**	.38**	-.01	.02	-.05	-.21**	-.14	-.13	0	.11	.03	-.06
DL	.07	-.51**	.40**	.01	-.08	-.09	-.28**	-.18*	-.21**	.08	.11	.05	-.01
CL	.05	-.41**	.24**	-.06	-.14	-.11	-.25**	-.22**	-.20**	.14	.12	-.01	-.01
SE	.07	-.49**	.36**	-.02	-.09	-.1	-.28**	-.20**	-.21**	.1	.13	.02	-.01
Aided													
DQ	.17*	-.16*	-.24**	-.12	.02	-.18*	-.1	.07	-.34**	.04	.06	.09	.12
DL	.1	-.21**	.29**	-.09	-.05	-.20**	-.17*	.01	-.30**	.16*	.09	.14	.09
CL	.06	-.19*	.14	-.01	-.09	-.15	-.15	-.06	-.22**	.19*	.1	.01	.04
SE	.1	-.21**	.22**	-.06	-.07	-.18*	-.16*	-.02	-.28**	.19*	.1	.07	.07

Note. PTA = pure-tone average; SII = speech intelligibility index; DIR = directionality; NR = noise reduction; NEO-FFI = NEO Five-Factor Inventory; N = neuroticism; E = extraversion; O = openness; A = agreeableness; C = conscientiousness; DQ = Dialogue in Quiet; DL = Directed Listening; CL = Complex Listening; SE = Self-Efficacy global score.

* $p = .05$ (two-tailed). ** $p = .01$ (two-tailed).

Figure 1. Boxplot of the Listening Self-Efficacy Questionnaire (LSEQ) ratings for each condition (DQ = Dialogue in Quiet; DL = Directed Listening; CL = Complex Listening; SE = Self-Efficacy global score). Boxes represent 25th–75th percentiles, with the middle bar representing the 50th percentile. Potential Tukey outliers are noted as circles.

Figure 2. Scatter plot of the Listening Self-Efficacy Questionnaire (LSEQ) aided and unaided global self-efficacy (SE) ratings in relation to pure-tone average. The circles represent individual data points, and linear regression lines fit to the data are represented as solid (aided) and dashed (unaided) lines.

Figure 3. Boxplot of the Listening Self-Efficacy Questionnaire (LSEQ) unaided and aided global self-efficacy (SE) ratings and the relation to daily hearing aid use (Satisfaction With Amplification in Daily Life Questionnaire, Item 18). Boxes represent 25th–75th percentiles, with the middle bar representing the 50th percentile. Potential Tukey outliers are noted as circles. Sample sizes in each category are as follows: 8–15 hr/day ($n = 115$), 4–8 hr/day ($n = 32$), 1–4 hr/day ($n = 16$), less than 1 hr/day ($n = 2$).

group mean for current and lifetime experience compared to the daily experience reference group.

Because both PTA and hearing aid experience significantly change the hearing aid effect on LSEQ ratings, further post hoc analyses were performed. Those with longer hearing aid experience are likely to be the same individuals

Figure 4. Boxplot of aided and unaided global self-efficacy (SE) ratings from the Listening Self-Efficacy Questionnaire (LSEQ) in relation to lifetime experience wearing hearing aids (Satisfaction With Amplification in Daily Life Questionnaire, Item 17). Boxes represent 25th–75th percentiles, with the middle bar representing the 50th percentile. Potential Tukey outliers are noted as circles. Sample sizes in each category are as follows: greater than 10 years ($n = 53$), 1–10 years ($n = 102$), 6 weeks to 11 months ($n = 11$).

with poorer PTAs and the same individuals who have not experienced unaided listening for quite some time. In fact, Figures 3 and 4 show similar LSEQ median ratings for aided data and a decreasing trend for unaided ratings with greater experience, which could be caused by more severe hearing loss. A series of hierarchical, multiple linear regression models were conducted to evaluate the order effect of these two variables on the benefit LSEQ metric (aided–unaided LSEQ). With PTA entered into the model first ($R^2 = .22$, $p < .0001$), daily hearing aid experience explained less than 4% of additional variance ($p = .006$). With daily hearing aid experience entered into the model first ($R^2 = .07$, $p = .001$), PTA explained 18.2% of additional variance ($p < .0001$). Therefore, PTA and daily hearing aid experience appear to be explaining unique variance in LSEQ degree of improvement, with the PTA effect being greater than the daily hearing aid use effect. Similar trends were observed with both current and lifetime experience metrics. In other words, those with poorer hearing showed the greatest improvement in LSEQ ratings, and further (smaller) improvements were observed with longer experience using hearing aids.

Other main effects that were significant but of tertiary interest to the study included PTA and personality. The significant main effect of PTA on LSEQ, $F(1, 153) = 19.98$, $p < .0001$, revealed poorer LSEQ ratings as hearing loss severity increased, with a decrease of 9.52 points for every 1 SD increase in hearing loss severity. Higher levels of neuroticism were also associated with poorer listening self-efficacy, with a 4.55-point decrease in LSEQ ratings for every 1 SD increase in neuroticism, $F(1, 153) = 11.53$, $p = .0009$ (see Figure 5). No other main effects were significant (i.e., age, gender, or other personality domains; $p > .05$).

Discussion

As previously stated, the effects of listening self-efficacy have not been extensively studied in the field of

Figure 5. Scatter plot of the Listening Self-Efficacy Questionnaire (LSEQ) aided and unaided global (Self-Efficacy [SE]) ratings in relation to the NEO Five-Factor Inventory (NEO-FFI) neuroticism domain. The circles represent individual data points, and linear regression lines fit to the data are represented as solid (aided) and dashed (unaided) lines.

audiology; however, inferences can be made about its value to clinical practice based on evidence from hearing aid self-efficacy. Such evidence supports a relationship between successful hearing aid outcomes and user confidence in ability to overcome issues with basic handling (e.g., hearing aid insertion/removal), advanced handling (e.g., troubleshooting, knowing the parts of their hearing aid), the adjustment period, and aided listening (West & Smith, 2007). Additionally, hearing aid self-efficacy has been linked to help-seeking behavior and increased use of hearing aids (Hickson et al., 2014). Results of this study confirm our prediction that use of hearing aids is associated with an improvement in listening self-efficacy. Severity of hearing loss, length of experience with hearing aids, and personality were identified as contributing factors to that relationship.

Greater degree of hearing loss was related to reduced listening self-efficacy in both the aided and unaided conditions (see Figure 2). Consistent with these results, Smith and West's (2006) findings indicated a significant relationship between audiometric results and hearing aid self-efficacy—adult hearing aid users with more severe hearing losses reported lower hearing aid self-efficacy than those with more mild hearing losses. In addition, poorer performance for word recognition in quiet was associated with lower reported hearing aid self-efficacy. Despite this trend of decreased confidence in ability with greater degrees of hearing loss, the important point to note in our findings is that, with greater degrees of hearing loss, the participants showed more improvement in reported listening self-efficacy between unaided and aided conditions. This suggests that people with more severe hearing loss may perceive more benefit and improved listening confidence from their hearing aids than their peers with milder losses. This is supported by similar findings in a study by Stark and Hickson (2004), who noted that participants with a three-frequency average hearing loss of more than 35 dB showed greater reductions in the Hearing Handicap Inventory for the Elderly (HHIE; Ventry & Weinstein, 1982) score posthearing aid fitting compared to participants with a three-frequency average hearing loss of less than 25 dB—participants with greater degrees of hearing loss experienced a decrease in perceived handicap related to hearing loss than those with milder hearing loss.

Greater degrees of hearing loss are also likely to be associated with longer experience with hearing aids, and the current study revealed that longer experience with hearing aids (either daily, current, or lifetime) was linked with greater improvements in self-efficacy ratings with hearing aids (see Figures 3 and 4). The experience effect was unique, yet smaller, than the PTA effect on improvements in self-efficacy, and both effects appear to be driven by the lower unaided LSEQ ratings reported by those with poorer hearing and longer experience. West and Smith (2007) also found that, in comparison to new hearing aid users (less than 6 months of experience), experienced hearing aid users (6 months or more of experience) had higher self-efficacy for hearing aid-related tasks. Collectively, these findings support treatment with hearing aids

and encourage longer hearing aid use. Additionally, the experience effect seen in our data gives rise to another point to consider—self-efficacy for some behaviors are time sensitive and can plateau. The benefits of high self-efficacy may only predict successful behaviors for a certain amount of time and/or self-efficacy can only improve so much (Clark & Dodge, 1999). An ongoing study of the relationship between listening self-efficacy and amplification should be conducted to understand its long-term effects. It would also be important to prioritize the consideration of variables such as fitting process and sources of experience effects.

Other factors contributed to reported listening self-efficacy, one being personality. Our results found the NEO-FFI personality domains of conscientiousness and neuroticism to have the most prominent effect on listening self-efficacy outcomes, with higher levels of conscientiousness correlated with greater improvement in listening self-efficacy with hearing aids (although of minor effects) and higher levels of neuroticism significantly correlated with lower listening self-efficacy in any listening condition. The conscientiousness domain is defined as a person's inclination to being persistent, productive, and organized, and the neuroticism domain is a person's inclination to experience emotional distress (Marshall, Wortman, Vickers, Kusulas, & Hervig, 1994). Although it is not feasible or clinically useful to modify personality traits, it is useful to understand where the patient is in their adjustment period and long-term feelings about using their hearing aids. Cox et al. (2007) notes that personality effects are present in patients' subjective reports about how much hearing loss limits their quality of life and range of activity. In part of their study, they explored personality traits derived from the NEO-FFI as precursor variables for outcome scores. They found that, when the focus is on the hearing aid user's personal problems and limitations with their devices, personality domains such as neuroticism and agreeableness were associated with the outcome scores of success and acceptance with hearing aids. Success was defined by the user's day-to-day frequency of success while wearing hearing aids and success when faced with the limitations of their devices (HHIE, APHAB global, SADL negative features). Acceptance was defined by psychological acceptance of hearing aids based on daily use, tolerable environmental sounds, and comfortable self-image (APHAB aversiveness, SADL personal image). Lower neuroticism and higher agreeableness scores correlated with higher success and acceptance. Contrary to findings in our study, conscientiousness was not a significant precursor in the Cox et al. study.

Amplification has an overall positive effect on self-reported listening self-efficacy ratings, and further study is necessary to evaluate appropriate next steps. It would also be important to consider other possible directions for interpretation. For example, part of Cox et al.'s (2007) study assessed the relative contribution of personality to self-reports of hearing and fitting outcomes, and personality was found to be associated with self-report outcome data. They found that questionnaire responses focusing

on residual disability postfitting are somewhat related to personality and responses focusing on benefit, use, and satisfaction are less related to personality. These results imply that there is a chance that the personality effects seen in our study could be the effects of personality on outcome questionnaires, in general, rather than the specific assessment of listening self-efficacy. There is research reporting that some aspects of personality can account for some variance in responses to some hearing aid benefit and satisfaction outcome questionnaires (Barry & Barry, 2002; Hutchinson, Duffy, & Kelly, 2005; Wu et al., 2017). The same Cox et al. study also noted that, when using unaided/aided score differences to measure benefit, relationships with personality may be misleading if interpreted on its own. To illustrate, their findings indicated that, for both unaided and aided listening, individuals with higher neuroticism scores on the NEO-FFI reported more problems compared to individuals with lower neuroticism scores. When the aided–unaided HHIE difference scores were computed to determine benefit, the benefit was greater for individuals with higher neuroticism scores. Although accurate, these findings present a counterintuitive relationship. For our purposes, it serves as a reminder to interpret difference scores with attention to the context.

It may be possible to maximize patient benefit by focusing counseling and rehabilitation efforts on improving listening self-efficacy through the four major sources of efficacy: personal performance accomplishments (e.g., successfully understanding in a group conversation), emotional arousal (e.g., stress in response to a challenging listening situation), vicarious experience (e.g., modeling of successful behaviors), and verbal persuasion (e.g., positive reinforcement from significant others; Bandura, 1977, 1992). This may entail more extensive patient instructions with situational role play, group sessions for sharing experience, and the inclusion of family and/or supportive friends. Increased listening self-efficacy may result in a reduction of listening effort, which is the purposeful distribution of mental resources to overcome challenges when performing a task that requires listening (Pichora-Fuller et al., 2016). How an individual decides to allocate their mental resources is dependent on their evaluation of difficulty, their own ability, and the importance of understanding the information, all of which can be complicated by the demands imposed by hearing loss. Higher listening self-efficacy may enhance the listener's judgment of difficulty level and reduce the amount of stress experienced when in complex listening situations (Pichora-Fuller, 2016). Further research is needed to clearly define the clinical implications of these results.

The primary limitation of the current study was the study design. Because this analysis used data from a larger study on hearing aid outcomes using an observational, cross-sectional design, the results are limited in interpretation as with all studies using this design. For example, the hearing aid intervention was not controlled, nor was a placebo group included; therefore, results that are being attributed to the hearing aid may have been due to other

effects instead. Attempts at controlling for the differences in the hearing aid intervention were made (e.g., the SII metrics), but some effects may have been missed. Different results may have been observed using a more robust study design, such as a blinded, randomized control trial, although a meta-analysis suggests that similar effects in health care outcomes can be found across a wide range of study designs (Anglemyer, Horvath, & Bero, 2014).

Conclusion

The primary question evaluated was whether hearing aid use influenced listening self-efficacy and whether the effects differed between subscales of the LSEQ. Of secondary interest was whether hearing aid effects on listening self-efficacy were moderated by age, hearing loss severity, personality, aided audibility, length of hearing aid use, and advanced signal processing. Overall, LSEQ ratings showed a statistically significant improvement between the unaided and aided conditions, which is in support of our primary hypothesis. This trend of improvement occurred in all subscales, with none showing significantly more improvement than the others—participants had more confidence in their listening abilities when using hearing aids regardless of the listening condition. Degree of hearing loss, experience with amplification, and some aspects of personality were found to be moderators of this relationship. Listening self-efficacy ratings may be applicable to clinical practice through individualized modifications to aural rehabilitation and counseling approaches. Further research is necessary to understand the specific sources of personality and experience effects and to explore the options for treatment.

Acknowledgments

We thank our funding sources for making this work possible: the American Speech-Language-Hearing Foundation (C. M.), National Institute on Deafness and Other Communication Disorders Grant R21 DC016380-01 (awarded to C. M.), National Institute on Deafness and Other Communication Disorders Grants R01 DC012769-04 (awarded to Kelly Tremblay and Ruth Bentler), P30 DC004661 (awarded to Edwin Rubel), and U54 TR001356 (awarded to Gary Rosenthal). We thank Xuyang Zhang for statistical assistance. We also thank Elizabeth Stangl, Erin Stewart, Casey Heidorn, Nicole Whittle, and Gina Hone for collecting data and Elisabeth Went for assistance with data analysis.

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