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Author(s): Mikkola, Tuija; Portegijs, Erja; Rantakokko, Merja; Gagné, Jean-Pierre; Rantanen, Taina; Viljanen, Anne

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Association of Self-Reported Hearing Difficulty to Objective and
Perceived Participation outside the Home in Older Community-Dwelling
Adults

Tuija M. Mikkola, PhD,¹ Erja Portegijs, PhD,¹ Merja Rantakokko, PhD,¹ Jean-Pierre Gagné,
PhD,^{2,3} Taina Rantanen, PhD,¹ and Anne Viljanen, PhD¹

¹Gerontology Research Center and Department of Health Sciences, University of Jyväskylä,
Finland, ²Université de Montréal, École d'orthophonie et d'audiologie, Montréal, Canada, ³Centre
de Recherche, Institute Universitaire de Geriatrie de Montréal, Canada

Corresponding author:

Tuija M. Mikkola

Gerontology Research Center, P.O. Box 35 (Viv), FI-40014 University of Jyväskylä, FINLAND

tel. +358405025772, email: tuija.m.mikkola@jyu.fi

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Association of Hearing to Participation outside the Home

1 ABSTRACT

2 Objectives

3 To investigate whether hearing difficulty is associated with objective and perceived
4 participation in social and leisure activities outside the home in older adults.

5 Methods

6 Self-reported hearing difficulty, frequency of participation, perceived participation and Mini-
7 Mental State Examination (MMSE) were obtained from 848 community-dwelling men and
8 women aged 75-90.

9 Results

10 Among persons with $MMSE \leq 24$, hearing was not associated with participation. In persons with
11 $MMSE > 24$, relative to persons who reported no difficulty hearing, participants with major
12 hearing difficulty had a higher odds ratio for infrequent participation in group activities (OR 2.1,
13 95%CI 1.2-3.6) and more restricted perceived participation (OR 2.1, 95%CI 1.2-3.7). Participants
14 with and without hearing difficulty did not differ in their frequency of attending non-group
15 activities or meeting (grand)children or acquaintances.

16 Discussion

17 Hearing difficulty may restrict older adults with normal cognition from participating in social
18 and leisure activities and living their life as they would like to outside the home.

19

20 **Key words:** aging, hearing, social participation, autonomy, cognition

21

22 INTRODUCTION

23

24 Good hearing is a prerequisite for verbal communication and thus essential for social
25 interaction with other people (Brink & Stones, 2007). However, hearing problems are extremely
26 common in older adults. Prevalence of hearing loss ranging from 27% to 63% (Lin, Thorpe,
27 Gordon-Salant, & Ferrucci, 2011) has been reported for audiometrically measured hearing
28 detection thresholds (Chia et al., 2007; Kiely, Gopinath, Mitchell, Browning, & Anstey, 2012; Lin
29 et al., 2011; Viljanen et al., 2009) and 37% to 56% for self-reported hearing impairment (Chia et
30 al., 2007; Hannula, Mäki-Torkko, Majamaa, & Sorri, 2010; Kiely et al., 2012) in older adults.
31 Hearing loss increases dramatically as a function of age (Chia et al., 2007; Kiely et al., 2012).
32 Excluding the ototoxic effects of some medications, hearing problems in older adults are most
33 often related to progressive degeneration of cochlear structures and the auditory nervous
34 system (Schuknecht, 1964; Schuknecht et al., 1974). Impaired hearing may cause frustration
35 and embarrassment in social interaction (Gopinath, Hickson et al., 2012) and older adults may
36 avoid situations in which good hearing abilities are needed (Gopinath et al., 2012; Stephens,
37 Jaworski, Lewis, & Aslan, 1999).

38

39 The World Health Organization (WHO) recognizes participation relative to one's needs,
40 including optimization of participation in social and cultural affairs, as a vital element of active
41 aging (WHO, 2002). The consequences of social withdrawal may be considerable: it has been
42 shown to be associated with poorer life satisfaction (Huxhold, Fiori, & Windsor, 2013; Sampaio
43 & Ito, 2013) as well as increased risk for institutionalization (Pynnönen, Törmäkangas,
44 Heikkinen, Rantanen, & Lyyra, 2012), and death (Holt-Lunstad, Smith, & Layton, 2010;
45 Pynnönen et al., 2012). Previous studies investigating the relationship between hearing and
46 social activity have used 'objective' measures of social participation, where respondents are
47 asked to rate the frequency or extent of their participation in various activities. However, it is
48 also possible to measure 'perceived' participation also referred as autonomy (Cardol, de Haan,
49 de Jong, van den Bos, & de Groot, 2001; Seekins et al., 2012). Perceived participation describes
50 a person's experience relative to the person's needs to be involved in various life situations (in
51 and outside the home, self-care, social relations, work) (Cardol et al., 2001; Wilkie et al., 2011).
52 In other words, perceived participation scales measure the opportunity that a person has to live
53 life in the way that s/he would like to (Cardol et al., 2001). Thus, perceived participation may be
54 more relevant for the well-being of an individual than objective participation. Perceived
55 participation has been found to be associated with number of health conditions, activity
56 limitations, mental problems, and income (Wilkie, Peat, Thomas, & Croft, 2007). However,
57 knowledge on perceived participation among persons with hearing difficulty appears to be very
58 limited. One study found that deaf persons had a 1.4 times higher odds ratio for perceived

59 participation restriction measured using the Keele Assessment of Participation questionnaire in
60 a large sample of adults aged 50 years and older (Wilkie et al., 2007). However, to our
61 knowledge, no studies have thus far explored the relationship of hearing to perceived
62 participation in persons with milder hearing impairment.

63

64 Some investigators (Crews & Campbell, 2004; Simonsick, Kasper, & Phillips, 1998), but not all
65 (Yamada, Nishiwaki, Michikawa, & Takebayashi, 2012), have reported an association between
66 self-reported hearing difficulty and a lower level of social participation. Crews et al. found that
67 persons with any hearing problem in a sample of nearly 10 000 older adults aged 70 or older
68 were less likely (OR 0.8-0.9) to visit friends, attend church and go to movies (Crews & Campbell,
69 2004). Simonsick and colleagues found that hearing difficulties in a crowded room were
70 associated with infrequent in-person contact (OR 1.6) in a sample of 1 000 community-dwelling
71 disabled women aged 65 and older. In another study, self-reported hearing difficulties were
72 associated with social loneliness but not with emotional loneliness in a sample of over 800
73 adults aged 55 to 85 (Pronk et al., 2011). However, in a longitudinal study conducted among
74 more than 1 000 adults aged 65 to 98, hearing another person in a quiet room did not have any
75 significant influence on decline in social participation over a 3-year follow-up period. The social
76 participation subscale was measured according to reported engagement in visiting friends,
77 giving advice to family or friends, visiting friends or family in the hospital, and initiating
78 conversations with young people (Yamada et al., 2012).

79 The differences between these investigations may be due to the particular different variables
80 chosen to measure social and leisure participation. Previous studies have either investigated
81 rather specific types of leisure activity separately or combined them as a scale. These
82 approaches do not take into account whether the activities require social contact with others or
83 are carried out in a non-group context, both of which might be relevant factors in terms of
84 hearing. This issue clearly warrants further investigation. Further, it has been suggested that
85 cognitive abilities may be related to both hearing and social participation (James, Wilson,
86 Barnes, & Bennett, 2011; Pronk et al., 2011; Rahman, Mohamed, Albanouby, & Bekhet, 2011;
87 Wang, Karp, Winblad, & Fratiglioni, 2002), although the relationships posited between these
88 three phenomena have not been confirmed when included in the same study (Pronk et al.,
89 2011; Simonsick et al., 1998). However, the possible associations necessitate the inclusion of
90 cognition when investigating the relationships between hearing and social participation.

91

92 The purpose of this study was to investigate whether self-reported hearing difficulty among
93 older community dwelling men and women is associated with 1) less frequent participation in
94 social activities and group or non-group leisure activities and 2) more restricted perceived
95 participation outside the home. Further, these relationships were investigated taking into
96 account the cognitive status of the participants.

97

98

99 METHODS

100

101 Design and sample

102 The analyses made use of cross-sectional data gathered for the LISPE (Life-Space Mobility in Old
103 Age) project, which is a study of community-dwelling older adults. The project has been
104 described in detail elsewhere (Rantanen et al., 2012). Briefly, a sample of 2 550 older persons
105 between 75 and 90 years of age and living in the municipalities of Muurame and Jyväskylä, both
106 located in Central Finland, was drawn from the population register. A telephone interview was
107 used to screen eligible participants. Of this sample, 268 persons were not reached. In total, 1
108 070 persons declined to participate. Most of the persons declined were either not interested in
109 participating in the project or perceived their health as too poor to participate. The inclusion
110 criteria included: living independently, residing in the recruitment area, being able to
111 communicate, and willingness to participate in the study. Based on these criteria, 321 persons,
112 of whom 47 persons were excluded since they were unable to communicate, were excluded
113 during the project recruitment phase. Further, the data of two participants were lost due to
114 technical problems. The final data set comprised 848 individuals who participated in structured
115 computer-assisted interviews in their homes. The LISPE project was approved by the ethical
116 committee of the University of Jyväskylä. The subjects signed an informed consent at the start
117 of the home interview.

118

119 Hearing

120 Hearing was assessed by the following question: “Do you have difficulty hearing when
121 conversing with another person in a noisy environment?” The response categories were 1) No
122 difficulty, 2) Sometimes, some difficulty, and 3) Yes, major difficulty. The participants were
123 asked to estimate their level of difficulty when using a hearing aid if they had one.

124

125 Participation in social and leisure activities

126 Objective participation was measured by asking the participants how often they 1) attend
127 group activities outside the home, such as a choir, physical activity class or church activities, 2)
128 engage in non-group cultural or other activities outside the home, such as going to a concert,
129 the theater, or a coffee house, 3) meet their children or grandchildren 4) meet close friends,
130 and 5) meet acquaintances. The response set included seven categories, from daily to never.

131

132 Perceived participation was measured using the Impact on Participation and Autonomy (IPA)
133 questionnaire (Cardol et al., 2001; Kanelisto & Salminen, 2011). In the LISPE study, only the
134 domain of autonomy outdoors was used. This domain contains 5 questions regarding perceived
135 opportunity to: 1) visit relatives and friends, 2) take trips and travel, 3) use leisure time, 4) meet

136 other people, and 5) live life the way one wants to. The response categories ranged from 0
137 (very good) to 4 (very poor). The scores of all the questions are then summed to yield an
138 aggregate score, with a higher score indicating poorer perceived participation. Total score was
139 also calculated for participants with one missing item (n=2).

140

141 Potential confounders

142 Cognitive function was assessed using the Mini-Mental State Examination (MMSE) (Folstein,
143 Folstein, & McHugh, 1975). The test contains 30 items and the score ranges from 0 to 30, with
144 higher scores indicating better cognitive functioning. For the present study, the MMSE scores
145 were dichotomized into $MMSE > 24$ and $MMSE \leq 24$. MMSE score ≤ 24 is considered to be
146 indicative of at least mild cognitive impairment in the Finnish evidence-based guidelines for
147 clinical practice (Working group appointed by the Finnish Medical Society Duodecim, Societas
148 Gerontologica Fennica, the Finnish Neurological Society, Finnish Psychogeriatric Association and
149 the Finnish Association for General Practice, 2010).

150

151 Number of chronic diseases was determined with a question that required the participant to
152 have been diagnosed with the disease in question by a physician. The question was followed by
153 a list of 22 chronic diseases and an open question. The relevance of diseases reported in the

154 open question was checked by a physician. Auditory diseases and traumas were omitted from
155 the total number of diseases.

156

157 Those who reported being unable to walk 2 km without difficulty were defined as having
158 mobility limitation. A participant was considered to have impaired vision if s/he reported that
159 vision problems restricted their mobility. The participants were also asked whether they lived
160 alone, whether they were a caregiver to a close relative (daily), whether they had sufficient
161 financial resources relative to their needs, and how many years of education they had
162 completed (Rantanen et al., 2012). These potential confounders were chosen, as poor mobility
163 has previously been found to be associated with lower social participation (Nilsson, Avlund, &
164 Lund, 2011). We also hypothesized that persons who live alone, care for a close relative, have
165 inadequate financial resources and less education are less likely to participate in social and
166 leisure activities than others.

167

168 **Statistics**

169 The statistical analyses were performed using IBM SPSS Statistics for Windows software version
170 20.0 (IBM Corp., Armonk, NY, USA). There were missing values: information on hearing, group
171 activities, non-group activities and meeting friends were missing for only one participant in
172 each case. The pairwise analysis option was used where possible i.e. subjects with some missing

173 values were not excluded from the analysis. First, the distributions of categorical variables
174 across the hearing groups were analyzed using cross-tabulations and chi-square tests. Due to
175 the non-normal distributions, median and interquartile range (IQR) were calculated for the
176 continuous variables. The Kruskal-Wallis H-test was used to compare the distributions of the
177 continuous variables between the hearing groups.

178

179 To investigate the relationship between self-reported hearing categories and participation,
180 ordered logistic regression analyses with proportional odds were used. The regression
181 coefficient describes the odds of a group (in the present study some difficulty or major difficulty
182 in hearing), compared to the reference group (no hearing difficulty), having a certain value of
183 the ordinal outcome variable (participation restriction) versus all the higher values. The
184 proportional odds model assumes constant distances between the outcome variable levels and
185 thus the model produces only one odds ratio (OR) for each group of the independent variable
186 (hearing) except for the reference group. In other words, OR that describes the odds of the
187 lowest versus all the higher categories of the outcome variable is the same as the OR that
188 describes the relationship between the next lowest category and all the higher categories. For
189 the ordered logistic regression analysis, the number of categories of the objective participation
190 variables was reduced. This was achieved by merging categories with a small number of
191 observations with adjacent categories in order to better meet the parallel line assumption of
192 the analysis. Owing to the different distributions of observations in the objective participation

193 variables, the final number of categories varied from 3 to 5 depending on the variable. Although
194 the IPA scale was continuous, its distribution was non-normal in the hearing groups. Hence, IPA
195 was divided into quartiles and ordered logistic regression analysis was also used for this
196 variable. The higher values of the outcome variables correspond to less frequent or poorer
197 perceived participation. Thus, the results show the odds for less frequent objective
198 participation or poorer perceived participation. Statistical significance was set at $p < 0.05$.

199

200 First, a crude model including all participants was constructed. Using the crude model, it was
201 tested whether hearing and age, gender, hearing aid ownership or MMSE had significant
202 ($p < 0.05$) interaction effects on participation. Only MMSE score was found to have
203 systematically significant interaction effects with hearing on participation. Consequently, crude
204 models were built separately for participants with $MMSE > 24$ and $MMSE \leq 24$ in order to
205 determine whether the association between self-reported hearing difficulty and participation
206 was significant in these two groups. The crude analyses in these subgroups revealed that
207 hearing difficulty was not associated with objective participation in the group of participants
208 with $MMSE \leq 24$. Adjusting the models for age, gender, number of diseases, mobility, vision,
209 living alone, financial situation, caregiving for a close relative and years of education did not
210 markedly change this result. Hence, the adjusted models of objective participation are reported
211 only for the participants with normal cognitive function. The first criteria for a covariate were its
212 associations ($p < 0.2$) with both hearing (independent variable) and participation (dependent).

213 This was done using ANOVA for continuous, and crosstabs with chi-square test for categorical
214 variables. The potential covariates meeting these criteria were added separately to the ordered
215 logistic regression models with hearing as the independent and participation as the dependent
216 variable. Next, the potential covariates were added to the ordered logistic regression model
217 one by one in the order of change induced in the regression coefficient of hearing (the variable
218 that induced the biggest change was added first). The criterion for keeping the covariate in the
219 model was that adding the covariate changed the OR of hearing by 10% or more.

220

221 RESULTS

222 Of the participants, 43% reported no difficulty, 46% some difficulty and 10% major difficulty in
223 hearing when conversing with another person in the presence noise (Table 1). The group with
224 major difficulty in hearing had the largest and the group with no hearing difficulty the smallest
225 proportion of participants who reported hearing aid ownership and mobility limitation. Also,
226 median age was highest in the group with major difficulty in hearing and lowest in the group
227 with no hearing difficulty. With respect to the distribution of number of diseases reported and
228 MMSE scores, significant differences were observed across the three categories of hearing
229 status: the group with major difficulty in hearing had greater median number of diseases and
230 lower median MMSE score than the other groups.

231

232 The participants with major hearing difficulty met close friends less frequently than those with
233 no or some hearing difficulty (chi square test $p=0.019$) (Table 2.). The data also showed a trend
234 indicating that hearing difficulty is associated with less frequent participation in group activities
235 ($p=0.082$). The majority of the participants with major hearing difficulty were in the quartile of
236 poorest perceived participation (i.e. high IPA score), whereas the majority of participants in the
237 no hearing difficulty group were in the quartile of greatest perceived participation (low IPA
238 score) ($p<0.001$). The hearing groups did not differ significantly in the frequency of attending

239 non-group activities outside the home, meeting children and grandchildren, or meeting
240 acquaintances.

241

242 Objective participation

243 The results of the ordered logistic regression analyses used to investigate the relationship
244 between hearing difficulty and participation are shown in Table 3. The crude models revealed
245 that, relative to the participants who reported no difficulty in hearing, those who reported
246 major difficulty in hearing had 1.6 (95%CI 1.1-2.5) times higher odds of infrequent participation
247 in group activities, 1.6 (95% CI 1.0-2.5) times higher odds of infrequent participation in non-
248 group activities outside the home and 1.7 (95%CI 1.1-2.6) times higher odds of meeting close
249 friends infrequently. In the crude models containing all the participants, hearing was not
250 significantly associated with meeting children and grandchildren or acquaintances.

251

252 When the participants were divided into groups based on their cognitive status, the crude
253 models showed that none of the types of objective participation was associated with hearing in
254 persons with MMSE \leq 24 (Table 3). Adjusting the models did not change the result. However,
255 among persons with MMSE $>$ 24, hearing was found to be associated with meeting friends and
256 attending to group activities: those with major hearing difficulty had 2.1 (95%CI 1.2-3.7) times
257 higher odds of infrequent attendance at group activities and 1.9 (95%CI 1.2-3.3) times higher

258 odds of meeting friends infrequently. Adjusting the models did not markedly change the odds
259 (2.0, 95%CI 1.2-3.6 and 1.7, 95%CI 1.0-2.9, respectively), although the p-value of the odds of
260 meeting friends increased ($p=0.054$). In persons with $MMSE>24$, hearing was not significantly
261 associated with frequency of engagement in non-group activities, meeting
262 children/grandchildren or meeting acquaintances. Also, participants who reported only some
263 difficulty in hearing did not significantly differ from the participants who reported no difficulty
264 in any of the measures of objective participation.

265

266 Perceived participation

267 In the crude models, participants who reported some or major difficulty hearing had 1.5 (95%CI
268 1.1-1.9) and 3.3 (95%CI 2.2-5.1) times higher odds of perceived participation restriction,
269 respectively, than those who reported no hearing difficulty (Table 3). The odds were of the
270 same order of magnitude among participants with $MMSE\leq 24$ and those with $MMSE>24$. After
271 introducing the covariates into the model, among participants with $MMSE>24$, the odds of
272 more restricted perceived participation were reduced to 2.3 (95%CI 1.3-4.0) in those with major
273 difficulty in hearing. After adjustment, the older adults with some difficulty in hearing no longer
274 differed significantly from those who reported no difficulty in hearing. After adjustment, among
275 participants with $MMSE\leq 24$, the odds of more restricted perceived participation was not
276 significant for those who reported some or major hearing difficulty. Specifically, the ORs of

277 participants with some and those with major hearing difficulty were 1.5 (95%CI 0.8-2.6) and 1.5
278 (95%CI 0.6-3.5), respectively.

279 DISCUSSION

280 The results of the present study suggest that, among older adults with normal cognition, there
281 is an association between self-reported hearing difficulty and social and leisure activity.

282 Moreover, the association appears to be activity-specific. Older adults with normal cognition
283 and who report major hearing difficulty participate less frequently in group activities and tend
284 to meet less frequently with their close friends than older adults who do not report any
285 difficulty in hearing. However, older adults who report hearing difficulty do not differ in their
286 frequency of participation in non-group activities and meeting relatives or acquaintances from
287 those who report no difficulty in hearing. Also, among older adults with normal cognition those
288 who report a major hearing difficulty perceive their participation to be more restricted relative
289 to their needs outside the home than the others.

290

291 Participation in social and leisure activities seems to be vital for older adults. In this population,
292 social activity has been shown to be associated with functional ability (Avlund, Lund, Holstein, &
293 Due, 2004; James, Boyle, Buchman, & Bennett, 2011), cognitive functioning (James et al., 2011;
294 Wang et al., 2002) and mortality (Holt-Lunstad et al., 2010; Pynnönen et al., 2012). In addition,
295 older adults who are socially active are more satisfied with their life than those who are less
296 active (Huxhold et al., 2013; Sampaio & Ito, 2013). Our results suggest that self-reported major
297 hearing difficulty may compromise active aging through a reduced level of social participation.

298 Previous studies investigating the relationship between hearing and social activity have
299 reported conflicting results. Recently, Yamada et al. found no associations between self-
300 reported hearing and decline in social participation (Yamada et al., 2012). In a study involving
301 adults aged 70 years and older, Marsiske et al. observed that good hearing acuity, assessed
302 using pure-tone audiometry, was associated with more time spent in leisure activities
303 (Marsiske, Klumb, & Baltes, 1997). Hearing loss has also been found to be related to feeling
304 lonely or left out in group situations (Pronk et al., 2011; Strawbridge, Wallhagen, Shema, &
305 Kaplan, 2000). Our results suggest that also severity of hearing problems counts. Those who
306 reported major hearing difficulty participated less often in some social activities while those
307 who reported only some hearing problems were equally socially active than persons who
308 reported good hearing.

309

310 The finding that reported major hearing difficulty was associated with less participation in some
311 activities, but not all, suggests that hearing ability may have an activity-specific effect on
312 participation. In relation to the activity of meeting relatives and friends, the trend seen in the
313 present results is consistent with those reported by Crews et al. who found that, compared to
314 older adults with no hearing or vision impairment, individuals with self-reported hearing loss
315 were less likely to have visited friends within the past two weeks (Crews & Campbell, 2004).
316 However, self-reported hearing difficulty did not have an effect on meeting relatives. In the
317 present investigation, reported major difficulty in hearing was negatively associated with

318 participation in group activities but not with non-group activities outside the home. These
319 findings are intuitively plausible. Group activities may be more challenging for people with
320 hearing loss, as they typically involve communicating with one or more persons in a noisy
321 environment. On the other hand, our results partly contradict the results of Crews et al., who
322 reported that, compared to older adults with no hearing difficulty, persons with reported
323 hearing loss less often go to church and the movies, both non-group activities (Crews &
324 Campbell, 2004). However, it could be argued that these activities may be challenging for
325 people with hearing loss. Further, the authors did not observe an effect of reported hearing
326 difficulty for two activities that, depending on the situation, may or may not have group-like
327 features, namely, eating out and exercising. Nevertheless, and notwithstanding the differences
328 between the present results and those reported by Crews et al., it appears as though at least
329 some of the inconsistencies that have been observed across the studies that have investigated
330 the relationship between hearing difficulty and participation may be resolved by taking into
331 account the specific type of social and leisure activities in question.

332

333 Cognitive function seems to be related to both hearing abilities and social participation. Hearing
334 impairment and a low level of social activity level have been shown to predict a steeper decline
335 in cognitive functions with aging (James et al., 2011; Lin et al., 2013; Wang et al., 2002). In the
336 present study, social and leisure activities were associated with hearing but only among
337 persons with normal cognitive function. Several factors could explain the influence of cognitive

338 function on the association observed between hearing difficulty and social participation. It is
339 possible that poor hearing makes it more difficult to understand the instructions when
340 cognitive tests are administered. This may result in poorer performance on cognitive tests
341 (Räihä et al., 2001) as well as strengthen the relationship observed between hearing difficulty
342 and cognition. It has also been shown that even mild cognitive impairment has a deleterious
343 effect on auditory processing (Rahman et al., 2011), which in turn may hamper verbal
344 communication. According to Brink et al., impaired verbal communication is a factor that
345 mediates the influence of hearing loss on social engagement (Brink & Stones, 2007). Further,
346 cognitive problems may disturb verbal communication due to the misinterpretations of
347 nonliteral meanings used in spoken language (Maki, Yamaguchi, Koeda, & Yamaguchi, 2013).

348

349 Novel components of the present study included the use of various indicators of social activity
350 and investigation of perceived participation. To our knowledge, the association between
351 hearing and perceived participation has been addressed in only one other study. Wilkie et al.
352 used the Keele Assessment of Participation questionnaire to explore the association between
353 hearing loss, among other health conditions, and participation in various aspects of life in older
354 adults (Wilkie et al., 2007). The authors reported that persons with hearing loss had 1.4 times
355 higher odds than persons without hearing loss for participation restrictions, i.e. not
356 participating when and in the way they wanted to all or most of the time. The present results
357 show that older adults with self-reported major hearing difficulty perceived more restrictions

358 on their participation in life situations outside the home than those who reported no hearing
359 difficulties. The questionnaire included the IPA domain of autonomy outdoors, which includes
360 items related to perceived opportunities for social activity, life in general, trips and leisure
361 (Cardol et al., 2001; Kanelisto & Salminen, 2011). Participation outside the home may be an
362 especially sensitive indicator of autonomy restriction among community-dwelling older adults,
363 as found in the present sample, as it is the most likely area of participation restriction in older
364 individuals (Wilkie, Peat, Thomas, & Croft, 2006). In the present study, participants with major
365 hearing difficulty met relatives and acquaintances and engaged in non-group activities as often
366 as persons with no hearing difficulty. However, it is noteworthy that this type of social
367 participation was not sufficient for the participants with hearing difficulty to experience a sense
368 of autonomy comparable to that of non-hearing impaired.

369

370 It should be noted that we studied self-rated hearing irrespective of hearing aid use.
371 Participants were asked to rate their hearing while wearing a hearing aid, if they had one. We
372 assessed hearing irrespective of hearing aid use, as we consider that perceived hearing ability in
373 everyday life is a more important determinant of participation than use of a hearing aid as such.
374 However, we used just one question to determine level of hearing in the analyses. Therefore,
375 we do not know whether some of those using a hearing aid and hence reporting good hearing,
376 have difficulties in other situations which might limit their participation. If so, our results
377 underestimate the strength of the association between hearing and participation. It is

378 challenging to study the influences of hearing aid use in an observational study, as hearing aid
379 use is statistically confounded by hearing difficulty. Owing to the design, we were unable to
380 determine the influence of hearing aid use on participation which could have yielded valuable
381 information on the importance of audiologic rehabilitation for participation in older people.

382
383 The results should be interpreted with caution. First, a cross-sectional design was used. This
384 limits any causal relationship that may be drawn among the variables investigated. However, it
385 seems intuitively more plausible that hearing loss leads to reduced participation than vice
386 versa. A strength of this study was having a population-based sample of community-dwelling
387 older adults. Although a marked number of those invited to participate declined to do so, this is
388 not exceptional in studies of older people (Mody et al., 2008). For one thing, poor health status
389 is likely to decrease the willingness to participate in research (Mody et al., 2008). In fact, the
390 non-participants significantly more often perceived their health as poor or very poor and
391 moved outdoors less often than those who participated in the present study (Rantanen et al.,
392 2012). Moreover, some persons were excluded because they were not able to communicate
393 during the telephone screening or home interview. This exclusion criterion is likely to have
394 diminished the number of persons with severe hearing impairment in this study. If these
395 persons had participated the associations observed between hearing and participation might
396 have been stronger. Unfortunately, the data on hearing status were based on responses to a
397 self-report question rather than on audiometric measurements. However, self-reports of

398 hearing are widely used in epidemiological research (Chia et al., 2007; Crews & Campbell, 2004;
399 Pronk et al., 2011; Strawbridge et al., 2000; Yamada, Nishiwaki, Michikawa, & Takebayashi,
400 2011) and have been shown to have sufficient sensitivity and specificity in comparison with
401 pure-tone audiometry (Salonen, Johansson, Karjalainen, Vahlberg, & Isoaho, 2011; Sindhusake
402 et al., 2001). Further, it could be argued that in some respects, relative to indices of hearing
403 detection thresholds, self-report estimates of hearing difficulty are a more appropriate variable
404 for investigating issues related to well-being (Gopinath, Schneider et al., 2012). Given the range
405 of adaptive strategies that can be used to optimize communication as well as the complex
406 constellation of physical and social environments in which individuals maneuver (Garstecki &
407 Erler, 1996; Gomez & Madey, 2001; Hallberg, Hallberg, & Kramer, 2008), it is possible that the
408 effects of hearing status on social participation are better accounted for by responses to a self-
409 reported questionnaire than hearing detection thresholds obtained in a sound treated test
410 suite. Further, our question on hearing when conversing in the presence of noise may be
411 especially suitable for assessing hearing in older adults since understanding speech in noise is
412 one of the most frequent hearing disabilities perceived by older people (Kramer, Kapteyn, &
413 Festen, 1998; Plomp & Mimpen, 1979).

414

415 In conclusion, major hearing difficulty among older community-dwelling adults with normal
416 cognition increases the risk for less frequent participation in group activities, fewer meetings
417 with friends and poorer perceived participation outside the home. Audiologic rehabilitation

418 services should be available for older adults with hearing difficulties in order to optimize their
419 participation in social and leisure activities. Pertinent rehabilitation intervention strategies may
420 include the use of technological equipment, learning strategies to appropriately manage the
421 social and physical environment and, the use of effective communication strategies.

422

423

AUTHOR'S NOTES

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TABLES

Table 1. Characteristics of the Participants Reporting No Difficulty, Some Difficulty, and Major Difficulty in Hearing When Conversing in Noisy Environment (N=847).

	Self-reported hearing						
	No		Some		Major		p ^c
	difficulty		difficulty		difficulty		
	(N=366)		(N=393)		(N=88)		
N	%	N	%	N	%		
Gender							0.55
Male	138	38	154	39	29	33	
Female	228	62	239	61	59	67	
Living alone	189	52	209	53	54	61	0.21
Hearing aid owner	13	4	57	15	44	50	<0.001
Mobility difficulty	124	34	176	45	55	63	<0.001
Sufficient financial resources	165	45	178	54	35	40	0.61
Caregiver for a close relative	22	6	18	5	5	6	0.67
MMSE≤24	75	21	91	23	31	35	0.013

	Median	IQR	Median	IQR	Median	IQR	p ^d
Age	80	6.9	81	7.4	83	6.6	<0.001
Number of diseases ^a	4	3	4	3	6	4	<0.001
MMSE score	27	3	27	3	26	4.9	0.002
Perceived participation outdoors ^b	5	4	6	5	8	6	<0.001
Years of education	8.5	5	9	6	8	5	0.191

MMSE, Mini Mental State Examination

^aear/hearing diseases omitted

^bImpact on Participation and Autonomy questionnaire, a higher score indicates more restricted perceived participation

^cChi-square test

^dKruskal-Wallis H-test

Table 2. Frequency Of Social Activity In Participants Reporting No Difficulty, Some Difficulty And Major Difficulty In Hearing When Conversing In Noisy Environment (N=847).

Type of participation	No difficulty (N=366)		Some difficulty (N=393)		Major difficulty (N=88)		p ^b
	N	%	N	%	N	%	
Objective							
Group activities							0.082
Weekly	158	43	181	46	27	31	
1 to 3 times a month	48	13	49	13	10	11	
A few times per year	11	3	19	4	6	7	
Not at all	149	41	143	36	45	51	
Non-group activities							0.253
outside the home							
Monthly	111	30	120	31	34	39	
A few times per year	126	35	141	36	34	39	
More seldom	128	35	132	34	20	23	
Meeting (grand)children							0.375
Daily	53	15	41	10	12	14	
Weekly	185	51	224	57	43	49	
Monthly	72	20	76	19	16	18	
A few times per year or more seldom	56	15	52	13	17	19	
Meeting close friends							0.019
Daily	46	13	53	14	10	11	

Weekly	190	52	178	45	34	39	
Monthly	83	23	78	20	24	27	
A few times per year	29	8	53	14	9	10	
More seldom	17	5	31	8	11	13	
Meeting acquaintances							0.591
Daily	59	16	66	17	8	9	
Weekly	179	49	191	49	43	49	
Monthly	74	20	79	20	19	22	
More seldom	54	15	57	15	18	21	
Perceived							
Participation outdoors^a							<0.001
Q1 (score 0-4)	142	39	114	29	16	18	
Q2 (5-6)	95	26	117	30	16	18	
Q3 (7-8)	65	18	61	16	17	19	
Q4 (>8)	64	18	101	26	39	44	

^aIPA, Impact on Participation and Autonomy; higher score indicates more restricted perceived

participation

^bChi square test

Table 3. Results of the Ordered Logistic Regression Analyses. The Odds for More Restricted Participation by Categories of Self-Reported Difficulty in Hearing.

		Total sample (N=848)			MMSE≤24 (N=197)			MMSE>24 (N=651)					
		Model crude			Model crude			Model crude			Model adjusted		
Type of restricted participation	Hearing difficulty	OR	95%CI	p	OR	95%CI	p	OR	95%CI	p	OR	95%CI	p
Objective													
Group activities													
	No	1.0			1.0			1.0			1.0 ^b		
	Some	0.9	0.7-1.1	0.31	1.0	0.6-1.8	0.97	0.8	0.6-1.1	0.19	0.8	0.6-1.0	0.10
	Major	1.6	1.1-2.5	0.03	0.8	0.4-1.8	0.65	2.1	1.2-3.7	0.007	2.0	1.2-3.6	0.012
Non-group activities outside the home													
	No	1.0			1.0			1.0			1.0 ^c		
	Some	1.0	0.8-1.4	0.78	0.8	0.5-1.5	0.53	1.1	0.8-1.5	0.61	1.0	0.7-1.3	0.78
	Major	1.6	1.0-2.5	0.034	1.0	0.5-2.3	0.88	1.6	1.0-2.8	0.064	1.3	0.7-2.2	0.37
Meeting (grand)children													

	No	1.0			1.0			1.0			1.0 ^d		
	Some	1.0	0.8-1.3	0.95	1.2	0.7-2.2	0.51	1.0	0.7-1.3	0.89	1.0	0.7-1.4	0.98
	Major	1.2	0.7-1.8	0.53	1.6	0.7-3.6	0.23	1.1	0.7-1.9	0.71	1.2	0.7-2.1	0.51
Meeting close friends													
	No	1.0			1.0			1.0			1.0 ^b		
	Some	1.3	1.0-1.7	0.080	1.0	0.6-1.8	0.85	1.3	1.0-1.8	0.062	1.2	0.9-1.7	0.16
	Major	1.7	1.1-2.6	0.014	1.3	0.6-2.7	0.56	1.9	1.2-3.3	0.013	1.7	1.0-2.9	0.054
Meeting acquaintances													
	No	1.0			1.0			1.0			1.0 ^e		
	Some	1.0	0.8-1.3	0.84	1.7	0.9-2.9	0.081	0.8	0.6-1.1	0.21	0.8	0.6-1.1	0.17
	Major	1.5	1.0-2.3	0.078	1.3	0.6-2.9	0.46	1.6	0.9-2.6	0.097	1.4	0.8-2.4	0.18
Perceived													
Participation outdoors^a													
	No	1.0			1.0			1.0			1.0 ^f		
	Some	1.5	1.1-1.9	0.004	1.7	1.0-2.9	0.076	1.4	1.1-1.9	0.020	1.2	0.9-1.6	0.20
	Major	3.3	2.2-5.1	<0.001	3.1	1.5-6.8	0.004	3.4	2.0-5.7	<0.001	2.3	1.3-4.0	0.003

^aIPA, Impact on Participation and Autonomy

^bModel adjusted for mobility and living alone

^cModel adjusted for age and mobility

^dModel adjusted for age

^eModel adjusted for mobility

^fModel adjusted for number of diseases and mobility