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Hearing Loss in Older Persons: Does the Rate of Decline Affect Psychosocial Health?

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Abstract

Objective: This study investigates whether the rate of decline in older persons' hearing status is associated with the rate of decrease in their psychosocial health and explores moderation by baseline hearing status, health-related factors, and sociodemographic factors. **Method:** Multilevel analyses were applied to data of 1,178 older participants from the Longitudinal Aging Study Amsterdam (LASA), covering 3 to 7 years of follow-up. **Results:** Faster decrease in speech-in-noise recognition was significantly associated with more increase in loneliness for persons with a moderate baseline speech-in-noise recognition (emotional and social loneliness) and for persons who recently lost their partner (emotional loneliness). No relationship was found with depression. **Discussion:** The results indicate

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that faster hearing decline results in more increase in loneliness in specific subgroups of older persons: in persons with an already impaired hearing and in widow(er)s. Monitoring older persons' hearing seems important and may be a relevant starting point for targeted loneliness prevention efforts.

Keywords
hearing loss, loneliness, psychosocial health, older persons, longitudinal

Introduction

Hearing impairment is one of the most prevalent chronic conditions in Western older populations (Campbell, Crews, Moriarty, Zack, & Blackman, 1999; Cruickshanks et al., 2010). The majority of the cases can be attributed to age-related hearing loss (ARHL), or presbycusis, the typical symmetrical sensorineural hearing loss that occurs with aging. A large individual variation exists in longitudinal patterns of hearing decline (Pearson et al., 1995). Several studies linked a faster deterioration in the speech frequencies to specific subgroups: the relatively older olds, men, women, persons with hypertension, and persons with poor cognition (Chao & Chen, 2009; Kiely, Gopinath, Mitchell, Luszcz, & Anstey, 2012; Pronk et al., 2013).

Hearing impairment in older persons is largely under-recognized and under-treated for reasons that relate to the insidious course of hearing loss, hearing loss stigma, and problems associated with hearing aid use (Knudsen, Öberg, Nielsen, Naylor, & Kramer, 2010). Australian and Dutch population-based data indicate that only around 30% to 40% of older individuals with considerable hearing problems own a hearing aid (Chia et al., 2007; Smits, Kramer, & Houtgast, 2006). As current treatments are not yet able to halt ARHL, all older adults who are faced with hearing loss are challenged to adjust to the generally ongoing and progressive decline.

Many studies showed that poor hearing is related to poor psychosocial health such as depression and loneliness (e.g., Kramer, Kapteyn, Kuik, & Deeg, 2002; Pronk et al., 2011; Saito et al., 2010; Strawbridge, Wallhagen, Shema, & Kaplan, 2000). Supposed causal paths generally include impaired communication, subsequently causing restricted participation in social activities, decreased satisfaction in the fulfillment of social roles, and problems maintaining the social network (e.g., Jones, Kyle, & Wood, 1987; Kramer et al., 2002; Broese van Groenou, Hoogendijk, & van Tilburg, 2013; Ventry & Weinstein, 1982). Thus far, only Corna, Wade, Streiner, and Cairney (2009) took into account the progressive nature of presbyacusis in their analyses. They found a larger but borderline statistically significant ($p = .06$) increase

in psychological distress in persons who declined in hearing as compared with persons who remained stable without hearing impairment (reference group). The stress increase in persons who remained stable with a hearing impairment did not differ from the reference group. This suggests that particularly a decline in hearing causes a decrease in psychosocial health. However, it is unclear whether the *rate* of hearing decline affects psychosocial health.

Poor psychosocial health outcomes following hearing impairment seem to result from an inability to effectively adapt to, or cope with, hearing decline and its consequences on daily life activities and social life (Andersson, Melin, Lindberg, & Scott, 1996). In the coping literature, "adaptation" is considered to differ from "coping" in that "coping" concerns an active role of the individual in adjusting to changing conditions whereas "adaptation" also covers passive and more or less automatic processes of habituation (Andersson et al., 1996; Lazarus & Folkman, 1984).

When an older person's hearing deteriorates slowly, it may require only small behavioral and emotional adjustments, whereas relatively fast declines may require more rigorous adjustments. In the former case, adaptation may play a more prominent role, whereas in the latter case, active coping may be required, and generally, it is more likely that the overall adjustment is less successful and leads to more psychosocial distress. Also, as it is more likely that a slower hearing decline may go unnoticed, automatic adaptation may occur resulting in relatively less distress. In the current study, we therefore hypothesize that a faster hearing decline is associated with a stronger decrease in psychosocial health.

Furthermore, we will explore whether a person's hearing status at baseline moderates the psychosocial effects. Less rigorous coping efforts and more automatic adaptations may be successfully applied in the first stages of ARHL because only relatively small restrictions may be experienced in daily life activities and participation in social life at this point. The individual may be able to compensate for them more effectively than individuals in more advanced stages of ARHL, for whom the ongoing hearing loss has resulted in an accumulation of functional losses. In contrast, when following the concept of "reduced responsiveness to chronic functional impairment" (Bevan, 1965), a different hypothesis can be raised (Schilling & Wahl, 2006; Schilling, Wahl, Horowitz, Reinhardt, & Boerner, 2011). The concept assumes that in a process of increasing impairment, the impairment has a reduced impact on psychological outcomes over time due to automatic adaptation. So, with continued hearing decline, further functional decline would not cause any *more* psychosocial worsening, causing an attenuating relationship between hearing decline and psychosocial health status across accumulated exposure

to hearing problems. In line with this, the relationship between the *rate* of hearing decline and the decrease in psychosocial health would be weaker for those who decline from a relatively poorer baseline hearing status assuming that they have been exposed to the hearing loss for a longer time.

In addition, previous studies showed that age, gender, socioeconomic status, partner status, hearing aid use, and comorbid conditions moderate the relationship between hearing status and psychosocial health (Chen, 1994; Ives, Bonino, Traven, & Kuller, 1995; Nachtegaal et al., 2009; Pronk et al., 2011). We will therefore explore whether such factors moderate the relationship between the rate of hearing decline and psychosocial health.

In summary, in the current study, we will investigate whether there is an association between the rate of hearing decline and the rate of decrease in psychosocial health (i.e., loneliness and depression) in a population-based sample of older adults. The second aim is to investigate whether baseline hearing status, sociodemographic characteristics, and health-related characteristics (age, gender, level of education, level of income, partner status, hearing aid use, comorbid conditions, vision problems, and cognition) moderate this association.

Method

Sample and Procedures

The sample originated from the Longitudinal Aging Study Amsterdam (LASA; Huisman et al., 2011). LASA is an ongoing cohort study on predictors and consequences of changes in autonomy and well-being in an aging population. For the first LASA measurement (1992/1993), a random sample of 3,107 older persons (aged 55-85 years) stratified for age and gender was drawn from the Dutch population. A second young birth cohort (aged 55-64 years) of 1,002 respondents was added in 2002 from the same sampling frame as the original birth cohort. Every 3 to 4 years, a follow-up measurement was conducted. All measurements were performed in the respondent's home by trained and supervised interviewers. Informed consent was obtained from all respondents. The study was approved by the Medical Ethics Committee of the VU University Medical Center.

From 2001/2002, hearing status was measured with a Speech-in-Noise Test (SNT) by telephone (details are described under "Measures" section). Data from this measurement and the subsequent 4- and 7-year follow-up measurements were used for the present study. The measurements will be referred to as T_1/baseline, T_2, and T_3, respectively.

The study sample consisted of 1,178 respondents, of which 607 had complete SNT data for both T_1 and T_2 and 1,000 had complete SNT data for both

T_2 and T_3. For 429 respondents, complete SNT data for all three measurements were available. The number of T_2T_3 observations is higher than that of T_1T_2 because in the new young birth cohort, the SNT was only measured in 2005/2006 and 2008/2009 (T_2 and T_3 of the current study) but not in 2002/2003.

Measures

SNT. The SNT was originally developed as a functional screening self-test by telephone (Smits & Houtgast, 2005; Smits, Kapteyn, & Houtgast, 2004). This test determines an individual's Speech Reception Threshold in noise by telephone (SRT_n) defined as the signal-to-noise ratio (SNR) in decibel (dB) corresponding to 50% intelligibility.

The interviewer used portable testing equipment comprising a telephone, an amplifier, and headphones. On T_3, the telephone and amplifier were replaced by a laptop. Before the actual assessment, hearing aids had to be removed and the respondent was instructed to adjust the level of the speech so as to make sure that signals were sufficiently audible. Subsequently, 23 different monosyllabic digit triplets were presented at different intensity levels against a constant level of stationary background noise according to an adaptive up-down procedure. The SNR decreased by 2 dB if the respondent repeated a triplet correctly and increased by 2 dB after an incorrect response. The SRT_n is determined by calculating the mean SNR of the last 20 presentations. For example, if someone has a score of −5.4 dB SNR, this means that this person understands 50% of the speech correctly if the mean level of the speech is 5.4 dB lower than the level of the noise. Higher (more positive) scores thus indicate poorer hearing. A cutoff of −5.5 dB SNR is generally considered to be the cutoff distinguishing a good SRT_n from a moderate to poor SRT_n. A ceiling of +8 dB SNR was incorporated in the software. Different administration and data collection modes caused slight systematic shifts in the SRT_ns (T_2: −0.86 dB SNR; T_3: −0.49 dB SNR, relatively to T_1 SRT_ns). We estimated the shifts by determining age–gender specific averages of the T_1, T_2, and T_3 SRT_n scores. T_1 averages were regressed on T_2 averages (weighing the data points for the summed sample size). The systematic shift (i.e., the constant in the regression equation) was estimated by setting the regression coefficient on 1. The same procedure was applied to the T_3 shift.

The SNT correlates highly (r = .87) with the standard Dutch sentences SNT (Plomp & Mimpen, 1979) indicating good validity (Smits et al., 2004). Test–retest reliability was satisfactory in an older subsample from Nachtegaal et al. (2009; Intraclass Correlation Coefficient, two-way random effects model = .70, n = 152, 58-82 years).

We calculated SRT_n change scores by extracting the T_1 and T_2 scores from the T_2 and T_3 scores, respectively. Change scores ranged from −8.33 to 7.97 dB SNR. Higher (positive) change scores indicated a faster rate of decline over time. The change scores will be referred to as T_2–T_1 and T_3–T_2.

Social and emotional loneliness. Loneliness was measured with the social (five items) and emotional (six items) loneliness subscale of the De Jong Gierveld scale (De Jong Gierveld & Kamphuis, 1985; De Jong Gierveld & van Tilburg, 1999). Social loneliness relates to felt deficits in social integration and embeddedness, whereas emotional loneliness represents the felt absence of an intimate attachment figure such as a partner or a best friend (Weiss, 1973). Each item held a statement for which the respondent had to indicate to what extent it applied to his or her situation ("no," "more or less," "yes"). The answers were dichotomized with "more or less" and "yes" referring to loneliness (Score 1) and "no" referring to no loneliness (Score 0). All item scores were summed (range = 0-5 for social loneliness; 0-6 for emotional loneliness; higher scores indicated more loneliness). The subscales are valid and reliable (De Jong Gierveld & van Tilburg, 1999; Dykstra & De Jong Gierveld, 2004). In the full T_2 sample, Kuder Richardson–20 (KR-20) coefficients were .78 (n = 1,161) for the social loneliness subscale and .75 (n = 1,162) for the emotional loneliness subscale. This indicated satisfactory internal consistency. T_3–T_2 and T_2–T_1 change scores were calculated for both loneliness measures. Scores ranged from −5 to 5 with higher (positive) scores indicating a higher rate of loneliness increase over time.

Depression. Depression was measured using the Center for Epidemiologic Studies–Depression (CES-D) scale (Radloff, 1977). Respondents had to indicate their rate of agreement (0-3) on 20 statements about feelings during the past week (range of total score = 0-60). A higher score indicated more depressive symptoms. In case of one or two missing items, the score was imputed with the mean value of the sample on this item (T_1: n = 16; T_2: n = 26; T_3: n = 21). The CES-D is widely used in older samples and has good psychometric properties (Beekman et al., 2002). In the full T_2 sample (n = 1,149), a Cronbach's alpha of .86 was found, indicating good internal consistency. T_3–T_2 and T_2–T_1 change scores were calculated (range = −36-32). Higher (positive) scores indicated a higher rate of depression increase over time.

Covariates. We tested confounding, suppressor, and moderator effects of baseline hearing status (SRT_n) and the covariates described below. For covariates that were changeable over time, change scores were calculated and used in the analyses.

Baseline speech reception threshold in noise. Baseline SRT_n (for T_1 and T_2) was categorized into good ($SRT_n < -5.5$ dB), moderate (-5.5 dB $\leq SRT_n \leq -2.8$ dB), and poor ($SRT_n > -2.8$ dB) as defined by Smits and colleagues (2006; Smits & Houtgast, 2005).

Sociodemographic covariates. Age in years (at T_1 and T_2) was included as a continuous variable. Gender was included as a dichotomous variable. Partner status was dichotomized into living with a partner in the household versus not. Change in partner status was categorized into the following: loss of the partner out of the household; stable, living with a partner in the household; and stable, not living with a partner in the household. Because only seven persons changed from living alone to living with a partner, these persons were assigned to the "living with a partner in the household" group. Education included self-reported highest educational level completed and was categorized into the following: low (uncompleted elementary, elementary, lower vocational), medium (general intermediate, intermediate vocational, general secondary, higher vocational), and high (college and university). Net monthly income (henceforth, income) was categorized into low (T_1: less than €815.49), medium (T_1: between €815.49 and €1,350.45), and high (T_1: greater or equal to €1,350.45). For participants with a partner living in the household, household income was multiplied by 0.7 to make it comparable with the incomes in a one-person household. The cutoffs for T_2 and T_3 were corrected for inflation (3% per year). Change in income was categorized into the following: stable, low; stable, medium; stable, high; increased; and decreased.

Health-related covariates. Hearing aid use was determined by asking, "Do you usually use a hearing aid?" ("yes," "no"). Change in hearing aid use was categorized into the following: stable, no hearing aid use; stable, hearing aid use; and started using a hearing aid. Because only 14 persons stopped using a hearing aid, these respondents were assigned to the "stable, no hearing aid use" group. Information on chronic diseases was derived from self-report. Self-report on chronic diseases is generally considered to be fairly accurate when compared with general practitioner data (Kriegsman, Penninx, van Eijk, Boeke, & Deeg, 1996). The chronic diseases included chronic non-specific lung disease, cardiac disease, peripheral arterial disease, diabetes mellitus, cerebrovascular accident or stroke, rheumatoid arthritis, and cancer. Because the seven diseases are chronic and/or may have a major and (life)long impact, the occurrence at one measurement was carried forward to later measurements, irrespective of the respondent's report of it at that time. Change in number of chronic diseases was included as a continuous

variable. A separate variable was developed to indicate change in the presence of cardiovascular conditions (CVCs), that is, incident stroke and myocardial infarction, presence of claudication, diabetes mellitus, and hypertension. Again, the occurrence at one measurement was carried forward to later measurements. Change in CVCs was categorized into the following: stable, no CVCs; stable, CVC(s); and increase in CVCs. Cognition was assessed with the Mini-Mental State Examination (MMSE; Folstein, Folstein, & Mchugh, 1975; range = 0-30, higher scores indicated better cognition). Change in cognition was dichotomized into statistically significant deterioration or not via the Edwards–Nunnally method (Speer & Greenbaum, 1995), thereby controlling for the reliability of the scale and regression to the mean. For vision, the scores of two items of the Organization for Economic Cooperation and Development (OECD) disability indicator (McWhinnie, 1979) were summed (range = 2-8, higher scores indicated poorer vision). For change in vision status, we calculated change scores (continuous variable; higher scores indicated a higher rate of vision decline over time.

Statistical Analyses

Outliers. To identify outliers of the SRT_n change scores, we linearly regressed the T_2 SRT_ns on the T_1 SRT_ns and the T_3 SRT_ns on the T_2 SRT_ns. Data points situated >3 standard deviations outside the regression lines were considered outliers.

Attrition. To test for selectivity in attrition, we compared the characteristics of those lost to follow-up with that of those remaining in the sample for three time intervals: (a) between the LASA measurement prior to T_1 (i.e., "T_0") and T_1; (b) between T_1 and T_2; and (c) between T_2 and T_3. Loss to follow-up due to death was not regarded as potentially selective and was therefore not considered. We tested group differences using Independent Samples *t* tests (continuous measures) and chi-square tests (dichotomous measures). For variables that had a skewed distribution, the natural logarithm was used in the analyses.

Descriptive analyses. In the descriptive analyses, the median T_1 and T_2 SRT_n scores and the mean SRT_n change scores were calculated for different participant categories with regard to sociodemographic and health-related factors, baseline SRT_n, and baseline psychosocial health.

Effect analyses. To examine the association between the SRT_n change score and the psychosocial health change scores, we carried out multilevel analyses. In general, the observations within one subject over time are correlated,

which needs to be accounted for in the statistical analyses. In multilevel analyses, respondents are allowed to have a different number of repeated measurements, and thus, no cases are lost due to missing values. So in the current study, both respondents with one change score (T_2–T_1 or T_3–T_2) and two change scores (T_2–T_1 and T_3–T_2) could be included within the same statistical model.

In separate multilevel models, change in social loneliness, emotional loneliness, and depression were used as the dependent variable, and change in SRT_n was incorporated as the main independent variable. Time was incorporated as a dichotomous variable, with 0 indicating the T_1T_2 period and 1 indicating the T_2T_3 period. Because the LASA sample was pre-stratified for age and gender, these variables were entered as covariates in all models. In addition, we adjusted all models for change in hearing aid use. Moderation was tested by assessing the statistical significance ($p < .10$) of the interaction term (covariate × SRT_n change score), and confounding or a suppressor effect was identified when the regression coefficient of the SRT_n change score changed by ≥10% after adding the covariate to the model.

Because there seems to be increasing public attention for hearing (testing) in older persons in the past decade in the Netherlands, we considered the possibility of a period effect, that is, the relationship under study could differ between the two time periods (e.g., stronger relationship in the second period). We examined this by testing whether the interaction between the measurement period (T_1T_2 or T_2T_3) and the SRT_n change score was significant ($p < .10$). If so, stratified analyses were performed.

Statistical software. Cross-sectional analyses were performed with SPSS, Version 15.0. Multilevel analyses were performed with MLwiN (Version 2.22; Centre for Multilevel Modeling, Institute of Education, London, The United Kingdom).

Results

Outliers

In total, 35 (7 T_2–T_1 scores and 28 T_3–T_2 scores) out of the 1,607 SRT_n change scores were identified as outliers. Inspection of the SRT_n data showed that the T_2–T_1 outliers were caused by an error in the SRT_n procedure on T_1. The T_3–T_2 outliers concerned such large changes in SRT_n (i.e., ranges = 5.17 to 14.17 dB SNR; −14.63, and −11.03 dB SNR) that were considered biologically implausible and were therefore excluded from the analyses.

Table 1. Selective Attrition Between Measurements T_0–T_1, T_1–T_2, and T_2–T_3.

	T_0–T_1		T_1–T_2	T_2–T_3
Variable	OC (n = 681)	NC (n = 346)	OC (n = 348)	OC and NC (n = 184)
Age (older)	X		X	
Gender (female)	X			
Hearing aid use (yes)	X	/		X
SRT_n (higher)	/	/	X	X
Depression (more)	X		X	X
Anxiety (more)	X	/		X
Social loneliness (more)		X		
Emotional loneliness (more)	X			

Note. X, variable differing significantly between those lost to follow-up and those remaining in the study sample; n, number of participants lost to follow-up; /, not measured on T_0. OC = Original Cohort; NC = New (young) Cohort, added to the original cohort before T2 of the current study; SRT_n = Speech Reception Threshold in noise in dB signal-to-noise ratio.

Attrition

For a number of characteristics, attrition across one or multiple measurement periods was selective (see Table 1). In general, those lost to follow-up were older, more likely to be women, more likely to use a hearing aid, more likely to have a poorer psychosocial health, and more likely to have poorer SRT_ns.

Cross-Sectional Description

The total sample comprised 855 women (53%) and 752 men (47%). The median baseline age of the respondents who provided data for the T_1T_2 period (n = 607) was 72.4 years (first quartile = 68.3 years; fourth quartile = 77.1 years; range = 63-93 years). The sample that provided data for the T_2T_3 period (n = 1,000) was somewhat younger, median age = 67.8 years (62.8 years; 75.3 years; range = 57-97 years). Table 2 shows the median baseline SRT_ns (at T_1 and T_2) and the mean SRT_n change scores (for T_2–T_1 and T_3–T_2) categorized for the selected study characteristics.

Effects of Change in SRT_n on Change in Psychosocial Health

Table 3 shows the results of the multilevel analyses. In both loneliness models, significant moderators were found, and thus, stratified analyses are presented.

Change in emotional loneliness. There was no significant relationship between the rate of change in SRT_n and the rate of change in emotional loneliness

Table 2. Selected Characteristics (Categorized) of the Study Sample by SRT in Noise (T_1 and T_2) and Change in SRT in Noise (T_2–T_1 and T_3–T_2).

		T_1	T_2–T_1		T_2	T_3–T_2
	n (%)	Median SRT_n (25th; 75th percentile)	*M* change in SRT_n (*SD*)	*n* (%)	Median SRT_n (25th; 75th percentile)	*M* change in SRT_n (*SD*)
Total sample	607 (100)	−5.80 (−7.00; −4.20)	0.66 (1.93)	1,000 (100)	−6.26 (−7.46; −4.51)	0.44 (2.05)
Baseline SRT_n						
Good	351 (58)	−6.80 (−7.40; −6.20)	0.91 (1.71)	607 (61)	−7.06 (−7.86; −6.46)	0.81 (1.57)
Moderate	173 (29)	−4.40 (−5.00; −3.80)	0.76 (1.79)	289 (29)	−4.46 (−5.06; −3.86)	−0.01 (2.06)
Poor	83 (14)	−1.40 (−2.20; 0.20)	−0.63 (2.52)	104 (10)	−1.26 (−2.26; −0.11)	−0.52 (3.42)
Age						
57-64	32 (5)	−6.30 (−7.75; 5.35)	0.57 (1.67)	361 (36)	−6.86 (−7.86; −5.86)	0.34 (1.70)
65-74	366 (60)	−6.20 (−7.20; −5.00)	0.59 (1.87)	379 (38)	−6.26 (−7.26; −4.66)	0.29 (2.10)
75-84	177 (29)	−5.00 (−6.40; −3.40)	0.87 (2.14)	207 (21)	−4.86 (−6.06; −3.06)	0.61 (2.25)
≥85	32 (5)	−3.30 (−5.50; −1.15)	0.37 (1.63)	53 (5)	−2.97 (−4.86; −1.76)	1.44 (2.72)
Gender						
Men	273 (45)	−5.40 (−6.70; −3.40)	0.56 (2.02)	479 (48)	−5.86 (−7.26; −4.26)	0.44 (2.06)
Women	334 (55)	−6.20 (−7.20; −4.80)	0.73 (1.85)	521 (52)	−6.46 (−7.46; −5.06)	0.43 (2.04)
Change in hearing aid use						
Stable, no hearing aid use	503 (83)	−6.20 (−7.20; −5.00)	0.72 (1.86)	885 (89)	−6.46 (−7.46; −5.06)	0.32 (1.92)
Stable, hearing aid use	51 (8)	−2.20 (−3.60; 0.00)	0.08 (2.41)	66 (7)	−3.06 (−5.06; −0.66)	1.50 (3.05)
Started using hearing aid	53 (9)	−4.20 (−5.60; −2.50)	0.65 (2.05)	49 (5)	−4.26 (−5.46; −2.66)	1.06 (2.20)
Change in partner status						
Stable, partner in hh	343 (57)	−6.00 (−7.20; −4.20)	0.73 (2.01)	649 (65)	−6.26 (−7.46; −4.86)	0.36 (1.99)
Stable, no partner in hh	225 (37)	−5.80 (−7.00; −4.40)	0.63 (1.81)	309 (31)	−6.06 (−7.26; −4.26)	0.63 (2.13)
Loss of partner out of hh	39 (6)	−5.00 (−6.60; −3.20)	0.17 (1.86)	42 (4)	−5.46 (−6.91; −3.01)	0.29 (2.30)
Change in emotional loneliness						
Improved (3-5 points)	21 (4)	−6.40 (−7.20; −4.60)	0.95 (2.00)	31 (3)	−6.26 (−7.66; −3.26)	0.60 (2.33)
Improved (1-2 points)	133 (19)	−6.00 (−7.00; −5.00)	0.49 (1.94)	160 (16)	−6.06 (−7.41; −4.46)	0.54 (2.11)

(continued)

Table 2. (continued)

	T_1		T_2–T_1	T_2		T_3–T_2
	n (%)	Median SRT_n (25th; 75th percentile)	*M* change in SRT_n (*SD*)	*n* (%)	Median SRT_n (25th; 75th percentile)	*M* change in SRT_n (*SD*)
Unchanged	315 (52)	−6.00 (−7.20; −4.40)	0.81 (1.85)	585 (60)	−6.26 (−7.46; −4.86)	0.34 (2.05)
Deteriorated (1-2 points)	115 (19)	−5.00 (−7.00; −3.40)	0.41 (2.17)	154 (16)	−6.26 (−7.46; −4.86)	0.49 (2.01)
Deteriorated (3-5 points)	40 (7)	−5.60 (−6.60; −3.30)	0.45 (1.73)	45 (5)	−5.26 (−6.86; −3.86)	1.05 (1.97)
Change in social loneliness						
Improved (3-5 points)	24 (4)	−5.50 (−7.00; −4.05)	0.95 (2.16)	26 (3)	−6.66 (−7.51; −4.61)	0.76 (2.70)
Improved (1-2 points)	106 (18)	−6.00 (−7.00; −4.00)	0.36 (2.09)	181 (19)	−5.66 (−7.06; −4.06)	0.27 (2.12)
Unchanged	325 (54)	−5.80 (−7.00; −4.20)	0.69 (1.90)	537 (55)	−6.26 (−7.46; −4.86)	0.38 (2.05)
Deteriorated (1-2 points)	134 (22)	−6.00 (−7.20; −4.60)	0.69 (1.88)	213 (22)	−6.26 (−7.26; −4.46)	0.65 (1.93)
Deteriorated (3-5 points)	16 (3)	−5.40 (−6.55; −2.30)	1.20 (1.58)	18 (2)	−6.36 (−7.76; −3.81)	0.69 (2.23)
Change in depression						
Improved (4-36 points)	131 (22)	−6.00 (−7.00; −4.20)	0.50 (1.84)	224 (22)	−6.06 (−7.26; −4.86)	0.45 (1.93)
Improved (1-3 points)	107 (18)	−6.00 (−7.00; −4.40)	0.94 (1.91	247 (25)	−6.06 (−7.46; −4.86)	0.49 (1.96)
Unchanged	74 (12)	−6.30 (−7.05; −4.40)	0.99 (2.26)	133 (13)	−6.26 (−7.66; −4.36)	0.44 (1.96)
Deteriorated (1-3 points)	138 (23)	−6.00 (−7.20; −4.60)	0.72 (1.80)	223 (22)	−6.06 (−7.26; −4.06)	0.27 (2.26)
Deteriorated (4-32 points)	156 (26)	−5.60 (−6.80; −3.85)	0.38 (1.94)	170 (17)	−6.46 (−7.66; −4.46)	0.60 (2.11)

Note. Percentages do not always total 100 because of rounding. SRT_n = Speech Reception Threshold in noise in dB signal-to-noise ratio; hh = household.

Table 3. Longitudinal Associations (Regression Coefficients) Between SRT in Noise Change Scores and Emotional Loneliness, Social Loneliness, and Depression, Change Scores, for the Total Sample and Stratified for Change in Partner Status and Baseline SRT in Noise.

		Change in emotional loneliness			Change in social loneliness			Change in depression		
		Change in SRT_n			Change in SRT_n			Change in SRT_n		
	Adj.	*n*	*B* (*SE*)	*p*	*n*	*B* (*SE*)	*p*	*n*	*B* (*SE*)	*p*
Total sample	Crude	1,579	0.005 (0.018)	.776	1,580	0.030 (0.017)	.079	1,603	0.027 (0.074)	0.720
	[a]		0.003 (0.018)	.868		0.029 (0.017)	.082		0.016 (0.075)	0.832
	[b]		0.003 (0.018)	.880		0.030 (0.017)	.078		0.014 (0.075)	0.849
Baseline SRT_n		1,579			1,580			—		
Good	[b]		0.005 (0.028)	.853	944	−0.018 (0.025)	.467	—	—	—
Moderate	[b]	944	0.057 (0.033)	.085	451	0.082 (0.030)	**.006**	—	—	—
	[c]	451	0.073 (0.031)	**.018**						
Poor	[b]	184	−0.048 (0.035)	.177	185	0.052 (0.033)	.122	—	—	—
Change in partner status		1,579			—			—	—	—
Stable, partner in hh	[b]	975	0.007 (0.021)	.982	—	—	—	—	—	—
Stable, no partner in hh	[b]	523	−0.014 (0.029)	.624	—	—	—	—	—	—
Loss partner out of hh	[b]	81	0.191 (0.071)	**.007**	—	—	—	—	—	—

Note. Sample sizes may vary due to missing values. adj. = adjusted for; SRT_n = Speech Reception Threshold in noise in dB signal-to-noise ratio; hh = household; —, No significant interaction by this variable, no stratified analyses performed; *n*, number of observations. Statistically significant p-values are printed in bold.

[a]Adjusted for age and gender.

[b]Adjusted for age, gender, and change in hearing aid use.

[c]Adjusted for age, gender, change in hearing aid use, and change in partner status.

(p = .880). However, baseline SRT_n ($p_{interaction}$ = .045) and change in partner status ($p_{interaction}$ = .025) were significant moderators, and stratified analyses yielded significant effects for one of the categories of the particular variable. The strongest subgroup effect appeared for persons who lost their partner. A deterioration of 1 dB SNR over time was associated with an increase of 0.191 points in loneliness. The effects remained non-significant for the groups with a stable partner status ($p \geq .624$). For those who had a moderate baseline SRT_n, there was a borderline significant relationship initially ($B = 0.057$, p = .085), which became significant and somewhat stronger ($B = 0.073$, $p = .018$) when adjusting for the suppressing effect of change in partner status. The effects for those with a good or poor baseline SRT_n remained non-significant ($p \geq .177$).

Change in social loneliness. The overall effect on social loneliness was borderline significant (p = .078). Baseline SRT_n was a significant moderator ($p_{interaction}$ = .024). As was the case in the emotional loneliness analyses, stratified analyses yielded a significant effect for those with a moderate baseline SRT_n ($B = 0.082$, $p = .006$). The effects for those with a good or poor baseline SRT_n remained non-significant ($p \geq .122$).

Change in depression. No significant overall effect appeared for depression ($B = 0.014$, p = .849), nor were there any significant interactions.

Period effect (data not shown). We found no significant interactions by period in any of the models.

Discussion

The aim of this study was to investigate the association between the rate of decline in hearing status and the decrease in psychosocial health in older persons. We hypothesized that faster hearing decline would result in stronger decrease in psychosocial health. The second objective was to investigate differences in effects across categories of participants. The findings show that a faster increase in SRT_n (i.e., faster decline in hearing) over time is associated with more increase in social and emotional loneliness. However, this was confined to specific categories of older persons suggesting that there were subgroup effects, that is, emotional and social loneliness increased particularly for persons who declined from an already moderate baseline hearing status, and emotional loneliness increased with hearing decline predominantly for persons who recently lost their partner.

The strongest effect appeared for older persons who had recently (within the past 3-4 years) lost their partner from the household: For them, a decline

of 1 dB SNR over time was associated with an increase of 0.19 points in emotional loneliness. In our sample, partner death was the most important reason for partner loss (i.e., in 69 out of the 81 cases). Also, apart from increased hearing decline, widowhood causes much psychological distress and a significant increase in emotional loneliness (van Baarsen, van Duijn, Smit, Snijders, & Knipscheer, 2001). As most of the older people find protection from emotional loneliness in their partner relationship (Dykstra & De Jong Gierveld, 2004), this is not a surprising finding. It is known that some persons use increased social interactions as a coping strategy (van Baarsen et al., 2001). Persons with larger hearing decline may be restricted in seeking and finding emotional support in other close ties to a greater extent than persons with smaller or no hearing decline. In addition, it may be that partner death has largely depleted the general reserves of the widow(er), further impeding successful coping. As in our study, partner loss and hearing decline were measured over the same time period; in some cases, the hearing decline could largely have taken place before the partner died. The increase in emotional loneliness may then be the result of an already increased emotional loneliness at the time when the partner was still alive. Pronk et al. (2011) found that only persons living with a partner in the household experienced an increase in emotional loneliness as a consequence of their poorer hearing at baseline, contrary to persons living without a partner for whom they found no significant effect. They suggested that hearing loss particularly affects the close partner relationship, which is also found in other studies (Jones et al., 1987; Scarinci, Worrall, & Hickson, 2008). Although such an explanation seems possible, this did not seem the case in our data as no effect was observed for those living (stable over time) with a partner in the household.

Second, we observed fairly modestly sized effects on increase of social and emotional loneliness for those with a moderate baseline SRT_n. We hypothesized that the association would be stronger for relatively poorer baseline hearing statuses because declining from good hearing to poorer hearing is likely to go unnoticed (automatic adaptation) and would not hamper daily social life activities so much (only subtle coping efforts required). According to the reduced responsiveness hypothesis (Bevan, 1965), the association would be weaker for poorer baseline hearing statuses as prolonged hearing decline shows reduced impact over time. Our findings support both hypotheses. In the first stage of ARHL, hearing decline does not affect social life activities, subjectively stays unnoticed, and does not affect loneliness. In persons with a moderate hearing loss, loneliness is related to the rate of hearing decline. Last, with poor baseline hearing, reduced responsiveness to hearing decline gets the upper hand, showing no loneliness effects.

We did not observe any significant effects on change in depression. Although most other longitudinal studies reported significant relationships

between baseline hearing and follow-up depression (Saito et al., 2010; Strawbridge et al., 2000; Wallhagen et al., 1996), these studies did not investigate hearing decline as a determinant but investigated baseline hearing loss, which is a different relationship. A possible reason for the lack of a significant effect is that the current study had some selective loss to follow-up: Those lost to follow-up were generally older, had poorer hearing, and had poorer psychosocial health, also regarding depression. This may have diluted the effect. Another explanation may stem from the course of depression in older adults. Beekman et al. (2002) followed a large cohort of community-based depressed older persons for 6 years and distinguished different depression trajectories based on 14 measurements. They found that 44% of the depressed sample experienced a fluctuating course. As such, depressive symptoms may occur shortly after the emergence of hearing problems but may diminish over time due to successful coping efforts. In other words, any depressive feelings caused by hearing declines may have disappeared at the 4- and 7-year follow-up measurements.

Strengths and Limitations

Our study had some limitations. First, there was some selective loss to follow-up which may have diluted some effects. Second, the change in SRT_n may have been rather small relative to the measurement error of the SNT. Previous work by Smits and Houtgast (2005) indicated that the measurement error is around 1 dB SNR, which leads to an error of 1.4 dB SNR in the change scores. The mean change in our sample was 0.66 dB SNR ($SD = 1.93$) between T_1 and T_2, and 0.44 dB SNR ($SD = 2.05$) between T_2 and T_3 (see Table 2). In about 29% of the observations, the measured decline was more than 1.4 dB SNR (so roughly exceeding the measurement error), which seems a modest proportion. The magnitude of the mean change scores, however, is in accordance with the age-group specific mean SRT_n values provided in Smits et al. (2006). Smits and Houtgast (2005) further showed that the measurement error increases with increasing SRT_ns. Whereas the measurement error is around 0.8 dB SNR for good SRT_ns (−8 to −7 dB SNR), it linearly increases to about 1.3 dB SNR for poor SRT_ns (−1 to 0 dB SNR). In our sample, the median SRT_n of those with poor baseline SRT_ns was −1.40 dB SNR, suggesting that the SRT_n change scores were particularly less precise in those with poorer baseline SRT_ns. The fact that we observed mean decreases (i.e., improvements) in SRT_n for this group supports this. As such, the loneliness effects for those with a poor baseline SRT_n may have been masked.

It should, however, be mentioned that we found significant associations in our effect analyses, despite generally small SRT_n changes. This suggests that

the observed effects are true effects, and that the observed effect sizes may even be an underestimation of the true effect sizes. Nonetheless, we recommend that future studies follow participants over a longer period of time or measure hearing status several times per measurement. This will yield measured differences that will better stand out from measurement error.

Second, because the change in the hearing status was measured over the same time period as the change in outcome measures, strictly, we have no evidence that a causal relation runs from hearing decline to poor psychosocial health. In our view, however, it seems unlikely that the causal relationship would be the other way around, that is, that a decrease in psychosocial health would cause a decline in hearing status.

This study also holds several strengths. First, a large population-based sample was used which allows extrapolation to the general older population. Second, a SNT was used to assess hearing status that has high face validity. It measures speech understandability in noise, which would reflect important and frequently occurring communication situations relevant to psychosocial health. In addition, an impaired ability to recognize speech in noise is a central feature of ARHL and is the most frequently reported disability in persons with hearing loss (Kramer et al., 1998).

Conclusion and Implications

This study showed that faster hearing decline results in more increase in social and emotional loneliness in certain subgroups of older persons—that is, widow(er)s and those with an already insufficient hearing status. Especially widow(er)s seem at risk of increased emotional loneliness. The effect sizes seem modest. However, given that hearing decline covers decades of older life, widowhood is a frequently occurring life event, and moderate hearing is highly prevalent, the findings suggest that on a population level, the impact of hearing declines need to be considered. Careful monitoring of older person's hearing status may be an important tool. This may be feasible for persons who are already enrolled as a patient in hearing health care. Others, however, seem harder to reach. Possibly, regular population-based screening efforts may serve as a means to not only discovering hearing impairment but also monitoring hearing decline.

As the Western population is aging, absolute numbers of persons developing hearing loss will increase, and older persons will live more years of their life with a disabling hearing loss and will experience increasingly longer periods of decline. As there is large individual variation in patterns of decline, further investigation of the associated psychosocial health effects is important and may provide useful targets for tailored preventive efforts.

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