

Emotional Responses to Pleasant Sounds Are Related to Social Disconnectedness and Loneliness Independent of Hearing Loss

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Abstract

The purpose of this study was to evaluate the relationship between emotional responses to sounds, hearing acuity, and isolation, specifically objective isolation (social disconnectedness) and subjective isolation (loneliness). It was predicted that ratings of valence in response to pleasant and unpleasant stimuli would influence the relationship between hearing loss and isolation. Participants included 83 adults, without depression, who were categorized into three groups (young with normal hearing, older with normal hearing, and adults with mild-to-moderately severe hearing loss). Participants made ratings of valence in response to pleasant and unpleasant nonspeech sounds, presented at a moderate overall level in the laboratory. Participants also completed questionnaires related to social disconnectedness and loneliness. Data were analyzed using multiple regression with questionnaire scores as dependent variables. Independent variables were age, gender, degree of hearing loss, perceived hearing handicap, number of depressive symptoms, mean valence rating in response to unpleasant sounds, and mean valence rating in response to pleasant sounds. Emotional responses to pleasant sounds explained significant variability in scores of both social disconnectedness and loneliness. Depressive symptoms also explained variability in loneliness scores. Hearing loss was not significantly related to social disconnectedness or loneliness, although it was the only variable significantly related to ratings of valence in response to pleasant sounds. Emotional responses to pleasant sounds are related to disconnectedness and loneliness. Although not related to isolation in this study, hearing loss was related to emotional responses. Thus, emotional responses should be considered in future models of isolation and hearing loss.

Keywords

self-report, quality of life, aging, hearing disorders, isolation

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Introduction

Isolation represents a significant challenge for clinicians because it is a clear and chronic threat to physical and mental health. Isolation has been linked to a myriad of health consequences, such as poor cardiovascular health, increased susceptibility to disease and increased mortality risk (Berkman & Syme, 1979; Gopinath, Rochtchina, Anstey, & Mitchell, 2013; Perissinotto, Cenzer, & Covinsky, 2012; Tomaka, Thompson, & Palacios, 2006; Uchino, Cacioppo, & Kiecolt-Glaser, 1996; Zhang, Norris, Gregg, & Beckles, 2007), as well as increased risk of dementia and cognitive decline (Bassuk, Glass, & Berkman, 1999; Wang, Karp, Winblad, & Fratiglioni, 2002; Wilson et al., 2007). In addition, social networks facilitate in-home

rehabilitation and reduce the risk of long stays in extended care facilities and hospitals (Anderson et al., 2000; Boaz & Muller, 1994; Skinner, Tennstedt, & Crawford, 1994). Consequently, it is of considerable interest to identify and mitigate factors that increase isolation.

One common distinction in the literature is difference between objective and subjective isolation (e.g., Rook, 1984; Steptoe, Shankar, Demakakos, & Wardle, 2013).

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Objective isolation has been described as a lack of social networks or social engagement; objective isolation has also been termed social disconnectedness (Cornwell & Waite, 2009) or social isolation (Weiss, 1973). Subjective isolation has been described as a sense of lack of belonging or a dissatisfaction with one's social network (Dahlberg & McKee, 2014); subjective isolation has also been termed loneliness (Step toe et al., 2013) or emotional isolation (Weiss, 1973). Subjective and objective isolation have been shown to differentially affect mortality (Step toe et al., 2013) and health outcomes (Cornwell & Waite, 2009) and are typically only moderately correlated (Tomaka et al., 2006; Van Baarsen, Snijders, Smit, & Van Duijn, 2001). For the remainder of the article, "disconnectedness" will be used to indicate objective isolation, and "loneliness" will be used to indicate subjective isolation.

Hearing loss is one factor that has received considerable research attention as a potential risk factor for isolation, which is not surprising given its high prevalence, particularly among the aging population (e.g., Lin, Thorpe, Gordon-Salant, & Ferrucci, 2011). In situations where hearing is difficult and greater cognitive resources are necessary for communication (e.g., Murphy, Craik, Li, & Schneider, 2000; Picou & Ricketts, 2014), it might be expected that adults with hearing loss would socially withdraw or avoid social encounters. For example, if communication is difficult, a person might choose to simply skip an event when motivation for attending is not high enough (Matthen, 2016). The consequences of this type of withdrawal could be significant. Monzani, Galeazzi, Genovese, Marrara, and Martini (2008) suggest that limited social engagement secondary to hearing loss leads to depressive symptoms and irritability, both of which compound the problem of isolation.

Indeed, researchers have confirmed a relationship between hearing loss using measures that evaluate disconnectedness and loneliness (Chia et al., 2007; Mick, Kawachi, & Lin, 2014; Perissinotto et al., 2012; Sung, Li, Blake, Betz, & Lin, 2016). For example, in a large scale population study, Hawthorne (2008) found that self-reported hearing loss was the second strongest predictor of loneliness behind depression. Similarly, Weinstein and Ventry (1982) reported that among United States military veterans, perceived hearing difficulties accounted for the greatest proportion of variance in loneliness scores. The relationship was related to degree of hearing loss; individuals with more perceived hearing difficulties were likely to report more loneliness.

However, not all studies have confirmed a consistent association between hearing loss and isolation. Several investigators have reported that the association is limited to certain subgroups. For example, Mick et al. (2014) found a significant relationship between hearing loss

and isolation, but only for women aged 60 to 69 years. Conversely, Pronk et al. (2011) have reported associations between hearing loss and isolation for men who were non-hearing aid users, men who deny their hearing loss, those with chronic health conditions, and people with higher socioeconomic status (Pronk, Deeg, & Kramer, 2013). Furthermore, Stam et al. (2016) reported that the relationship between hearing-in-noise ability was significantly related to isolation, but only for participants with a higher educational level.

One of the themes in the literature that can explain the apparent inconsistencies in the findings is advanced age, which could have a complex effect on the interaction between hearing loss and isolation. Specifically, the prevalence of hearing loss increases with age (e.g., Lin et al., 2011). However, the overall prevalence of isolation might actually decrease with age due to unbalanced samples resulting from the increased mortality rate associated with isolation (e.g., Mick et al., 2014). Furthermore, older adults tend to have lifestyles which put fewer demands on hearing (Wu & Bentler, 2012), so hearing loss might have a smaller psychosocial effect for an older adult than a younger one. These factors might explain some of the inconsistent findings, particularly in studies where specific age-related subgroups demonstrated a significant relationship between hearing loss and isolation.

Emotional Responses

One factor not previously investigated as affecting the relationship between hearing loss and isolation is auditory emotion perception. There are at least two general facets related to auditory emotion, emotion recognition, and elicited emotion (Picou et al., 2018). For this article, emotion recognition is defined as a listener's ability to identify or recognize the emotional content in a message. Emotion recognition is often measured as a listener's ability to perceive emotion in others. Conversely, elicited emotion is defined here as the degree to which someone is affected by emotional stimuli. That is, elicited emotion is measured as a listener's own emotional response to a stimulus. Both emotion recognition and elicited emotion have the potential to affect isolation. However, the focus of this article is on elicited emotion, specifically in response to sounds.

Most of the variability in emotional responses can be captured with two dimensions: valence (pleasant vs. unpleasant) and arousal (exciting vs. calming; Bradley & Lang, 1994; Osgood, Suci, & Tannenbaum, 1957; Russell, 1980; Russell & Mehrabian, 1977; Watson & Tellegen, 1985). According to this dimensional view, emotions can be high or low on either dimension. Bradley, Codispoti, Cuthbert, and Lang (2001) propose that the two dimensions reflect the underlying

organization of human behavior. The authors argue that the arousal dimension reflects the intensity of an experienced emotion, whereas the valence dimension reflects direction. Unpleasant or aversive stimuli serve to prepare a body for action (e.g., tending to a crying baby), while pleasant or appetitive stimuli serve to motivate a person to move toward them to enhance a person's well-being (e.g., listening to music; Lang, 1995).

Based on this theory of behavioral organization, one might expect that factors which limit pleasant or appetitive responses to situations would reduce the likelihood that a person would approach a situation. Within the context of social function, if responses to pleasantly valenced stimuli were more neutral, it would be reasonable to expect a person to be less likely to approach or engage in pleasant social situations, especially under less than optimal circumstances. In other words, without the reward of pleasant emotions, the cost of participating might outweigh the reward, which would lead to increased motivation to perform alternative tasks, such as watching television alone. Although not the only factor, reduced pleasant emotional responses might limit motivation for leaving the house, which might eventually lead to isolation.

If a listener's emotional responses to unpleasant or aversive stimuli are somehow heightened, they might also be less likely to approach or engage in social activities if they find sounds they encounter to be aversive. Consistent with this hypothesis, Cacioppo, Norris, Decety, Monteleone, and Nusbaum (2009) found that people who are lonely are less rewarded by visual social stimuli compared to people who are not lonely. The authors also reported that people who are lonely were more sensitive to unpleasant social pictures than their nonlonely counterparts.

Emotional Responses and Hearing Loss

One factor that has recently been shown to affect ratings of valence in response to pleasant and unpleasant auditory stimuli in laboratory settings is hearing loss. To date, two studies have documented effects of hearing loss on elicited emotion. Husain, Carpenter-Thompson, and Schmidt (2014) used a combination of imaging and behavioral tasks to evaluate responses to emotional stimuli for middle-aged listeners with normal hearing or mild-to-moderate hearing loss. Results indicated that listeners with hearing loss were less affected by both pleasant and unpleasant emotional stimuli than their peers with normal hearing. The behavioral results were also reflected by differences in cortical activation between groups. These findings are consistent with those reported by Picou (2016), which indicated listeners with mild-to-moderate hearing loss demonstrated a reduced range of ratings of valence in response to nonspeech sounds

compared to similarly aged listeners with normal hearing. Although hearing loss disrupts ratings of valence and hearing loss increases the risk of isolation, the relationship between ratings of valence and isolation has not been previously evaluated.

Purpose

The purpose of this project was to evaluate the relationship between emotional responses measured in the laboratory, isolation, and hearing acuity. The Social Disconnectedness and Perceived Isolation scales (Cornwell & Waite, 2009) were used to measure objective and subjective isolation, respectively. It was expected that hearing loss would explain some of the variability in isolation. In addition, based on the dimensional view of human behavior organization proposed by Bradley et al. (2001), it was expected that ratings of valence in response to pleasant and unpleasant sounds would explain additional variability in isolation. Specifically, it was expected that people with hearing loss who rated pleasant and unpleasant sounds as neutral would be more likely to exhibit isolation than their peers who rated pleasant sounds as pleasant and unpleasant sounds as unpleasant.

Materials and Methods

Participants

Participants included 83 native English-speaking adults (51 females), all of whom participated in this study as part of one of two larger study protocols. Forty participants were included in a previous study investigating the effects of hearing loss on emotional responses to sounds (Picou, 2016). The remainder participated in a study related to hearing aids and emotional responses (unpublished data). Both studies included groups of listeners with normal hearing. Participants with normal hearing were identified via word of mouth in the Department of Hearing and Speech Sciences and also via e-mail blast to Vanderbilt University Medical Center affiliates who have opted in to research recruitment notifications. Participants with hearing loss were recruited via the Vanderbilt Bill Wilkerson Center hearing clinic; potential participants were identified via chart review and were mailed a letter inviting them to participate in the study. Scheduling was accomplished via follow-up phone calls or e-mail exchanges.

Participant demographics are shown in Table 1. Participants were not at an elevated risk of depression, based on the depression subscale of the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). Most participants exhibited low risk of anxiety, as evidenced by HADS-anxiety scores less

Table 1. Participant Demographics for the Three Types of Participants.

Variable	Young listeners with normal hearing	Older listeners with (near) normal hearing	Listeners with hearing loss
Number	15	39	29
Gender ^a	11 females and 4 males	27 females and 12 males	12 females and 17 males
Married or living with significant other	10 yes; 5 no	28 yes; 10 no	21 yes; 8 no
Age (years) ^a	26.1 (3.9)	57.3 (7.7)	63.9 (10.5)
Age range	22–34	48–80	23–75
Pure-tone average (dB HL; 0.5, 1.0, 2.0, 4.0 kHz) ^a	20	15.3 (4.6)	39.3 (10.9)
Pure-tone average range	20–20	6.7–24.7	16.3–58.1
HADS-Anxiety score	6.8 (3.7)	4.2 (2.6)	4.1 (2.7)
Anxiety range	0–15	0–11	0–9
HADS-Depression score ^a	2.4 (3.2)	1.2 (1.7)	2.0 (2.3)
Depression range	0–11	0–8	0–8
HHIA score ^a	0.0 (0.0)	2.67 (6.1)	25.0 (19.1)
HHIA range	0–0	0–32	0–90
Duration of hearing loss (years)			11.6 (7.2)
Duration range			0.5–30
Number of experienced hearing aid users			23
Duration of hearing aid use (years)			3.6 (5.5)
Duration range			0.25–20.0

Note. Numbers reflect means, numbers in parentheses reflect standard deviations, and ranges are displayed in the row below each demographic.

^aDemographic variables included in multiple linear regression analyses. HADS=Hospital Anxiety and Depression Scale; HHIA=Hearing Handicap Inventory for Adults total score.

than 9. One participant (33-year-old woman with normal hearing) was at an elevated risk of anxiety, as evidenced by HADS-anxiety score larger than 11. Four additional participants (22-, 23-, 26-, and 48-year-olds with normal hearing) demonstrated a slightly elevated risk of anxiety as evidenced by HADS-anxiety scores larger than 9. Despite elevated risk of anxiety, these participants were included in data analyses. All participants denied recent history of otologic, psychiatric, neurogenic, or cognitive disorders. Participants also denied use of antidepressants. All participants exhibited normal middle ear function, as evidenced by normal middle ear immittance measures and air-bone gaps of less than 15 dB. Hearing thresholds were symmetrical, as evidenced by interaural-asymmetries <20 dB at any one frequency and <15 dB at any three consecutive audiometric frequencies. In addition, participants had normal, or corrected normal, vision, as evidenced by self-report. Participants all had at least a high school education and sufficient dexterity to manipulate a computer keypad.

Participants' better ear, pure-tone average (PTA) thresholds were calculated based on air conduction audiometric hearing thresholds of 0.5, 1.0, 2.0, and 4.0 Hz. Participants with normal hearing who were young did not undergo full audiometric evaluation and

were instead screened at 20 dB HL as part of the procedures outlined in Picou (2016). For the purpose of this study, they were each assigned PTA values of 20 dB as a conservative estimate of their hearing thresholds. Measured hearing thresholds for the remainder of the participants are shown in Figure 1.

Participants exhibited a range of perceived hearing handicap, as evidenced by their scores on the Hearing Handicap Inventory for Adults (HHIA; Newman, Weinstein, Jacobson, & Hug, 1990), shown in Table 1. The HHIA consists of 25 questions related to social (12 questions) or emotional (13 questions) effects of hearing loss. For each question, response options are *yes* (4 points), *sometimes* (2 points), and *no* (0 points). Thus, the range of possible total scores (combined across social and emotional scales) is 0 to 100. Participants were instructed to complete the HHIA and HADS scales based on their perception during every day activities with or without hearing aids, whichever was most common. All study recruitment and data collection procedures were conducted with approval from Vanderbilt University Medical Center's Institutional Review Board (#140837 and #150523). Study procedures were explained to the participants, who provided written consent prior to testing. Participants were compensated for their time.

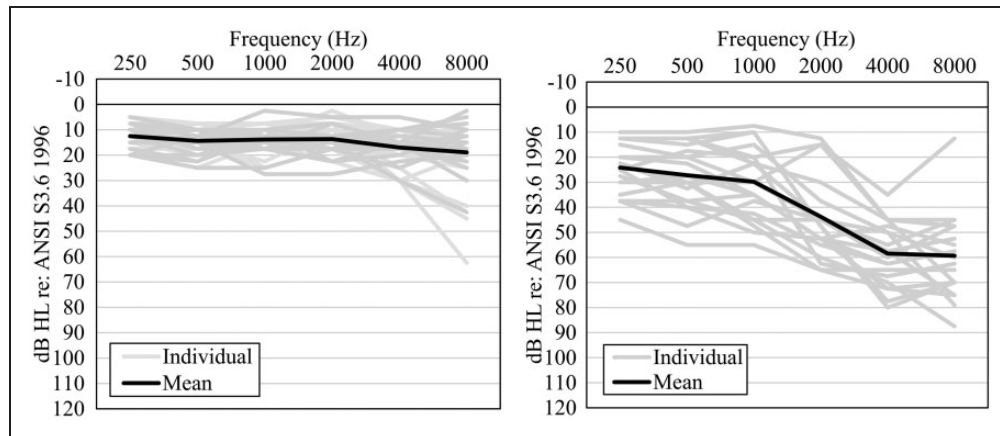


Figure 1. Mean right and left pure-tone, air conduction audiometric thresholds for study participants with normal or near normal hearing (left panel) and with hearing loss (right panel). Light gray lines indicate individual participants and black lines indicate mean data for the group.

Isolation

Participants completed the Social Disconnectedness and Perceived Isolation Scales (Cornwell & Waite, 2009). All participants completed the scales in a “paper and pencil” format. Cornwell and Waite’s (2009) Social Disconnectedness scale consists of 11 questions related to social isolation. Six of the 11 questions are related to the size of the respondent’s social network (marriage status, number of cohabitants, number of friends, and number of children). The remaining five questions are related to the frequency of social activity. For each activity, participants indicate on a scale of 0 to 7 how often they engage in an activity, where 0 indicates “never” and 7 indicates “every day of the week.”

To calculate a total Disconnectedness score, the responses to the question related to number of friends and the questions related to frequency of activities were summed. Regarding number of friends, a score of “1” was assigned to the response “more than 20,” a score of “2” was assigned to the response “10–20,” a score of “3” was assigned to the response “4–9,” a score of “4” was assigned to the response option “2–3,” a score of “5” was assigned to the response option “1,” and a score of “6” was assigned to the response “0.” For the questions related to frequency of activities, responses were subtracted from 7, so if someone participates in an activity 7 days a week, the score would be “0.” In this manner, higher scores on the Disconnectedness scale reflect more disconnectedness, as indicated by fewer friends and less frequent social participation. Using this scoring method, total possible scores range from 1 (*not disconnected*) to 42 (*very disconnected*). See Table 2 for median responses to each question and calculated total scores. The items within the scale had high internal consistency (DeVellis, 2016), as evidenced by an overall Cronbach’s

α values of .73, which was approximately equal across all three groups.

Cornwell and Waite’s (2009) Perceived Isolation scale consists of nine questions. Three questions in this scale relate to how often a respondent feels they can talk about worries with their family, friends, and spouse (if applicable). Three questions related to how often a respondent feels they can rely on their family, friends, and spouse (if applicable) if they have a problem. Response options were 1—*often*, 2—*some of the time*, or 3—*hardly ever or never*. Analysis of responses to these six questions revealed poor internal consistency for the young listeners with normal hearing (Cronbach’s $\alpha = .28$), although higher internal consistency for the older listeners with normal hearing and the listeners with hearing loss (Cronbach’s $\alpha = .66$ and $.87$, respectively). Consequently, the responses to these six questions were not analyzed further.

The remaining three questions of the Perceived Isolation Scale explicitly ask how often a respondent lacks companionship, feels left out, and feels isolated. Response options were 1—*hardly ever*, 2—*some of the time*, or 3—*often*. Responses to these three questions were summed to create a score, now referred to as the Loneliness Scale; possible scores ranged from 3 (*not lonely*) to 9 (*lonely*). See Table 3 for median responses to each question, calculated total scores. The scale was internally consistent (Cronbach’s $\alpha = .82$) and approximately equal across all three participant groups.

Emotional Responses

Laboratory testing included a hearing evaluation (or hearing screening) and responding to emotionally evocative nonspeech sounds. The nonspeech sounds used were 61 tokens from the International Affective Digitized

Table 2. Central Tendencies for Each Group of Listeners on the Disconnectedness Scale.

Scale question	Young listeners with normal hearing	Older listeners with (near) normal hearing	Listeners with hearing loss
Live alone	6 yes; 9 no	6 yes; 33 no	8 yes; 21 no
Have spouse or significant other	10 yes; 5 no	29 yes; 10 no	21 yes; 8 no
Number of children (standard deviation)	0.3 (0.7)	1.8 (1.1)	1.6 (1.1)
Number of grandchildren	0 (0.0)	0.9 (1.6)	1.6 (1.8)
Number of friends (range) ^a	“4–9” (“2–3” to “10–20”)	“4–9” (“1” to “10–20”)	“4–9” (“1” to “10–20”)
Frequency of attendance of organized meetings ^a	5 (2–7)	5 (0–7)	6 (0–5)
Frequency of socialization with friends ^a	3 (0–6)	3 (0–6.5)	3 (0–6)
Frequency of socialization with neighbors ^a	6 (3–6)	5 (0–7)	6 (0–7)
Frequency of volunteer activities ^a	7 (1–7)	6 (0–7)	6 (0–7)
Frequency of religious services ^a	7 (1–7)	6 (2–7)	6 (0–7)
Median Disconnectedness Score	30 (15–37)	28 (8–39)	28 (8–37)
Mean Disconnectedness Score (standard deviation)	28.9 (5.4)	27.5 (7.4)	26.7 (6.7)
Standardized Disconnectedness (standard deviation)	0.19 (0.80)	–0.01 (1.10)	–0.13 (0.99)

Note. Unless otherwise indicated, values reflect median, with the range in parentheses. Responses to questions related to frequency are on a scale of 0 to 7 where 0 indicates every day of the week and 7 indicates never. Standardized z-scores in the bottom row were used for multiple regression analysis.

^aTotal score reflects the sum of questions.

Table 3. Central Tendencies for Each Group of Listeners on the Loneliness Scale.

Question	Young listeners with normal hearing	Older listeners with (near) normal hearing	Listeners with hearing loss
Lack companionship ^a	1 (1–3)	1 (1–3)	1 (1–3)
Feel left out ^a	1 (1–3)	1 (1–3)	1 (1–3)
Feel isolated ^a	1 (1–3)	1 (1–3)	1 (1–2)
Median Loneliness Score	4 (3–8)	3 (3–8)	3 (3–8)
Mean Loneliness Score (standard deviation)	4.20 (1.52)	4.03 (1.46)	3.86 (1.30)
Standardized Loneliness Score (standard deviation)	0.14 (1.08)	0.02 (1.04)	–0.10 (0.93)

Note. For each question, values of 1, 2, and 3 indicate “hardly ever,” “some of the time,” and “often,” respectively. Unless otherwise indicated, values reflect median, with the range in parentheses. Standardized z-scores in the bottom row were used for analysis.

^aTotal score reflects the sum of questions.

Sounds (IADS) Corpus (Bradley & Lang, 2007), a large corpus of nonspeech sounds which elicit a range of valence and arousal responses (Bradley & Lang, 2000). Participants rated 26 tokens expected to elicit pleasant responses (e.g., applause, laughter, birds chirping) and 35 tokens expected to elicit unpleasant responses (e.g., dentist drill, crying, vomiting). See the Appendix for the list of sounds and their expected valence category. The sounds were 1.5 s in length and matched for peak level.

The Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was used to assist participants in rating their emotional responses. The SAM includes figures representing the valence and arousal dimensions of emotion. For each dimension, the SAM has five cartoons illustrating the range of the dimension (e.g., for valence, the pictures range from a smiling face to a frowning face

with a neutral face in the middle). Possible scores range from 1 to 9, where 9 indicates a high score on a dimension (very pleasant or very exciting) and 1 indicates a low score on the dimension (very unpleasant or very calming).

During testing in the laboratory, a participant was seated in the center of a sound-attenuating, audiometric test booth (4.0 × 4.3 × 2.7 m) while facing a computer screen (21.5-in. Dell S2240T) and holding a universal serial bus (USB) keypad (Targus). Stimuli were presented from a computer (Dell) outside the test booth via custom programming (Neurobehavioral Systems Presentation v 14) to an audiometer (Madsen Orbiter 922 v.2) for level control and then to a transducer (see later for transducer details). During stimulus presentation, a black cross was displayed on a white background.

Table 4. Mean Rating of Valence for Each Group of Listeners.

Stimulus category	Young listeners with normal hearing	Older listeners with (near) normal hearing	Listeners with hearing loss
Pleasant	6.26 (0.86)	6.89 (0.86)	6.08 (0.86)
Unpleasant	3.42 (0.62)	3.46 (0.95)	3.74 (0.60)

Note. Numbers in parentheses reflect standard deviation. Ratings of valence range from 1 (most unpleasant) to 9 (most pleasant), with 5 indicating neutrality.

After each sound finished playing, the SAM valence scale was displayed with the numbers 9 through 1 marked under the figures. A participant was expected to make a numerical response using the keypad. Following the valence rating, the SAM arousal figures were displayed with the numbers 9 through 1 indicated under the figures. A participant was expected to make another rating using the computer keypad. Testing was self-paced, although participants were instructed not to spend too long on any single item.

Stimuli were presented in a random order at a moderate input level. Because participants were tested as part of one of two larger study protocols, the presentation level was 50 dBA for 25 participants, 60 dBA for 40 participants, and 65 dBA for 18 participants. In addition, the transducer was either headphones (Sennheiser HDA 200; $n = 42$) or a loudspeaker (Tannoy Series 600; $n = 41$). Because previous work suggests that presentation level does not affect emotional responses to sounds across input levels between 50 and 65 dBA (Picou, 2016), the difference in level was not expected to affect the results (confirmed statistically for the current data set later).

To calibrate the test stimuli, a steady state noise with the same long-term average shape and level as test stimuli was created and used for setting the audiometer prior to testing. The sampling rate of all the stimuli and the calibration noise was 44.1 kHz. Immediately prior to testing, participants were instructed according to the IADS manual. They were also instructed that they could change their response if they changed their mind or accidentally pressed the wrong button. The most recent response was the one used for data analysis. Because the valence dimension is thought to underlie human behavior organization (Bradley et al., 2001) and hearing loss has previously been shown to affect valence, but not arousal (Picou, 2016), the focus of this article is on the ratings of valence. Table 4 shows the mean rating of valence for each group in each expected stimulus category.

Data Analysis

Multiple regression analyses were conducted with social disconnectedness or loneliness scores as dependent variables. To facilitate data interpretation and analysis,

scores for each scale were converted to z -scores based on the sample mean and standard deviation, where positive values reflect more disconnectedness or loneliness. These converted scores were used in all analyses. Each analysis included six independent variables: (1) gender (male and female), (2) age (in years), (3) better ear PTA (average of 0.5, 1.0, 2.0, 4.0 kHz in dB HL), (4) perceived handicap (total HHIA score; higher value indicates higher perceived handicap), (5) depressive symptoms (HADS-D scale, higher value indicates more depressive symptoms), (6) mean valence ratings of unpleasant IADS stimuli (lower value indicates higher perceived unpleasantness), and (7) mean valence rating of pleasant IADS stimuli (higher value indicates higher perceived pleasantness).

Prior to multiple regression analyses, cases with leverage values greater or equal to 0.5 and studentized residuals of greater than three standard deviations were excluded. As a result, three data points were removed, leaving a sample size of 81 for both social disconnectedness and loneliness. Although the responses to individual items on the scales and during the emotional response task are Likert-like and ordinal (e.g., rank ordered), the data entered into regression analyses reflect overall scores based on a combination of scale items or ratings. Thus, the overall scores, which reflect the summing or averaging across individual items, are interval in nature and are appropriate for parametric analysis, such as multiple linear regression (for summary of this argument, see Carifio & Perla, 2008). Importantly, empirical work demonstrates that satisfying the assumptions of normality is more important than the type of measurement scale type for parametric analyses (e.g., Armstrong, 1981; Baker, Hardyck, & Petrinovich, 1966; Kim, 1975; Sullivan & Artino, 2013). Data in this study were normally distributed and met all assumptions necessary for multiple linear regression analysis.

Results

Isolation Scores

Scores on the Disconnectedness and Loneliness Scales were moderately correlated ($r = .32$, $p = .004$). Table 5 shows the results of the regression analysis of the Disconnectedness scores. The overall model was not

Table 5. Regression Coefficients and Standard Errors of the Model of Disconnectedness.

Variable	B	SE _B	β	p
Gender	-0.13	0.25	-0.07	.60
Age	-0.01	0.01	-0.12	.33
Pure-tone average	-0.02	0.01	-0.21	.17
Hearing handicap	0.01	0.01	0.08	.62
Depressive symptoms	0.03	0.05	0.07	.52
Valence rating of unpleasant stimuli	0.01	0.15	0.01	.92
Valence rating of pleasant stimuli	-0.31	0.13	-0.30	.022*

Note. B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; β = standardized coefficient; p = significance value.

*p < .05.

significant, $F(7, 72) = 1.77$, $p = .09$, $1 - \beta = 0.77$, adj $R^2 = .07$. Of the six independent variables included, only emotional responses to pleasant sounds explained a significant portion of the variance in social disconnectedness ($p < .05$); higher ratings of valence were associated with less social disconnectedness.

Table 6 shows the results of the regression analysis of the Loneliness scores. The overall model was significant, $F(7, 72) = 3.65$, $p < .01$, $1 - \beta = 0.89$, adj $R^2 = .19$. Of the six independent variables included, two variables added statistically significantly to the prediction, number of depressive symptoms ($p < .01$) and emotional responses to pleasant sounds ($p < .05$). Fewer depressive symptoms and higher ratings of valence were both associated with less loneliness.

Exploratory Analyses of Isolation

Note that the regression analyses did not include all potentially relevant dependent variables. For example, a person's experience with hearing loss, as indicated by duration of loss, might affect isolation. However, in this study population, duration of hearing loss and PTA were significantly correlated ($r = .75$, $p < .001$). Thus, the collinearity of degree and duration of hearing loss would have confounded the multiple regression analyses.

Excluded from original analyses were two variables that have been related to isolation, including socioeconomic status (e.g., Perissinotto et al., 2012), and hearing aid use (Joore, Brunenberg, Chenault, & Anteonis, 2003; Pronk et al., 2013; Stam et al., 2016; Tesch-Römer, 1997; Weinstein, Sirow, & Moser, 2016). It is also possible that the assignment of 20 dB HL thresholds for younger participants with normal hearing affected the regression results. However, the inclusion of socioeconomic status (as indicated by median income for a participant's zip code) and hearing aid use (as indicated by the length of

Table 6. Regression Coefficients and Standard Errors of the Regression Model of Loneliness.

Variable	B	SE _B	β	p
Gender	0.22	0.23	0.11	.34
Age	-0.004	0.01	-0.07	.53
Pure-tone average	-0.02	0.01	-0.23	.11
Hearing handicap	0.01	0.01	0.12	.42
Depressive symptoms	0.14	0.05	0.34	.003**
Valence rating of unpleasant stimuli	0.12	0.14	0.10	.39
Valence rating of pleasant stimuli	-0.32	0.12	-0.32	.01*

Note. B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; β = standardized coefficient; p = significance value.

*p < .05. **p < .01.

hearing aid experience) did not affect the results of the regression analyses, neither did changing the threshold assignment for younger listeners with normal hearing to a more conservative estimate of 10 dB HL.

Finally, sound stimuli in the study included a mixture of nonspeech sounds, some of which convey social information (e.g., laughter, crying) and some of which do not (e.g., carousel, hiccup). Previous work demonstrates that lonely and nonlonely participants are evident in responses to social stimuli, but not nonsocial stimuli (Cacioppo et al., 2009; Silva et al., 2017). To explore the possibility that the nature of the sounds influenced the relationship between emotional responses and isolation, emotional responses were calculated separately for responses to social and nonsocial sounds (see Appendix for indication of which sounds were labeled "social"). Emotional responses to both social and nonsocial sounds were highly correlated ($r = .70$, $p < .001$ for pleasant and $r = .54$, $p < .001$ for unpleasant). In addition, both exhibit high internal reliability (Cronbach's $\alpha = .81$ and $.70$ for pleasant and unpleasant sounds, respectively). These data indicate that responses to social and nonsocial sounds used in this study were quite similar, but not identical. Exploratory multiple regression analyses using responses to social and nonsocial sounds separately revealed responses to pleasant social sounds might be more strongly related to disconnectedness ($\beta = -0.31$) and loneliness ($\beta = -0.33$) than nonsocial sounds ($\beta = -0.20$ and $\beta = -0.22$ for disconnectedness and loneliness, respectively), supporting the distinction in future investigations.

Ratings of Valence

As a result of the significant contribution of ratings of valence to isolation, it was of interest to evaluate variables that have the potential to explain some of the

variability in emotional responses. The independent variables evaluated were gender (male and female), age (in years), PTA (0.5, 1.0, 2.0, 4.0 kHz in dB HL), and depressive symptoms (HADS-D score). It was also of interest to include variables that were inherent to the data set and could affect emotional responses, notably transducer (headphones and loudspeaker) and stimulus level used for testing (50, 60, or 65 dBA).

Table 7 shows the results of the regression analysis with valence ratings in response to pleasant sounds as the dependent variable. The overall regression model was significant, $F(6, 73) = 2.97, p < .05, 1 - \beta = 0.84, \text{adj } R^2 = .13$. Only PTA explained significant portion of

variance in ratings of valence ($p < .05$); higher degree of hearing loss was associated with less pleasant ratings of pleasant sounds (see Figure 2).

Table 8 shows the results of the regression analysis with valence ratings in response to unpleasant sounds as the dependent variable. The overall regression model was not significant, $F(6, 72) = 2.03, p = .07, 1 - \beta = 0.75, \text{adj } R^2 = .07$. Only gender was statistically significantly related to emotional responses to unpleasant sounds ($p < .05$). Females rated unpleasant sounds as more unpleasant than males (males: $M = 3.84, SD = 0.68$; females: $M = 3.35, SD = 0.81$).

Table 7. Regression Coefficients and Standard Errors of the Regression Model of Ratings of Valence in Response to Pleasant Sounds.

Variable	B	SE _B	β	p
Transducer	0.26	0.23	-0.14	.27
Level	-0.01	0.02	-0.04	.73
Gender	0.43	0.23	0.22	.06
Age	0.01	0.01	0.19	.13
Pure-tone average	-0.02	0.01	-0.29	.012*
Depressive symptoms	-0.04	0.05	-0.10	.41

Note. B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; β = standardized coefficient; p = significance value. *p < .05.

Table 8. Regression Coefficients and Standard Errors of the Regression Model of Ratings of Valence in Response to Unpleasant Sounds.

Variable	B	SE _B	β	p
Transducer	0.05	0.20	0.03	.80
Level	-0.02	0.02	-0.13	.29
Gender	-0.41	0.20	-0.25	.042*
Age	-0.003	0.01	-0.06	.65
Pure-tone average	0.01	0.01	0.17	.15
Depressive symptoms	0.03	0.04	0.09	.47

Note. B = unstandardized regression coefficient; SE_B = Standard error of the coefficient; β = standardized coefficient; p = significance value. *p < .05.

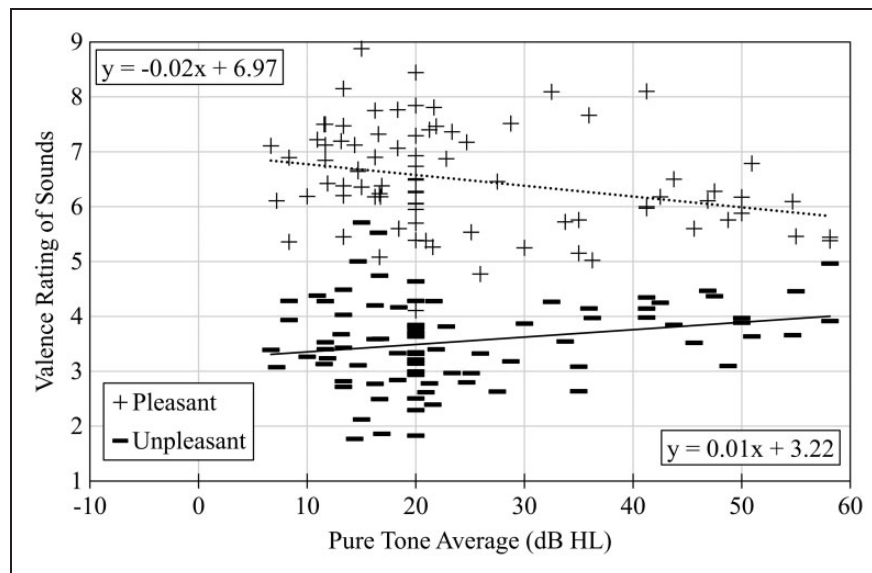


Figure 2. Relationship between degree of hearing loss and emotional responses to pleasant (+) and unpleasant (-) sounds. Linear equations are displayed for each relationship. The relationship between pure-tone average and emotional responses are significant for the pleasant sounds ($p < .05$).

Discussion

Isolation is a threat to physical and mental well-being. Previous work suggests that people with hearing loss, especially older adults, are at increased risk of isolation (Chia et al., 2007; Hawthorne, 2008; Sung et al., 2016; Weinstein & Ventry, 1982). However, the relationship has not been clearly established and is not consistent across studies or populations (Mick et al., 2014; Pronk et al., 2011, 2013; Stam et al., 2016; Weinstein et al., 2016). The purpose of this project was to evaluate the relationship between emotional responses measured in the laboratory, isolation, and hearing acuity. Based on previous work, it was expected that a combination of age, degree of hearing loss, and ratings of valence in response to sounds (both pleasant and unpleasant) would explain significant variability in disconnectedness and loneliness scores.

However, the results of this study suggest that valence ratings of pleasant sounds were the only factor that was significantly related to both disconnectedness and loneliness. Depressive symptoms also explained significant variability in loneliness, consistent with previous findings (e.g., Nolen-Hoeksema & Ahrens, 2002). Age, gender, perceived hearing handicap, PTA, and responses to unpleasant sounds did not significantly explain variability in disconnectedness or loneliness scores. This finding highlights the importance of emotional responses to sounds for disconnectedness and loneliness and also suggests that emotional responses should be considered in future models of isolation and hearing loss. Although the relationships between emotional responses and disconnectedness and loneliness are significant, this study does not answer the question of causality. At least three plausible competing explanations could explain the relationship between ratings of valence and isolation. These are the (1) isolation explanation, (2) common cause explanation, and (3) hearing loss explanation.

Isolation explanation

One possible explanation is that isolation colors emotional responses to sounds measured in the laboratory. Decades of previous literature has documented the significant negative consequences of isolation on coping, cognition, and health (Cacioppo & Hawkey, 2009). Emotional responses to sounds may be one of these secondary consequences of isolation. People who are disconnected might provide responses that are less positive than their nonisolated peers because they have fewer social experiences. If they have limited social encounters or spend most of their time isolated at home, short audio clips of music, laughter, or birds chirping might not conjure pleasant memories of similar experiences in the real world. Furthermore, people who are lonely are less likely to expect positive social

interactions (e.g., Gable, 2006). Previous investigations reveal that lonely participants respond less positively to pleasant social images than their nonlonely peers (Cacioppo et al., 2009), although the effect might not generalize to nonsocial, pleasant pictures (Cacioppo et al., 2009; Silva et al., 2017).

Common cause explanation

An alternative hypothesis is that the relationships between emotional responses and disconnectedness or loneliness are driven by a third factor that influences both emotional responses and isolation, but was not measured in this study. For both social disconnectedness and loneliness, the independent variables only explained a small percentage of the variability, 7% and 19%, respectively. An example third factor could be a personality aspect, such as extraversion. Extraversion could simultaneously predispose people to respond positively to pleasant sounds (e.g., Costa & McCrae, 1980; Larsen & Ketelaar, 1989) and to engage in social activities that strengthen their social networks.

Hearing loss explanation

If hearing loss disrupts the way listeners feel about sound in their lives, it might change the likelihood people approach or engage in situations where sounds are typically perceived as pleasant (e.g., cocktail party with music and laughter). This might be especially true if communication in the situations is difficult, perhaps as a result of hearing loss. This hypothesis is partially supported by the finding that well fit hearing aids reduce subjective isolation (Weinstein et al., 2016), suggesting that improving communication in social situations encourages patients to interact socially. However, the role of hearing aids on emotional responses to sound has not yet been reported in the literature and warrants further investigation.

Factors Associated With Emotional Responses

Based on the significant role of ratings of valence in response to pleasant sounds in the statistical models of perceived social function, the variables associated with ratings of valence were evaluated. The data revealed only one factor, degree of hearing loss, was significantly related to emotional responses to pleasant sounds (see Table 7). This finding is consistent with previous work, which identified the negative effect of hearing loss on ratings of valence in response to nonspeech sounds (Picou, 2016) and documented cortical changes associated with hearing loss when listening to non-neutral stimuli (Husain et al., 2014). This study extends the previous findings to demonstrate a relationship between

degree of hearing loss and ratings of valence in response to pleasant, nonspeech sounds.

Unlike pleasant sounds, emotional responses to unpleasant sounds were not related to hearing loss and instead were related to gender (see Table 8). Females rated unpleasant sounds as more unpleasant than males. Previous work suggests that gender can play a role in emotional responses to stimuli (Kamenetsky, Hill, & Trehub, 1997; Lang, Greenwald, Bradley, & Hamm, 1993; Vrana & Rollock, 2002), although previous investigations with the IADS (Bradley & Lang, 2000) and some music samples (Lundqvist, Carlsson, Hilmersson, & Juslin, 2009) have not confirmed gender effects. The present results extend previous findings by demonstrating that gender has an asymmetric effect on emotional responses to nonspeech sounds; women rated unpleasant sounds as more unpleasant than men, whereas gender differences were not apparent in response to pleasant sounds.

Importantly, two factors identified as potentially affecting emotional responses were not associated with ratings of valence. First, two methodological variables were introduced as a result of study design. Specifically, participants were tested as part of two larger study protocols, which employed different stimuli levels and transducers. To ensure stimulus level and transducer did not contribute to the variability associated with responses to pleasant stimuli, they were included in the regression models of ratings of valence. However, as indicated in Tables 7 and 8, neither level nor transducer explained significant variability in emotional responses to sounds.

Finally, age did not explain variability in ratings of valence in response to pleasant or unpleasant stimuli (Tables 7 and 8, respectively). Although there is a positivity bias associated with age reported for some methodologies (Carstensen, Pasupathi, Mayr, & Nesselrode, 2000; Mather & Carstensen, 2005; Mather & Knight, 2005), the results of this study did not support an age effect in emotional responses. This finding is consistent with previous findings reported by (Picou, 2016), who reported no group differences between younger and older listeners with normal hearing. These data are also consistent with the broader literature regarding emotional responses, which suggests that effects of age tend to be small and difficult to measure, particularly with a small set of stimuli (e.g., Mather & Carstensen, 2005; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005; Wieser, Mühlberger, Kenntner-Mabiala, & Pauli, 2006).

Future Directions

The study has some limitations that should be acknowledged. Each limitation represents an area where future research is warranted to fully understand the complex

interplay between hearing loss, emotional responses to sound, and isolation.

Participants. One primary limitation of the study was related to the voluntary, laboratory-based nature of the procedures. Because a visit to the laboratory was necessary, only people who were willing to make a trip to the laboratory participated. Consequently, the results do not reflect a population of participants who are most at risk for isolation. Similarly, the exclusion of people at risk for depression limited the number of participants who were isolated, because people depressed people tend to be isolated (Hawthorne, 2008; Perissinotto et al., 2012). Therefore, the results of the study are only generalizable to people who are not depressed and who are socially engaged enough to voluntarily choose study participation in a laboratory.

Hearing loss configuration. PTA was used as an indication of hearing loss. It is not clear how hearing loss configuration interacts with the spectral content of the stimuli to affect ratings of valence. One might expect the effects of hearing loss to be related to high frequency audibility because most participants exhibited sloping hearing loss (see Figure 1). However, existing models have not successfully identified acoustic cues that encode valence (Banse & Scherer, 1996; Goudbeek & Scherer, 2010; Juslin & Laukka, 2001; Laukka, Juslin, & Bresin, 2005; Picou, 2016). It is possible that degree of low- or high-frequency hearing loss could independently contribute to emotional responses to sounds.

Sample size. This study is limited by the relatively small sample size. Many previous investigations into the relationship between hearing loss and included participants in large-scale, population based samples, such as the Blue Mountain Hearing Study (Chia et al., 2007) and the Health and Retirement Study (Perissinotto et al., 2012), with 2,965 and 1,604 participants, respectively. However, these sample sizes would be difficult to achieve within the context of emotional responses measured in the laboratory, since participants must visit the laboratory to participate. Consequently, the sample size in this study is considerably smaller than other isolation studies.

Conclusions

The purpose of this project was to evaluate the relationship between emotional responses measured in the laboratory, isolation, and hearing acuity. Results revealed that mean ratings of valence in response to pleasant sounds in the laboratory was the only variable that explained significant variability in both disconnectedness and loneliness scores. In turn, only degree of hearing loss explained significant variability in ratings of

valence in response to pleasant sounds. These findings suggest that how a listener responds to pleasant sounds is related to disconnectedness and loneliness; emotional responses could help explain the mixed findings in the literature regarding the relationship between hearing loss and isolation. Future work is warranted to establish the direction of causality of the identified relationships and to develop targeted clinical interventions that can reduce isolation for listeners with hearing loss.

Appendix Stimulus Tokens From the International Affective Digitized Sounds (Bradley & Lang, 2007) and Their Descriptions for Pleasant, and Unpleasant Stimuli.

#	Title	#	Title
Pleasant			
110	Baby ^a	151	Robin ^b
112	Kids ^a	152	Tropi-cal ^b
220	Boy Laugh ^a	363	Horse Race ^b
221	Male Laugh ^a	366	Casino ^b
224	Kids ^a	378	Door- bell ^b
226	Laugh ^a	601	Colonial Music ^b
230	Giggling ^a	721	Beer ^b
351	Clap ^a	725	Soda Fizz ^b
351	Clap ^a	802	Native Song ^b
355	Crowd ^a	808	Bugle ^b
365	Party ^a	811	Bach ^b
110	Baby ^a	816	Guitar ^b
112	Kids ^a	817	Bongos ^b
Unpleasant			
280	Woman Crying ^a	104	Panting ^b
283	Fight ^a	105	Puppy ^b
293	Man Sobbing ^a	106	Growl ^b
295	Couple Sobbing ^a	114	Cattle ^b
296	Woman Crying ^a	116	Buzzing ^b
423	Injury ^a	130	Pig ^b
		255	Vomit ^b
241	Male Cough ^c	319	Office ^b
242	Female Cough ^c	320	Office ^b
243	Couple Sneeze ^c	322	Type Writer ^b
244	Man Wheeze ^c	410	Heli-copter ^b
245	Hiccup ^c	425	Train ^b
250	Male Sneeze ^c	502	Engine Failure ^b
251	Nose Blow ^c	700	Toilet ^b
252	Male Snore ^c	703	Busy Signal ^b
289	Gun Shot ^c	706	War ^b
702	Belch ^c	714	Siren ^b
720	Brush Teeth ^c	719	Dentist Drill ^b

^aStimuli categorized as “social” for exploratory analyses.

^bStimuli categorized as “nonsocial” for exploratory analyses.

^cStimuli not included in the exploratory analyses.

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References

- Anderson, C., Rubenach, S., Mhurchu, C. N., Clark, M., Spencer, C., & Winsor, A. (2000). Home or hospital for stroke rehabilitation? Results of a randomized controlled trial I: Health outcomes at 6 months. *Stroke*, *31*, 1024–1031. doi:10.1161/01.STR.31.5.1024.
- Armstrong, G. D. (1981). Parametric statistics and ordinal data: A pervasive misconception. *Nursing Research*, *30*, 60–62.
- Baker, B. O., Hardyck, C. D., & Petrinovich, L. F. (1966). Weak measurements vs. strong statistics: An empirical critique of S. S. Stevens' proscriptions on statistics. *Educational and Psychological Measurement*, *26*, 291–309. doi: 10.1177/001316446602600204.
- Banse, R., & Scherer, K. R. (1996). Acoustic profiles in vocal emotion expression. *Journal of Personality and Social Psychology*, *70*, 614–636. doi:10.1037/0022-3514.70.3.614.
- Bassuk, S. S., Glass, T. A., & Berkman, L. F. (1999). Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Annals of Internal Medicine*, *131*, 165–173. doi:10.7326/0003-4819-131-3-199908030-00002.
- Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance, and mortality: A nine-year follow-up study of alameda county residents. *American Journal of Epidemiology*, *109*, 186–204. doi:10.1093/oxfordjournals.aje.a112674.
- Boaz, R. F., & Muller, C. F. (1994). Predicting the risk of “permanent” nursing home residence: The role of community help as indicated by family helpers and prior living arrangements. *Health Services Research*, *29*, 391–414.

- Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion, 1*, 276–298. doi:10.1037//1528-3542.1.3.276.
- Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The Self-Assessment Manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*, 49–59. doi:10.1016/0005-7916(94)90063-9.
- Bradley, M. M., & Lang, P. J. (2000). Affective reactions to acoustic stimuli. *Psychophysiology, 37*, 204–215. doi:10.1111/1469-8986.3720204.
- Bradley, M. M., & Lang, P. J. (2007). *The international affective digitized sounds (IADS-2): Affective ratings of sounds and instruction manual*. Technical Report B-3. Gainesville, FL: University of Florida.
- Cacioppo, J. T., & Hawley, L. C. (2009). Perceived social isolation and cognition. *Trends in Cognitive Sciences, 13*, 447–454. doi:10.1016/j.tics.2009.06.005.
- Cacioppo, J. T., Norris, C. J., Decety, J., Monteleone, G., & Nusbaum, H. (2009). In the eye of the beholder: Individual differences in perceived social isolation predict regional brain activation to social stimuli. *Journal of Cognitive Neuroscience, 21*, 83–92. doi:10.1162/jocn.2009.21007.
- Carifio, J., & Perla, R. (2008). Resolving the 50-year debate around using and misusing likert scales. *Medical Education, 42*, 1150–1152. doi: 10.1111/j.1365-2923.2008.03172.x.
- Carstensen, L. L., Pasupathi, M., Mayr, U., & Nesselroade, J. R. (2000). Emotional experience in everyday life across the adult life span. *Journal of Personality and Social Psychology, 79*, 644–655. doi:10.1037//0022-3514.79.4.64.
- Chia, E.-M., Wang, J. J., Rochtchina, E., Cumming, R. R., Newall, P., & Mitchell, P. (2007). Hearing impairment and health-related quality of life: The blue mountains hearing study. *Ear and Hearing, 28*, 187–195. doi:10.1097/AUD.0b013e31803126b6.
- Cornwell, E. Y., & Waite, L. J. (2009). Social disconnectedness, perceived isolation, and health among older adults. *Journal of Health and Social Behavior, 50*, 31–48. doi:10.1177/002214650905000103.
- Costa, P. T., & McCrae, R. R. (1980). Influence of extraversion and neuroticism on subjective well-being: Happy and unhappy people. *Journal of Personality and Social Psychology, 38*, 668–678. doi:10.1037/0022-3514.38.4.668.
- Dahlberg, L., & McKee, K. J. (2014). Correlates of social and emotional loneliness in older people: Evidence from an English community study. *Aging & Mental Health, 18*, 504–514. doi: 10.1080/13607863.2013.856863.
- DeVellis, R. F. (2016). *Scale development: Theory and applications* (vol. 26). Thousand Oaks, CA: SAGE.
- Gable, S. L. (2006). Approach and avoidance social motives and goals. *Journal of Personality, 74*, 175–222. doi:10.1111/j.1467-6494.2005.00373.x.
- Gopinath, B., Rochtchina, E., Anstey, K. J., & Mitchell, P. (2013). Living alone and risk of mortality in older, community-dwelling adults. *JAMA Internal Medicine, 173*, 320–321. doi:10.1001/jamainternmed.2013.1597.
- Goudbeek, M., & Scherer, K. (2010). Beyond arousal: Valence and potency/control cues in the vocal expression of emotion. *Journal of the Acoustical Society of America, 128*, 1322–1336. doi:10.1121/1.3466853.
- Hawthorne, G. (2008). Perceived social isolation in a community sample: Its prevalence and correlates with aspects of peoples' lives. *Social Psychiatry and Psychiatric Epidemiology, 43*, 140–150. doi:10.1007/s00127-007-0279-8.
- Husain, F. T., Carpenter-Thompson, J. R., & Schmidt, S. A. (2014). The effect of mild-to-moderate hearing loss on auditory and emotion processing networks. *Frontiers in Systems Neuroscience, 8*, 1–13. doi:10.3389/fnsys.2014.00010.
- Joore, M. A., Brunenberg, D. E., Chenault, M. N., & Anteunis, L. J. (2003). Societal effects of hearing aid fitting among the moderately hearing impaired: Efectos sociales de la adaptación de auxiliares auditivos en pacientes con impedimentos auditivos moderados. *International Journal of Audiology, 42*, 152–160. doi:10.3109/14992020309090424.
- Juslin, P. N., & Laukka, P. (2001). Impact of intended emotion intensity on cue utilization and decoding accuracy in vocal expression of emotion. *Emotion, 1*, 381–412. doi:10.1037//1528-3542.1.4.381.
- Kamenetsky, S. B., Hill, D. S., & Trehub, S. E. (1997). Effect of tempo and dynamics on the perception of emotion in music. *Psychology of Music, 25*, 149–160. doi:10.1177/0305735697252005.
- Kim, J.-O. (1975). Multivariate analysis of ordinal variables. *American Journal of Sociology, 81*, 261–298. doi: 10.1086/226074.
- Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist, 50*, 372–385. doi:10.1037/0003-066X.50.5.372.
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*, 261–273. doi:10.1111/j.1469-8986.1993.tb03352.x.
- Larsen, R. J., & Ketelaar, T. (1989). Extraversion, neuroticism and susceptibility to positive and negative mood induction procedures. *Personality and Individual Differences, 10*, 1221–1228. doi:10.1016/0191-8869(89)90233-X.
- Laukka, P., Juslin, P., & Bresin, R. (2005). A dimensional approach to vocal expression of emotion. *Cognition & Emotion, 19*, 633–653. doi:10.1080/02699930441000445.
- Lin, F. R., Thorpe, R., Gordon-Salant, S., & Ferrucci, L. (2011). Hearing loss prevalence and risk factors among older adults in the United States. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 66*, 582–590. doi:10.1093/gerona/66.4.582.
- Lundqvist, L.-O., Carlsson, F., Hilmersson, P., & Juslin, P. (2009). Emotional responses to music: Experience, expression, and physiology. *Psychology of Music, 37*, 61–90. doi:10.1177/0305735607086048.
- Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences, 9*, 496–502. doi:10.1016/j.tics.2005.08.005.
- Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging, 20*, 554–570. doi:10.1037/0882-7974.20.4.554.
- Matthen, M. (2016). Effort and displeasure in people who are hard of hearing. *Ear and Hearing, 37*, 28S–34S. doi:10.1097/AUD.0000000000000292.

- Mick, P., Kawachi, I., & Lin, F. R. (2014). The association between hearing loss and social isolation in older adults. *Otolaryngol Head Neck Surg*, *150*, 378–384. doi:10.1177/0194599813518021.
- Mikels, J. A., Larkin, G. R., Reuter-Lorenz, P. A., & Carstensen, L. L. (2005). Divergent trajectories in the aging mind: Changes in working memory for affective versus visual information with age. *Psychology and Aging*, *20*, 542–553. doi:10.1037/0882-7974.20.4.542.
- Monzani, D., Galeazzi, G., Genovese, E., Marrara, A., & Martini, A. (2008). Psychological profile and social behaviour of working adults with mild or moderate hearing loss. *Acta Otorhinolaryngologica Italica*, *28*, 61–66.
- Murphy, D., Craik, F., Li, K., & Schneider, B. (2000). Comparing the effects of aging and background noise on short-term memory performance. *Psychology and Aging*, *15*, 323–334. doi:10.1037/0882-7974.15.2.323.
- Newman, C. W., Weinstein, B. E., Jacobson, G. P., & Hug, G. A. (1990). The hearing handicap inventory for adults: Psychometric adequacy and audiometric correlates. *Ear and Hearing*, *11*, 430–433.
- Nolen-Hoeksema, S., & Ahrens, C. (2002). Age differences and similarities in the correlates of depressive symptoms. *Psychology and Aging*, *17*, 116–124. doi: 10.1037/0882-7974.17.1.116.
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning* (vol. 47). Urbana, IL: University of Illinois Press.
- Perissinotto, C. M., Cenzer, I. S., & Covinsky, K. E. (2012). Loneliness in older persons: A predictor of functional decline and death. *Archives of Internal Medicine*, *172*, 1078–1084. doi:10.1001/archinternmed.2012.1993.
- Picou, E. M. (2016). How hearing loss and age affect emotional responses to nonspeech sounds. *Journal of Speech Language Hearing Research*, *59*, 1233–1246. doi:10.1044/2016_JSLHR-H-15-0231.
- Picou, E. M., & Ricketts, T. A. (2014). The effect of changing the secondary task in dual-task paradigms for measuring listening effort. *Ear and Hearing*, *35*, 611–622. doi:10.1097/AUD.000000000000055.
- Picou, E. M., Singh, G., Goy, H., Russo, F. A., Hickson, L., Oxenham, A. J., ... Launer, S. (2018). Hearing, emotion, amplification, research, and training workshop: Current understanding of hearing loss and emotion perception and priorities for future research. *Trends in Hearing*, *22*, 1–24. doi:10.1177/2331216518803215.
- Pronk, M., Deeg, D. J., & Kramer, S. E. (2013). Hearing status in older persons: A significant determinant of depression and loneliness? Results from the longitudinal aging study Amsterdam. *Am J Audiol*, *22*, 316–320. doi:10.1044/1059-0889(2013/12-0069).
- Pronk, M., Deeg, D. J., Smits, C., van Tilburg, T. G., Kuik, D. J., Festen, J. M., & Kramer, S. E. (2011). Prospective effects of hearing status on loneliness and depression in older persons: Identification of subgroups. *International Journal of Audiology*, *50*, 887–896. doi:10.3109/14992027.2011.599871.
- Rook, K. S. (1984). Research on social support, loneliness, and social isolation: Toward an integration. *Review of Personality & Social Psychology*, *5*, 239–264.
- Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*, 1161–1178. doi:10.1037/0022-3514.36.10.1152.
- Russell, J. A., & Mehrabian, A. (1977). Evidence for a three-factor theory of emotions. *Journal of Research in Personality*, *11*, 273–294. doi:10.1016/0092-6566(77)90037-X.
- Silva, H., Campagnoli, R. R., Mota, B. E. F., Araujo, C. R. V., Alvares, R. S. R., Mocaiber, I., ... Souza, G. G. L. (2017). Bonding pictures: Affective ratings are specifically associated to loneliness but not to empathy. *Frontiers in Psychology*, *8*, 1136. doi:10.3389/fpsyg.2017.011136.
- Skinner, K. M., Tennstedt, S. L., & Crawford, S. L. (1994). Do characteristics of informal caregivers affect the length of hospital stay for frail elders? *Journal of Aging and Health*, *6*, 255–269. doi:10.1177/089826439400600207.
- Stam, M., Smit, J. H., Twisk, J. W., Lemke, U., Smits, C., Festen, J. M., & Kramer, S. E. (2016). Change in psychosocial health status over 5 years in relation to adults' hearing ability in noise. *Ear and Hearing*, *37*, 680–689. doi:10.1097/AUD.0000000000000332.
- Stephoe, A., Shankar, A., Demakakos, P., & Wardle, J. (2013). Social isolation, loneliness, and all-cause mortality in older men and women. *Proceedings of the National Academy of Sciences*, *110*, 5797–5801. doi: 10.1073/pnas.1219686110.
- Sullivan, G. M., & Artino, A. R. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education*, *5*, 541–542. doi: 10.4300/JGME-5-4-18.
- Sung, Y.-k., Li, L., Blake, C., Betz, J., & Lin, F. R. (2016). Association of hearing loss and loneliness in older adults. *Journal of Aging and Health*, *28*, 979–994. doi:10.1177/0898264315614570.
- Tesch-Römer, C. (1997). Psychological effects of hearing aid use in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *52*, P127–P138. doi:10.1093/geronb/52B.3.P127.
- Tomaka, J., Thompson, S., & Palacios, R. (2006). The relation of social isolation, loneliness, and social support to disease outcomes among the elderly. *Journal of Aging and Health*, *18*, 359–384. doi:10.1177/0898264305280993.
- Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*, 488–531. doi:10.1037/0033-2909.119.3.488.
- Van Baarsen, B., Snijders, T. A., Smit, J. H., & Van Duijn, M. A. (2001). Lonely but not alone: Emotional isolation and social isolation as two distinct dimensions of loneliness in older people. *Educational Psychological Measurement*, *61*, 119–135. doi: 10.1177/00131640121971103.
- Vrana, S. R., & Rollock, D. (2002). The role of ethnicity, gender, emotional content, and contextual differences in physiological, expressive, and self-reported emotional responses to imagery. *Cognition & Emotion*, *16*, 165–192. doi:10.1080/02699930143000185.
- Wang, H.-X., Karp, A., Winblad, B., & Fratiglioni, L. (2002). Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: A longitudinal study from the Kungsholmen project. *American Journal*

- of *Epidemiology*, 155, 1081–1087. doi:10.1093/aje/155.12.1081.
- Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, 98, 219–235. doi:10.1037/0033-2909.98.2.219.
- Weinstein, B. E., Sirow, L. W., & Moser, S. (2016). Relating hearing aid use to social and emotional loneliness in older adults. *American Journal of Audiology*, 25, 54–61. doi:10.1044/2015_AJA-15-0055.
- Weinstein, B. E., & Ventry, I. M. (1982). Hearing impairment and social isolation in the elderly. *Journal of Speech Hearing Research*, 25, 593–599. doi:10.1044/jshr.2504.593.
- Weiss, R. S. (1973). *Loneliness: The experience of emotional and social isolation*. Cambridge, MA: MIT Press.
- Wieser, M. J., Mühlberger, A., Kenntner-Mabiala, R., & Pauli, P. (2006). Is emotion processing affected by advancing age? An event-related brain potential study. *Brain Research*, 1096, 138–147. doi:10.1016/j.brainres.2006.04.028.
- Wilson, R. S., Krueger, K. R., Arnold, S. E., Schneider, J. A., Kelly, J. F., Barnes, L. L., . . . Bennett, D. A. (2007). Loneliness and risk of Alzheimer disease. *Archives of General Psychiatry*, 64, 234–240. doi:10.1001/archpsyc.64.2.234.
- Wu, Y.-H., & Bentler, R. A. (2012). Do older adults have social lifestyles that place fewer demands on hearing? *Journal of American Academy of Audiology*, 23, 697–711. doi:10.3766/jaaa.23.9.4.
- Zhang, X., Norris, S. L., Gregg, E. W., & Beckles, G. (2007). Social support and mortality among older persons with diabetes. *The Diabetes Educator*, 33, 273–281. doi:10.1177/0145721707299265.
- Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, 67, 361–370. doi:10.1111/j.1600-0447.1983.tb09716.x.