Hearing ability in working life, and its relationship with sick leave and self-reported work productivity

Nachtegaal J, Festen JM & Kramer SE. Hearing ability in working life and its relationship with sick leave and self-reported work productivity. Revision under review.
ABSTRACT

Hearing impairment has been shown to influence various aspects of daily life, such as communication, psychosocial functioning, and working life. The aim of this study is to examine the association between hearing ability and both sick leave and self-reported work productivity. Additionally, the relationship between hearing ability and perceived health-caused limitations at work is examined. Data were collected at the baseline measurement of the Dutch National Longitudinal Study on Hearing, and at each month during a subsequent period of three months. Hearing ability was determined by means of the National Hearing test, a speech-in-noise test over the Internet using digit triplets. The sample comprised 748 workers (385 with normal hearing ability and 363 with insufficient or poor hearing ability). Linear regression analyses revealed a significant adverse association between reduced hearing ability and self-reported absolute and differential productivity; for every dB signal-to-noise ratio (dB SNR) poorer hearing ability, absolute productivity for people experiencing little social support decreased with 0.054 points on a scale from 0 to 10 (b=-0.054; 95% confidence interval (CI)= -0.088 - -0.02). For people with less than three other chronic conditions, differential productivity also decreased significantly with decreasing hearing ability (no chronic conditions: b= -0.048 points/dB SNR on a scale from -10 to +10, 95% CI= -0.094 - -0.001; one or two other chronic conditions: b= -0.035 points/dB SNR, 95% CI= -0.067 - -0.002). With adjustment for confounders, poorer hearing ability in noise furthermore significantly increased the odds for experiencing limitations (in the type or amount of work one could do) sometimes (OR=1.14; 95%-CI= 1.07 – 1.21) and often to very often (OR=1.24; 95%-CI= 1.05 – 1.45) in comparison with experiencing limitation seldom to never. After adjustment for covariates, no significant relationship was found between hearing ability in noise and sick leave of more than five days during four months (OR=1.03; 95%-CI= 0.97 – 1.10). However, need for recovery seems to act as a mediating variable in this relationship. Reduced hearing ability was significantly associated with a lower self-reported absolute and differential productivity in specific cases. Also, poorer hearing increased the odds for experiencing health caused limitations in the type or amount of work one can do. The significant relationship between hearing ability and sick leave, which was found when not adjusting for confounders, could partly be explained by a higher need for recovery among people with hearing impairment.
INTRODUCTION

Hearing impairment has an impact on various aspects of daily life. Not only communication and interpersonal relationships are affected (Kramer 2005), psychosocial functioning is influenced as well. Several studies demonstrated higher levels of depression, loneliness, distress, somatization, and anxiety among people with auditory difficulties, compared to peers with normal hearing (Cacciatiore et al. 1999; Kramer et al. 2002; Tambs 2004; Hallam et al. 2006; Fellinger et al. 2007; Nachtegaal et al. 2009a). Consequences of hearing impairment for educational and work areas are also reported. Danermark and Gellerstedt (2004) observed that people with hearing loss were overrepresented in the group of employees taking early retirement. Other studies reported higher levels of unemployment, lower educational levels, and underemployment among people with hearing difficulties (Järvelin et al. 1997; Parving et al. 2001; Hogan et al. 2009). In a study among 210 employees, Kramer et al. (2006) compared the psychosocial working conditions (i.e. job demands and job control) of normally hearing and hearing impaired employees. Job demands refer to the mental workload and psychological requirements of an employee’s work and job control is related to social autonomy over making decisions and the breadth of skills useable on the job (Karasek and Theorell 1990). The study revealed that hearing impaired employees experienced lower levels of job control compared to their normally hearing colleagues. Other studies reported similar results. Those with hearing impairment significantly more often experienced an imbalance between job demands and job control compared to normally hearing colleagues (Danermark and Gellerstedt 2004; Gellerstedt and Danermark 2004).

Another phenomenon often reported by hearing impaired employees is lack of energy or fatigue (Ringdahl and Grimby 2000; Grimby and Ringdahl 2000; Backenroth et al. 2003; Danermark and Gellerstedt 2004; Kramer et al. 2006). Grimby and Ringdahl (2000) interviewed 35 full-time workers with hearing impairment. The participants expressed their concern about stress and strain resulting from conversations in the coffee room or in their offices, leading to exhaustion both at work and during the hours after work.
In itself, fatigue is a common phenomenon among employees in general. However, repeated insufficient recovery from work-related fatigue triggers a vicious circle, where extra effort has to be exerted at the beginning of a new working period to prevent performance breakdown (Sluiter et al. 1999). This cumulating fatigue might be expressed as an increased need for recovery after work. Need for recovery is seen as an acute, short term reaction to work-related fatigue. It is believed to be an intermediate stage between the exposure to stressful psychosocial working conditions, such as high job demands and low job control, and the development of psychosomatic health problems in the longer term (Sluiter et al. 1999; Sluiter et al. 2003). Furthermore, need for recovery appeared to be associated with the duration of future sick leave (Sluiter et al. 2003; De Croon 2003). A prospective cohort study among truck drivers showed that those with a high need for recovery had an increased chance to drop out after two years because of sick leave which lasted longer than 14 days (De Croon et al. 2003).

In a recent study, hearing ability was also found to be associated with need for recovery after work (Nachtegaal et al. 2009b). Additionally, the odds for risky levels of need for recovery increased with decreasing hearing ability, in which risky levels of need for recovery are defined according to criteria opted by Broersen et al. (2004). Based on these findings and given the fact that high levels of need for recovery are associated with sick leave (Sluiter et al. 2003; De Croon et al. 2003), one would expect that workers with hearing loss more often need time off as a result of sickness than normally hearing workers. Only few studies have focused on the relationship between hearing loss and sick leave, but there are indeed indications that people with hearing impairment are overrepresented in the group taking (long term) sick leave (Danermark 2005). In a study of Kramer et al. (2006), 77% of the hearing impaired employees reported occasional sick leave, which was significantly higher than the incidence of sick leave in the normally hearing group (55% reported sick leave). However, further substantiation of this hypothesis is needed. The present investigation reports on the association between hearing ability and sick leave in a large cohort of workers.
Besides sick leave, this study focuses on self-assessed work productivity (i.e. performance at work), yet another work related outcome which might be affected by hearing impairment. Several studies suggest a significant relationship between health problems and reduced productivity at work. However, specific knowledge about work productivity among people with hearing impairment is scarce. In a systematic review, Schultz and Edington (2007) reported on significant associations between various health conditions, such as allergies and arthritis, and self-assessed (on-the-job) work productivity loss. The sample included 22,759 employees. Suffering from more than one longstanding condition was associated with a higher odds for both self-reported productivity loss and sick leave (Van den Heuvel et al. 2009). One of the longstanding conditions in this study concerned problems with hearing. This was reported by 2.2% of the sample. Although the odds for self-reported productivity loss and sick leave were higher for people reporting hearing problems, this finding was not significant. Another study employing a focus group among 48 workers working in an office or office-like environment revealed that most of them believed that hearing loss had negatively affected their ability to perform their job (Tye-Murray et al. 2009). In addition, Mohr et al. (2000) estimated that most of the societal costs of hearing impairment are caused by reduced working productivity.

The main goal of this study is to obtain further insight into the consequences of impaired hearing on an individual’s participation in work. The first aim is to examine the association between hearing ability in noise and sick leave, and the role of need for recovery in this relationship. The second goal is to investigate the relationship between hearing ability in noise and work productivity. Additionally, the extent to which hearing ability is associated with perceived limitations in the kind and amount of work one can perform as a result of health problems is investigated.
CHAPTER 4

METHODS

Data for this study were derived from the Dutch “National Longitudinal Study on Hearing” (NL-SH). The NL-SH is an ongoing prospective cohort study examining the relationship between hearing impairment and several domains in the life of adults between 18 and 70 years of age, and is conducted over the Internet. A website was used to enroll and inform the participants and to collect data. A more detailed description of the NL-SH can be found in Nachtegaal et al (2009a; 2009b). The Medical Ethics Committee of the VU University Medical Center approved the study. The data analyzed in the present study were collected at baseline (demographic data, hearing ability, psychosocial work characteristics, need for recovery, work performance, and sick-leave) and a subset of questions on sick leave and work performance was repeated every month during a period of three months. Times of data collection are referred to as T0 (baseline), T1, T2, and T3. Data were collected in four, one-month intervals between November 2006 and September 2007.

Participants

The baseline and follow-up questionnaires were sent to 1295 adults. However, as we aimed to study work related outcomes in the present study, people who worked less than 12 hours per week at T0, T1, T2, or T3 were excluded from the analyses. A cut-off of 12 hours per week was chosen, as this is one of the criteria used by “Statistics Netherlands” to define the working population. Hence, a total of 748 participants were included in the analyses. Their ages ranged from 20 to 64 years (Mean age=44.6; SD=10.6). The sample comprised people with a wide variety of professions varying from workers performing manual labor (e.g. service mechanic) to office workers (e.g. manager). In all, 31.0% of the 748 participants completed all measures (T0-T3) and 75.8% completed at least two measures. Missing value analyses showed that the lowest response rate (53.5%) was observed at T3. The mean overall response rate (T0-T3) was 66.0% (SD=29.0%). There were no significant differences in hearing ability in noise, age or gender between participants who completed all measures (Mean SRT_n= -4.4 dB SNR, SD =
3.7 dB SNR; mean age = 44.5, SD= 10.3) and participants who completed only some of the retests (mean SRT\text{\textsubscript{n}} = -4.7 dB SNR, SD = 3.4 dB SNR; mean age = 44.7, SD=10.7) (hearing ability: p=0.204; age: p=0.855; gender: p=0.342).

### Outcome Measures

#### Hearing ability

Hearing ability was determined using the “National Hearing Test”, an adaptive speech-in-noise screening test over the Internet. The test uses digits that are presented diotically against a background of masking noise, according to an adaptive (one up, one down) procedure (Smits et al. 2004; Smits et al. 2006a). With the test, the speech-reception-threshold in noise (signal-to-noise ratio corresponding to 50% intelligibility) is determined. Participants were allowed to use either headphones or speakers and were instructed to perform the test in a quiet room. The test has been proven to have good validity and reliability (Smits et al. 2004; Smits and Houtgast 2005; Smits et al. 2006a; Smits et al. 2006b).

#### Sick leave

Self-reported sick leave was determined by using the WHO Health Performance Questionnaire (HPQ) (Kessler et al. 2003). For the analyses, the absolute number of workdays missed because of problems with physical or mental health during the past four weeks, reported at T0, T1, T2, and T3 were summed. Thus, sick leave is expressed as the absolute number of days missed because of physical or mental health problems during a period of four months.

#### Self-reported productivity

Self-reported productivity was also determined with the HPQ. In this questionnaire, work productivity is conceptualized as a measure of actual performance in relation to potential performance (Kessler et al. 2003). Blinded validation studies have documented significant associations of HPQ productivity reports with supervisor assessment of a worker’s actual performance and other
administrative indicators of worker job performance (Kessler et al. 2003, 2004; Schultz and Edington 2007). Productivity was measured using two questions: 1) “On a scale from 0 to 10, in which 0 is the worst job performance anyone could have at your job, and 10 is the performance of a top worker, how would you rate your overall job performance during the past 4 weeks (28 days)?” and 2) “On a scale from 0 to 10, in which 0 is the worst job performance anyone could have, and 10 is the performance of a top worker, how would you rate the usual performance of most workers in a profession similar to yours?” The first question is used to determine one’s perceived absolute productivity. The difference between the first and the second question is expressed as differential productivity. Differential productivity accounts for possible differences between workers in calibration on the 0 to 10 self-anchoring scale. Productivity was expressed as the mean absolute and differential productivity at T0, T1, T2 & T3. Scale scores range from 0 to 10 for absolute productivity, and from -10 to +10 for differential productivity. A positive differential productivity means that the worker’s own productivity is rated higher than the (self) estimated normal productivity of workers with a similar job.

*Experienced limitations at work caused by health problems*

The HPQ question “How often did health problems limit the kind or amount of work you could do?” was used to determine the extent to which people experienced limitations in their work caused by health problems. Responses were given on a five-point scale ranging from ‘very often’ to ‘never’. To create an overall measure of T0-T3, the responses on the different questionnaires at T0-T3 were combined into a single overall measure, by calculating the mean experienced limitations during the four month period. Mean scores between 1.0 and 2.5 were defined as “often to very often”, scores between 2.6 and 3.5 as “sometimes”, and between 3.6 and 5.0 as “seldom to never”.

Confounders

As it is likely that demographic, socio-economic, and psychosocial work variables influence sick leave and work performance (Van den Heuvel et al. 2009), age, gender, educational level, income, living arrangement, number of working hours per week, job demands, job control, social support, and the presence of other chronic conditions were examined for confounding effects. Need for recovery has shown to be related to sick leave as well and was thus also considered as a potential confounder. While performing the National Hearing test, 65% of the participants did not use headphones. Therefore, confounding effects of headphone versus speaker-use were also investigated for relationships which included hearing ability. Confounding effects of type of job were examined too, as there is some evidence that people with different types of jobs experience different hearing-related challenges (Rubin 2000; Tye-Murray et al. 2009).

The psychosocial work characteristics job demands, job control, and social support were measured using the validated Dutch version of the Job Content Questionnaire (JCQ) (Karasek et al. 1998). Answers were given on a four point scale, varying from “strongly agree” to “strongly disagree”. The scale psychological job demands contains five items addressing excessive work, conflicting demands, and work pace. Job demand scale scores ranged from 12 to 48 with a higher score indicating a higher demand. Job control was expressed as the sum of two subscales: skill discretion and decision authority. Skill discretion is covered by 6 items dealing with learning new things and task variety. Decision authority contains three items dealing with the freedom to make decisions. The job control scale score ranged from 24 to 96, a higher score indicating more control. Social support was determined by the sum of the subscales ‘supervisor support’ and ‘co-worker support’. Each subscale contains four questions addressing the level of helpful social interaction, from co-workers and supervisors respectively, available on the job. For example, people I work with take a personal interest in me. The total social support scores ranged from 8 to 32, with a higher score indicating more social support.
Need for recovery after work was measured using the Need for Recovery scale, an 11-item scale assessing the short term effects of fatigue caused by work activities. It is a subscale of the Vragenlijst Beleving en Beoordeling van de Arbeid (VBBA), a Dutch questionnaire on the experience and assessment of work. The VBBA is a reliable and valid instrument (Van Veldhoven and Meijman 1994; De Croon et al. 2006). An example of characteristic items is: “In general, it takes me over an hour to feel fully recovered after work”. Each question has two answer categories: “yes” or “no”. Items were recoded such that a higher score indicates a higher need for recovery. Individual scores on the 11 items were added and transformed into a scale ranging from 0 to 100, with a higher score indicating a higher need for recovery (Van Veldhoven and Meijman 1994).

**Educational level** was determined by asking the participants to report their highest completed educational level: low (no finished elementary school to lower vocational), mid (general intermediate to general secondary), or high education (higher vocational to post-academic). **Income** was measured by asking the participants to indicate their gross monthly income category. Four categories were distinguished: low (less than € 1050), mid (between €1050 and €2550), high income (more than €2550), and unknown (don’t know; don’t want to report). **Number of working hours** per week was determined by asking the number of hours a worker was expected to work in a week, according to their contract. A total of 36 hours or more was defined as full-time employment. **Type of job** was distinguished by three categories: office jobs (e.g. manager or researcher), jobs in the (public) service field (e.g. teacher or nurse), and industrial and manual labor jobs (e.g. service mechanic or electrician). The presence of **chronic conditions** (other than hearing impairment) was assessed by asking workers to report whether they had a disease, condition or handicap out of a list of 28 health conditions. Presence or absence of each condition was based on self-report. Health conditions varied from migraines to diabetes or multiple scleroses.
Statistical analyses

Multiple imputation (MI) was used to impute missing data in the outcome measures, applying the multiple imputation option in SPSS 17.0. MI accounts for the uncertainty caused by missing data (Schafer 1999; Briggs et al. 2003) and is a flexible imputation method. This allows one to specify the multivariate structure in the data as a series of conditional regression models based on the information of all other variables. With the MI procedure, missing data are replaced by several estimated values: a total of five imputed datasets were created, which is regarded as a sufficient number even with 50% missing information (Schafer 1999). Each imputed data set was analyzed by standard methods, followed by pooling these results in a final estimate by SPSS. It is known that analyses of only the complete-cases data may suffer more from chance variation than analyses with missing data replaced by multiple values (Sterne et al. 2009). Hence, the final estimates are reported in the present study.

Sick leave had a skewed distribution, with many participants reporting no sick leave, and was therefore dichotomized (0 – 5 days of sick leave; >5 days of sick leave). Consequently, logistic regression analyses were used with sick leave as the dependent variable and hearing ability as the independent variable. To analyze the relationship between hearing ability in noise and self-reported work productivity (both absolute and differential), linear regression analyses were used. The association between hearing ability in noise and experienced limitations was examined with multinominal regression models, as the dependent variable “experienced limitations” was a categorical variable. Note that hearing ability was entered as a continues variable in all analyses.

All analyses were conducted without adjustment for confounders first, and with adjustment for relevant confounders in the second step. A variable was considered as a relevant confounder when the regression coefficient of the independent variable changed with 10% or more when entering the potential confounder in the model. Confounding effects were investigated for all potential confounders separately. Then, the confounder which caused the largest relevant change was added. With this new model, the remaining variables were checked
for confounding again, after which the variable causing the largest relevant change was added to the model. When none of the remaining potential confounders caused a relevant change of the regression coefficient, the process determining the relevant confounders was stopped. Confounding effects were examined for the variables mentioned under *Confounders*.

In statistics, a variable can be defined as a mediator when it accounts for all or part of the relation between the independent and the dependent variable (Baron and Kenny 1986). As described earlier, significant relationships between need for recovery and sick leave and between hearing ability and need for recovery were found in previous studies (Sluiter et al. 2003; De Croon et al. 2003; Nachtegaal et al. 2009b). Therefore, it is hypothesized that when a significant adverse relationship between hearing ability and sick leave is observed, this could (partly) be explained by a higher level of need for recovery among people with a reduced hearing ability. To examine whether need for recovery works as a mediator (either partially or fully) in this association, the relationships between a) hearing ability and sick leave, b) hearing ability and need for recovery, c) and need for recovery and sick leave are performed successively. In the case of mediation, the effect of hearing ability on sick leave becomes non-significant or is reduced when need for recovery is controlled (Baron and Kenny 1986).

Effect modification (interaction effect) was checked as well. When effect modification showed a *p* value below 0.10, stratified analyses were conducted. This condition was met for social support in the association between hearing ability in noise and absolute productivity, and for the presence of chronic conditions other than hearing impairment in the association between hearing ability in noise and differential productivity. The association between hearing ability and absolute productivity was therefore performed separately for participants with low social support and respondents with high social support. The median of the support score was taken as the cut-off value: a social support score of 24 or higher was identified as high social support, a lower score was defined as low social support. Separate analyses were conducted for respondents with a) no chronic conditions, b) one or two chronic conditions, or c) more than two chronic
conditions when examining the relationship between hearing ability and self-reported differential productivity.

RESULTS

Study population and descriptives
On average, people who were working 12 hours or more per week were significantly younger than people without a job (or working less than 12 hours) (44.6 yrs versus 49.0 yrs, p<0.001) and had significantly better hearing ability in noise (-4.6 dB SNR versus -4.1 dB SNR, p=0.008). A total of 385 (51.5%) participants were classified as having good hearing, 182 (24.3%) had insufficient hearing, and 181 (24.2%) participants had poor hearing according to the national hearing test. Women were significantly younger than men (female mean age = 42.8 years, SD=10.2; male mean age 47.8 years, SD= 10.4, p<0.001) and had on average significantly poorer hearing ability in noise than men (female mean SRT<sub>n</sub>= -4.3, SD= 3.5; male mean SRT<sub>n</sub>= -5.2, SD= 3.4, p<0.001). Men worked significantly more hours per week than women (36.7 versus 29.1 hours per week, p<0.001). On average, participants worked 31.9 hours per week. 47.8% of the participants were classified as having an office job, 44.8% had a job in the public service field, whereas the other 7.4% of the participants performed a job which was identified as manual labor. Means and standard deviations, stratified by hearing ability category representing good (SRT<sub>n</sub>&lt;-5.5dB), insufficient (-5.5≤SRT<sub>n</sub>≤-2.8) and poor hearing (SRT<sub>n</sub>&gt;-2.8dB) as determined by Smits et al. (2006a) are presented in Table 4.1.
Table 4.1. Descriptive statistics for need for recovery, psychosocial job characteristics, hearing ability, and demographic variables stratified by National Hearing test category.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Good (N=385)</th>
<th>Insufficient (N=181)</th>
<th>Poor (N=182)</th>
<th>Total (N=748)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Age</td>
<td>43.7</td>
<td>10.3</td>
<td>45.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N ♂</td>
<td>165</td>
<td>-</td>
<td>57</td>
<td>-</td>
</tr>
<tr>
<td>N ♀</td>
<td>220</td>
<td>-</td>
<td>125</td>
<td>-</td>
</tr>
<tr>
<td>Hearing ability (SRT&lt;sub&gt;n&lt;/sub&gt;)</td>
<td>-7.3</td>
<td>1.1</td>
<td>-4.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Need for recovery</td>
<td>38.0</td>
<td>30.5</td>
<td>46.6</td>
<td>30.6</td>
</tr>
<tr>
<td>Job Control</td>
<td>77.0</td>
<td>10.0</td>
<td>76.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Psychological job demand</td>
<td>34.4</td>
<td>5.1</td>
<td>34.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Social support</td>
<td>23.7</td>
<td>3.7</td>
<td>23.2</td>
<td>4.0</td>
</tr>
<tr>
<td>No. work hours</td>
<td>32.7</td>
<td>8.9</td>
<td>32.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Absolute productivity (0 - 10)</td>
<td>7.5</td>
<td>1.0</td>
<td>7.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Differential productivity† (-10 – 10)</td>
<td>0.32</td>
<td>1.37</td>
<td>0.18</td>
<td>1.03</td>
</tr>
<tr>
<td>Sick leave (days in past 4 months)</td>
<td>3.1</td>
<td>10.1</td>
<td>4.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Sick leave (% yes)</td>
<td>47.2</td>
<td>50.5</td>
<td>51.5</td>
<td>-15.0</td>
</tr>
</tbody>
</table>

† Difference between the usual mean job performance during the past four months of the respondent and the usual performance of an average worker with the same job. A positive score means that the usual job performance during four months is better than the usual performance of the average employee with a comparable job.

Hearing ability and sick leave

Of those having good hearing ability in noise, 47.2% reported one or more days of sick leave during the past four months and these proportions in the group of workers with insufficient and poor hearing were 50.5% and 51.5% respectively. The results of the analyses examining the relationship between hearing ability in noise and sick leave and the possible mediating effect from need for recovery are shown in Table 4.2. Sick leave was dichotomized. Without adjustment for confounders, the odds for more than five days of sick leave during the four month period increased significantly with decreasing hearing ability in noise (OR=1.07, 95%-CI=1.00 – 1.13).
**Table 4.2.** Results of the regression analyses testing the four hypotheses of the mediation model: 1) hearing ability is significantly associated to sick leave, 2) hearing ability is significantly associated to need for recovery (NFR), 3) need for recovery is significantly associated to sick leave, and 4) the relationship between hearing ability and sick leave is significantly weakened when controlling for need for recovery. 5): additional analysis correcting for the confounders chronic conditions and educational level.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>OR*</th>
<th>95%-CI</th>
<th>p</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Hearing ability – sick leave</td>
<td>1.07</td>
<td>1.00 – 1.13</td>
<td>0.041</td>
<td>0.008</td>
</tr>
<tr>
<td>2) Hearing ability – NFR*</td>
<td>b=1.26</td>
<td>0.63 – 1.89*</td>
<td>&lt;0.001</td>
<td>0.021</td>
</tr>
<tr>
<td>3) NFR – sick leave</td>
<td>1.01</td>
<td>1.00 – 1.01</td>
<td>&lt;0.001</td>
<td>0.043</td>
</tr>
<tr>
<td>4) Hearing ability – sick leave, corrected for NFR</td>
<td>1.05</td>
<td>0.98 – 1.11</td>
<td>0.164</td>
<td>0.052</td>
</tr>
<tr>
<td>5) Hearing ability – sick leave, corrected for NFR and chronic conditions and educational level</td>
<td>1.02</td>
<td>1.01 – 1.03</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.03</td>
<td>0.97 – 1.10</td>
<td>0.329</td>
<td>0.073</td>
</tr>
</tbody>
</table>

* For the association between hearing ability and NFR linear regression analysis was used, so regression coefficient (b) and not OR is presented for this particular analysis.

Furthermore, we found that hearing ability in noise was significantly associated with need for recovery (b=1.26, 95%-CI= 0.63 – 1.89, p<0.001), and need for recovery was significantly associated with sick leave (OR=1.01; 95%-CI= 1.00 – 1.01 p<0.001). When adding need for recovery to the association between hearing ability in noise and sick leave, hearing ability in noise loses its predictive value (OR=1.05, 95%-CI=0.98 – 1.11), while need for recovery explains the variance in sick leave (OR=1.02, 95%-CI= 1.01 – 1.03). This suggests a mediating effect from need for recovery: the higher odds for sick leave of more than five days can partly be explained by a higher need for recovery among those with poorer hearing ability in noise. However, relevant confounding was found for the variables chronic conditions (21% change) and educational level (17% change). An additional analysis showed that these variables attribute to the higher level of sick leave as well (see analyses 5 in Table 4.2). The Sobel test to examine whether a mediating effect is significant (Baron and Kenny 1986) showed a trend for a mediating effect from need for recovery in the relationship between hearing ability and sick leave (p=0.067).
Hearing ability and self-reported productivity

Table 4.3 shows the results of the analysis examining the association between hearing ability in noise and absolute productivity. In this relationship, social support appeared to be an effect-modifier. Hence, separate analyses were performed for participants with low social support (n=372) and for the group with high social support (n=376). From all the tested potential confounders, only need for recovery led to a relevant change of the regression coefficient (-11%). For those who experienced high social support, no significant relationship between hearing ability and absolute productivity was found. In the group of respondents experiencing little social support from their colleagues and supervisors, the absolute productivity decreased significantly with poorer hearing ability in noise. After adjustment for need for recovery, absolute productivity (scale from 0 to 10) decreased with 0.054 points for every dB SNR poorer hearing ability in noise (95%-CI: -0.088 – -0.02).

Table 4.3. Association between hearing ability and absolute productivity during four months. Unadjusted and adjusted pooled regression coefficient (b), 95% confidence intervals (CI), and p-values. The regression coefficient expresses the change in absolute productivity for every dB SNR poorer hearing ability.

<table>
<thead>
<tr>
<th></th>
<th>b</th>
<th>95%-CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low social support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-0.060</td>
<td>-0.095 – -0.025</td>
<td>0.002</td>
</tr>
<tr>
<td>Model 2</td>
<td>-0.054</td>
<td>-0.088 – -0.020</td>
<td>0.003</td>
</tr>
<tr>
<td>High social support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-0.004</td>
<td>-0.039 – 0.031</td>
<td>0.823</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.002</td>
<td>-0.031 – 0.034</td>
<td>0.923</td>
</tr>
</tbody>
</table>

Model 1: unadjusted
Model 2: adjusted for need for recovery

When examining the relationship between hearing ability and differential productivity, significant effect modification was found for the variable ‘chronic conditions’. As described above, this variable measures the presence of chronic conditions other than a reduced hearing ability. Therefore, stratified analyses, unadjusted (model 1) and adjusted for the relevant confounders need for
recovery and number of working hours per week (model 2), were performed and these results are presented in Table 4.4.

Table 4.4. Association between hearing ability and differential productivity during four months. Unadjusted and adjusted pooled regression coefficient (b), 95% confidence intervals (CI), and p-values. Separate analyses for people with no other chronic conditions, one or two other chronic conditions, and more than two other chronic conditions. The regression coefficient expresses the change in differential productivity (scale -10 to 10) for every dB SNR poorer hearing ability.

<table>
<thead>
<tr>
<th></th>
<th>b</th>
<th>95%-CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>No other chronic conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-0.049</td>
<td>-0.096 – -0.002</td>
<td>0.041</td>
</tr>
<tr>
<td>Model 2</td>
<td>-0.048</td>
<td>-0.094 – -0.001</td>
<td>0.043</td>
</tr>
<tr>
<td>One or two chronic conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-0.047</td>
<td>-0.081 – -0.014</td>
<td>0.007</td>
</tr>
<tr>
<td>Model 2</td>
<td>-0.035</td>
<td>-0.067 – -0.002</td>
<td>0.038</td>
</tr>
<tr>
<td>&gt; two other chronic conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>0.028</td>
<td>-0.037 – 0.094</td>
<td>0.374</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.038</td>
<td>-0.027 – 0.103</td>
<td>0.237</td>
</tr>
</tbody>
</table>

Model 1: unadjusted
Model 2: adjusted for need for recovery & number of working hours per week

The data demonstrate that for people with two or fewer chronic conditions, the differential productivity decreased significantly with poorer hearing ability. For people with no chronic conditions, differential productivity decreased with 0.048 points (on a scale from -10 to +10) for every dB SNR poorer hearing ability in noise (95%-CI: -0.094 – -0.001; p=0.043). For those with one or two chronic conditions, the differential productivity decreased with 0.035 points for every dB SNR poorer hearing ability in noise (95%-CI: -0.067 – -0.002; p=0.038). This association was not significant for the group of respondents with more than two other chronic conditions.

Hearing ability and experienced limitations at work

Results of the multinomial regression analyses are presented in Table 4.5. None of the tested confounders led to a change of the regression coefficient of hearing
ability of 10% or more, so only unadjusted analyses are presented. A significant association was found between hearing ability and the extent to which people experience health-related limitations at work. For every dB SNR poorer hearing ability in noise, the odds for sometimes experiencing limitations was 1.14 times greater than the odds for seldom or never experiencing limitations (95%-CI: 1.07 – 1.21, p<0.001). Furthermore, the odds for experiencing limitations often to very often was 1.24 times greater than the odds for experiencing limitations seldom to never for every dB SNR poorer hearing ability in noise score (95%-CI: 1.05 – 1.45).

Table 4.5. Association between hearing ability and experienced limitations in amount and kind of work because of health problems. Unadjusted and adjusted pooled odds ratios, 95% confidence intervals (CI), and p-values. The odds ratio expresses the change of the odds for experiencing limitations sometimes (or often to very often respectively) in comparison with the odds for experiencing limitations seldom to never, for a 1 dB SNR change in hearing ability.

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95%-CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.14</td>
<td>1.07 – 1.21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Often to very often</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.24</td>
<td>1.05 – 1.45</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Reference category: “seldom to never”
Model 1: unadjusted

DISCUSSION

Findings and comparison with other studies

The main aim of the present study was to examine the association between hearing ability and sick leave and the role of need for recovery in this relationship, and the association between hearing ability and productivity at work. The results revealed that the odds for more than five days of sick leave during the four months of reports increased with poorer hearing ability in noise, when not adjusting for confounders. Testing for mediation revealed a trend for a mediating effect from need for recovery in this relationship. It (partly) explained the association between hearing ability in noise and sick leave. Other variables that
contributed to the relationship between hearing ability and sick leave were chronic conditions and educational level.

Kramer et al. (2006), observed a higher incidence of sick leave among employees with hearing loss (77%) compared to normally hearing colleagues (55%). The higher incidence of sick leave was solely a result of a higher prevalence of psychological distress and strain in the hearing impaired group. Although the reason for sick leave was not available in the present study, the finding of (a trend for) a mediating effect from need for recovery is in line with the previous findings, as a high need for recovery is seen as a result from psychological strain. The percentage of hearing impaired people reporting sick leave in the study of Kramer et al. (2006) was higher than in the current study. We observed that 50.5% of those with insufficient hearing ability and 51.5% of those with poor hearing ability reported sick leave. This is in contrast with Kramer et al. (2006), who reported an incidence of 77% in the group of participants with hearing loss. A possible explanation for this difference could be that the sample of Kramer et al. (2006) comprised patients of audiology clinics with the majority of them having moderate to severe hearing loss (Kramer et al. 2006). Participants in the present study subscribed through the Internet and the sample was a mixture of both patients of audiology clinics and those not having sought out services yet, with a wide range of hearing abilities. Another explanation for the difference between the results of this study and those of previous studies relates to the way sick leave was measured. Whereas Kramer et al. (2006) asked their participants to report the number of days off because of sick leave in the past twelve months, we asked about sick leave in the past month, at four consecutive time intervals. Although a period of 12 months covers a longer period and is less time consuming, a disadvantage is that it may be difficult for the respondents to accurately recall the number of sick days taken in the past year. Such a task may have led to recall bias, which may explain the difference in incidence rates.

The other variable we examined in this study was self-reported work productivity, which was divided into absolute productivity and differential productivity. Among people experiencing little social support, the absolute productivity declined
slightly with poorer hearing ability, after adjustment for need for recovery. In the group of respondents experiencing high social support no significant relationship was found between hearing ability and absolute productivity. This finding underlines the importance of social support at the workplace for people with hearing impairment and is in line with the results of Tye-Murray at al. (2009). In this qualitative study, acceptance of the hearing loss by supervisors and co-workers and the adaptations made in the workplace were defined as one of five factors influencing self-perceived job competency. Furthermore, the results of this study revealed that hearing ability appeared to have no (additional) influence on differential work productivity when two or more other chronic conditions were present. Hearing ability in noise also did appear to influence the type or amount of work respondents could do. Multinomial regression analyses showed that for every dB SNR poorer hearing ability in noise, the odds for experiencing sometimes limitations in the type or amount of work caused by health problems, was 1.14 times greater than the odds for seldom to never experiencing limitations caused by health problems. Compared to the odds for the reference category of seldom to never experiencing limitations, the odds for often to very often experiencing limitations at work was even 1.24 times greater for every dB SNR poorer hearing ability in noise. Although we cannot specify the type of restrictions the participants in the present study experienced, the results are in line with other studies. For example, Hogan et al. (2009) found that among employees with hearing loss and communication difficulties, more than 50% reported that their disability restricted their employment. Most of those restrictions related to the type of job, and difficulties in changing profession or getting the preferred job (Hogan et al. 2009).

The NL-SH sample comprised a mixture of people with and without hearing aids: about 25% of the population reported to have a hearing aid. One may wonder whether owning a hearing aid would have had a significant influence on the results. Additional analyses examining this issue were performed. The results revealed no differences between hearing impaired participants with and without aids in the associations between hearing ability and sick leave, absolute and differential productivity or experienced limitations caused by health problems.
Any effect modification from hearing aid use was not found either. In other words, sick leave, self-reported work productivity, and experiencing health-caused limitations were similar for those owning hearing aids and those not owning hearing aids. However, these results do not justify the conclusion that hearing aids are useless. We did not compare an employee’s work performance with and without hearing aids. Hence, workers with hearing aids might have benefited from their hearing aids, and their functioning may have been worse without the aids.

**Possible limitations**

The results of a previous study on sick leave showed that differences in sick leave between hearing impaired and normally hearing employees could mainly be explained by a higher incidence of absence due to mental distress (Kramer et al. 2006). Unfortunately, with the questions used in the present study it was not possible to differentiate between absence because of mental distress or because of common reasons, such as a flu. Hence, we were not able to examine whether the reasons for sick leave differed between hearing impaired and normally hearing workers in the present population, and if hearing impairment was associated with higher sick leave because of mental distress. We argue that this issue deserves further attention in future research.

Another possible limitation is the response rate. Overall response rate on all four questionnaires was 66.0%. Selective non-response could have biased the results. However, there were no significant differences in hearing ability, age or gender between the respondents who completed all measures and those who did not, so the non-response can be assumed to be a-selective. In addition, to handle the missing data, multiple imputation was used. This method is known in the literature as the most adequate and reliable method to minimize change variation in outcomes (Sterne et al. 2009). It thus seems justified to state that highly similar findings would have been obtained if a response rate of 100% was achieved.

Participants were allowed to use either headphones or speakers during the speech-in-noise test. When using speakers, the participants were recommended
to do the test in a quiet environment, because of the possible disturbing effects of a noisy environment. The majority of the participants (65%) used speakers during the test, and one may wonder whether this would have biased the hearing test outcomes. The absence of relevant confounding or significant effect modification, however, implies that the results were not influenced by headphones versus speaker use. This is in line with our previous studies reporting on data collected within the NL-SH (e.g. Nachtegaal et al. 2009a), were an influence of headphone use (yes/no) on the studied associations was not observed either. Note that we used speech-in-noise thresholds (rather than absolute thresholds). These are less sensitive to the effects of environmental noise.

In the current study, women had significantly poorer hearing ability than men and were significantly younger. Females having poorer hearing than males is in contrast with some other population studies (e.g. Dalton et al. 2003), and may have resulted from the way participants were enrolled. Subjects had to subscribe themselves actively and it seems as if females were more compliant to participating in this study than their male peers. This may have led to a more biased selection than one would expect when using a random list of addresses to invite participants. In addition, a few population studies, using questionnaires, observed lower response rates for men than for women (e.g. Eaker et al. 1998). Whereas we were expecting a similar gender difference in the response rate, no such difference in response rate was observed.

**Implications**

Although for some subgroups in this study a significant decline in self-reported productivity with decreasing hearing ability was found, the self-reported productivity loss was small. Its relevance might therefore be questioned. For example, with a decline in hearing ability of one standard deviation (3.5 dB SNR), the absolute productivity decreased with 0.19 points on a scale ranging from 0 to 10 for people with little social support at work. The small decline might be related to an individual’s adaptation to a reduced hearing ability. For example, people with severe chronic diseases, such as cancer or mobility disabilities, often rate
their quality of life to be equal to people who are healthy or less severely ill (Rapkin and Schwartz 2004). This so-called response shift may have happened to the respondents with hearing impairment in the current study, when rating their work performance. If so, the association between hearing ability and productivity might have been underestimated. Another factor which might have led to an underestimation of the association is the so-called healthy worker effect. According to that effect, an individual must be relatively healthy in order to be employable at all (Li and Sung 1999). This would imply that only the relatively healthy persons with hearing impairment are able to work, and as a consequence, the real impact from a reduced hearing ability on working life may have been obscured.

The mean differential productivity was higher than zero in all three categories (good, insufficient, and poor) of the National Hearing Test. This means that although differential productivity decreases with poorer hearing ability in noise, respondents in all three categories rated their own productivity on average higher than the productivity of their colleagues (see Table 4.1). In a different study, participants spoke about their need to work twice as hard as their coworkers to compensate for their hearing loss (Tye-Murray et al. 2009). This experience could explain why workers with reduced hearing felt to be more productive than their coworkers in the current study.

The results of this study furthermore highlight the relevance of the variable need for recovery after work. The higher odds for long term sick leave in workers with poorer hearing appeared to be partially mediated by a higher level of need for recovery in this group. Hence, monitoring the need for recovery after work among patients with hearing loss by the occupational physician or in an audiological context might be considered as an appropriate action (see also Nachtegaal et al., 2009b). The need to develop rehabilitation programs addressing the specific problems of people with hearing impairment in the working place has been stressed by several previous studies (i.e. Jennings and Shaw 2008 ) and examples of such programs or tools have been described (Hétu and Getty 1991, Kramer 2008, Jennings et al. 2009). These include, for example, modifications in the
workplace, psychosocial counseling, communication training such as lip-reading, and restructuring time schedules. In addition, it might be useful to implement need for recovery management in these programs, for example by providing relaxation techniques or other tools. In this way, preventive measures could be taken to avoid high levels of need for recovery, and thus lower the risk for sick leave. Such rehabilitation programs should also address the issue of ‘social support’. The significant association between poorer hearing ability and poorer absolute productivity in this study was only observed in those receiving little support from their coworkers or supervisors.

Finally, it is worth mentioning here that the results of this study could also be interpreted in a positive light. The positive mean differential productivity in all three hearing test categories indicates that, despite a decreased hearing ability, people still come to work and feel that they are as productive as their colleagues. Also, the absence of a significant association between hearing ability and absolute self-reported productivity among employees experiencing high social support, and the role of need for recovery in the relationship between hearing ability and sick leave suggest that with efficient support employees with reduced hearing ability might function just like their normally hearing colleagues.

CONCLUSIONS
This study examined the association between hearing ability in noise and sick leave and the association between hearing ability in noise and self-reported productivity at work. Poorer hearing ability was associated with lower absolute self-reported productivity in workers experiencing little social support, and with lower differential productivity in those with less than two other chronic conditions. Also, when not adjusting for confounders, decreasing hearing ability in noise significantly increased the odds for sick leave of five days or more during a four-month period. The relationship could be partially explained by higher levels of need for recovery after work, for which a trend in a mediating effect was observed. Hence, in addition to rehabilitation programs addressing the specific
problems of workers with hearing impairment, programs to control or monitor
the need for recovery after work and adequate social support are recommended
to prevent long term sick leave and self-assessed productivity loss in workers with
limited hearing ability. It is emphasized that despite having limited hearing ability,
workers with reduced hearing ability feel that they are as productive as their co-
workers.

REFERENCES

between hearing impaired persons and a normal hearing population. *Soc Behav Pers, 31*, 191-
204.

Baron, R. & Kenny, D. (1986). The moderator-mediator variable distinction in social psychological

Briggs, A., Clark, T., Wolstenholme, & Clarke, P. (2003). Missing.... presumed at random: cost-

Arboconvenanten: ketallen en grenswaarden. *TBV, 12*: 100-104.

determinants and hearing function in an elderly population: Osservatorio Geriatrico Campano
Study. *Gerontology, 45*, 323-328.


Danermark, B. & Gellerstedt, L. (2004). Psychosocial work environment, hearing impairment and


for recovery after work scale: test-retest reliability and sensitivity to detect change. *Occup

sickness absence: a 2-year prospective cohort study in truck drivers. *J Psychosom Res, 55*, 331-
339.


*SJR, 6*, 225-244.


health and other characteristics of a large sample. *Int J Audiol, 45*, 715-723.

occupational hearing loss, *Audiology, 30*: 305-316.

Hogan, A., O'Loughlin, K., Davis, A., & Kendig, H. (2009). Hearing loss and paid employment:


Van Veldhoven, M. & Meijman, T.F. (1994). *Het meten van psychosociale arbeidsbelasting met een vragenlijst: de vragenlijst beleving en beoordeling van de arbeid (VBBA) [The measurement of psychosocial job demands with a questionnaire]*.