Psychological Effects of Hearing Aid Use in Older Adults

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Hearing impairment in older adults is a chronic condition with high prevalence that shows negative correlations with communication, social integration, well-being, and cognition. In the present study, a group of elderly individuals with mild to moderate hearing loss who received a hearing aid for the first time in their lives (aural rehabilitation group, \( n = 70 \)) and two age-matched control groups (hearing-impaired control group without hearing aids, \( n = 42 \); approximately normal hearing control group, \( n = 28 \)) were tested longitudinally over a 6-month period. Measures examined their performance in the domains of communication problems, social activities, satisfaction with social relationships, well-being, and cognition. Data analyses show that in older persons with mild to moderate hearing loss, hearing aid use has positive effects on self-perceived hearing handicap, but there is no effect of hearing aid use in domains like social activities, satisfaction with social relations, well-being, and cognitive functioning.

The psychological effects of hearing aid use in elderly hearing-impaired adults were analyzed in the present study. Does the use of hearing aids help elderly hearing-impaired adults in coping with the negative consequences of hearing loss in old age? A 6-month longitudinal intervention study was conducted comparing elderly hearing aid users with two control groups: hearing-impaired elderly persons without hearing aids and approximately normally-hearing older adults. Both hearing-impaired groups had mild to moderate hearing loss.

Presbycusis is a high-frequency symmetric hearing loss in old age beginning gradually around the fifth decade and leading progressively and irreversibly to moderate to severe losses of hearing capacity in higher ages (Corso, 1981; Fozard, 1990; Olsho, Harkins, & Lenhardt, 1985). Causes of hearing loss in old age include peripheral changes in the inner ear (degeneration of the basilar membrane, especially loss of hair cells) and changes in central auditory processing (Kline & Scialfa, 1996; Willott, 1991). Age effects for auditory and speech processing independent from hearing sensitivity have also been documented (Humes & Christopherson, 1991; Hutchinson, 1989; Neils, Newman, Hill, & Weiler, 1991; Wingfield, Aberdeen, & Stine, 1991).

Hearing impairment is the second most prevalent chronic condition in old age (U.S. Department of Health and Human Services, 1992). Prevalence estimates of hearing loss in old age depend on the criterion used, but it is probably safe to say that at least 30% of those over 65 are so severely hearing impaired that they would benefit from a hearing aid (Davis, 1983, 1989; Davis & Thornton, 1990; Parving, Ostri, Paulsen, & Gyntelberg, 1983; Rudin, Rosenhall, & Svärdssudd, 1988). In nursing homes prevalence rates are even higher: It has been estimated that between 45% and 75% of nursing home residents suffer from moderate to severe hearing loss (Garahan, Waller, Houghton, Tisdale, & Runge, 1992; Voecks, Gallagher, Langer, & Drinka, 1990).

The auditory system fulfills several functions for the person. These are the communication function (speech is the most common way to convey information, to express inner states, and to appeal to others), the alarm function (the person can detect events without seeing them), the orientation function (the person is able to orient him- or herself in space and to locate sounds even with closed eyes), and the emotional-aesthetic function (the person can hear loved voices and the sounds of music). Hearing loss in old age affects all these functions negatively, but probably losses in communication ability are most serious to the person. Communication problems might lead to feelings of isolation and loneliness in the hearing-impaired person and stress the relationship with an unimpaired communication partner. Finally, one can assume that hearing loss might affect the environmental information intake negatively.

There is evidence to suggest that presbycusis-related communication problems have consequences in some areas of psychological functioning. Research has focused on the relationships between hearing capacity and the areas of communication problems, social integration, well-being, cognitive capacity, and functional impairment. Well-documented are negative correlations of hearing loss with communication ability (Garstecki, 1987; Lichtenstein, Bess, & Logan, 1988; Mulrow et al., 1990b; Pedersen & Rosenhall, 1991; Sever, Harry, & Rittenhouse, 1989; Weinstein & Ventry, 1983), depression (Carabellese et al., 1993; Jones, Victor, & Vetter, 1984) and cognitive capacity (Granik, Kleban, & Weiss, 1976; Lindenberger & Baltes, 1994; Marsiske, Delius, Lindenberger, Scherer, & Tesch-Römer, 1996; Sands & Meredith, 1989; Schae, Baltes, & Strother, 1964; Thomas et al., 1983; Uhllmann, Teri, Rees, Mozolowski, & Larson, 1989; but cf. also Gennis, Garry, Haaland, Yeo, & Goodwin, 1991, who found no correlation between hearing loss and cognitive capacity). Equivocal results on the correlates of hearing loss have been found in respect to social isolation and functional impairment (Bess,
Lichtenstein, Logan, Burger, & Nelson, 1989; Norris & Cunningham, 1981; Rudberg, Furner, Dunn, & Cassel, 1993; Thomas et al., 1983; Weinstein & Ventry, 1982). One might conclude that hearing loss is rather consistently related to communication problems, depression, and intellectual decline in old age, while social isolation and functional impairment do not seem to be as strongly associated with hearing loss.

At present there is no medical cure for presbycusis. The only way to help elderly hearing-impaired adults is through rehabilitation with hearing aids (Glass, 1986; Henoch, 1979; McCarthy, 1987a, 1987b; Stephens & Goldstein, 1983). Hearing aids are small technical devices that amplify environmental sounds. Although there have been technological advances in hearing aid technology in the last decades, hearing aids are problematic assistive devices. Four problem areas in the use of hearing aids have been identified: Elderly hearing aid users point to low quality of amplification, stigmatization, financial costs, and handling problems, such as inserting the hearing aid in the earmold or manipulating small levers (Franks & Beckmann, 1985; May, Upfold, & Battaglia, 1990; Plath, 1991; Tonning, Warland, & Tonning, 1991; Upfold, May, & Battaglia, 1990).

In the face of these problems one might ask if hearing aids have positive effects on those psychological variables negatively correlated with presbycusis. In most studies concerning psychological effects of hearing aid use only narrow domains of psychological functioning, like self-perceived hearing handicap, were measured (Harless & McConnell, 1982; Malinoff & Weinstein, 1989; Newman & Weinstein, 1988; von Wedel, von Wedel, & Streppel, 1991; Weinstein, 1991). Since hearing problems are a risk factor for a variety of psychological domains of functioning, not only communication problems should be measured to test intervention effects of hearing aids. It seems necessary to also include measures of well-being, social integration, and cognition. Since empirical results concerning correlation between presbycusis and social integration are equivocal (see above), it might be useful to distinguish between two aspects of social integration (Antonucci, 1990): social activities (what people do in social relations) and satisfaction with social relations (how people evaluate social relations). Hence, in the present study the effects of hearing aid use on the following five domains of psychological functioning have been analyzed using standard psychometric measures: communication problems, social activities, satisfaction with social relationships, psychosomatic well-being, and cognitive functioning.

In the present study hearing aid use was examined under an aural rehabilitation perspective, which implies two considerations. First, to analyze effects of aural rehabilitation it is necessary to use a (quasi-)experimental design. For this reason, a quasi-experimental treatment group (hearing-impaired persons who received hearing aids) was compared to a control group (hearing-impaired persons who did not receive hearing aids). Ideally, assignment of participants to experimental and control conditions should be randomized; for ethical reasons this was not done in the present study. To get baseline information about persons without hearing handicap, a group of approximately normal-hearing persons was added to the design. Second, an intervention perspective implies a longitudinal pre-post design, since it is necessary to measure the effects of hearing aid use within an appropriate time frame before and after introducing the aural rehabilitation device. Presbycusis is a chronic process that progressively develops over an extended period of time (years). One might therefore assume that aural rehabilitation is a process in time, too. Empirical results suggest that hearing aid use becomes stabilized after about 6 months (Henrichsen, Noring, Lindemann, Christensen, & Parving, 1991). Hence, in the present study a pre-post time period of 6 months was chosen to measure the accumulated effects of hearing aid use. Also, for ethical reasons there was no withdrawal of treatment after 6 months in the present study.

The present study asks whether there is any evidence that the provision of hearing aids leads to positive intervention effects in their recipients. To answer this question, an aurally rehabilitated group of elderly individuals with hearing loss was compared longitudinally with two control groups (hearing-impaired elderly without hearing aid and approximately normal-hearing elderly) with regard to five psychological domains known to be negatively affected by presbycusis.

**Method**

**Design**

The design of the study was a planned follow-up intervention trial consisting of a quasi-experimental aural rehabilitation group and two control groups. For ethical reasons there was no random assignment of hearing impaired participants to quasi-experimental and control conditions. The aural rehabilitation group consisted of hearing-impaired persons who had been prescribed a hearing aid by an ear-nose-and-throat (ENT) physician. Participants in the hearing-impaired control group did not wish to receive a hearing aid at the time of the study and had the intention of waiting at least 6 months before getting a hearing aid. An approximately normal-hearing control group did not require a hearing aid at the time of the study. No subject had prior experience with hearing aids. According to the rules of hearing aid prescription used by German public health insurance companies, all hearing-impaired respondents were entitled to get financial help with a hearing aid, and no approximately normal-hearing subject was similarly entitled. According to these rules for hearing aid prescription, those persons who have a hearing loss of more than 30 dB in at least one of the frequencies 0.5, 1, 2, or 3 kHz in the better ear or who have a hearing loss of more than 30 dB in at least two of the frequencies 0.5, 1, 2, or 3 kHz in the worse ear are eligible for at least one hearing aid. It should be pointed out that this criterion is liberal (even persons with mild hearing loss can be entitled for aural rehabilitation according to these rules).

Hearing aid prescription and fitting was done independently of the study by ENT physicians and hearing aid acousticians before respondents entered the study (Figure 1). In Germany aural rehabilitation is carried out in a three-step process by registered hearing aid acousticians under the supervision of ENT physicians (Niemeyer, 1980). ENT physicians prescribe hearing aid(s), hearing aid acousticians fit hearing aid(s) with the goals of comfortable sound amplification and improved speech discrimination, and finally
ENT physicians inspect the function of the fitted hearing aid(s). All hearing-impaired respondents with hearing aids received their hearing aid(s) no more than 4 weeks before and less than 8 weeks after the first study interview. Rehabilitative instructions were provided by hearing aid acousticians; no additional instructions were given within this study. At baseline, hearing loss, communication problems, social integration, well-being, and cognitive abilities were measured. Following the first testing session, respondents kept a standardized "hearing diary" for about 2 months. Six months after hearing aid fitting there was a follow-up session concerning social integration, well-being, and cognition. In addition, all respondents kept a hearing diary for another week. After completing the last testing session subjects received an amount of 100 DM (about $70) for participating in the study.

Respondents

A total of 148 respondents was recruited in two ways. First, 36 ENT physicians and 22 hearing aid acousticians in Berlin referred respondents to the study. Second, respondents were recruited via announcements in public media outlets (local radio and newspapers). Eight respondents were excluded for the following reasons: severe visual impairment (n = 2), no audiometric information (n = 5), and monaural deafness since childhood (n = 1). Thus, the study sample consisted at baseline of 140 respondents (aural rehabilitation group, n = 70; hearing-impaired control group, n = 42; approximately normal hearing control group, n = 28). Longitudinal attrition from the study panel consisted of 10 persons (2 respondents from the aural rehabilitation group returned their hearing aids to the hearing aid acoustician, 1 subject from the aural rehabilitation group did not receive hearing aids until 4 months after first study interview, 1 hearing-impaired control subject got hearing aids before follow-up, 4 respondents refused to participate at follow-up, and 2 respondents had died). Sample size at follow-up was N = 130 (aural rehabilitation group, n = 62; hearing-impaired control group, n = 41; approximately normal hearing control group, n = 27).

ENT physicians and hearing aid acousticians referred 56 respondents (mainly hearing-impaired persons with hearing aids), and 84 respondents answered public announcements. Recruitment was different for the three groups (see Table 1). In the aural rehabilitation group most respondents were referred by ENT physicians or hearing aid acousticians while in the other two groups, most subjects were recruited by media announcements (chi-square = 43.46, df = 2, p < .01). Respondents were between 51 and 87 years old (mean 71.2 years, SD = 7.3). Of the sample, 55% were women, 59% were married, and 95% were retired. Education was 10.0 years on average (SD = 1.9). A monthly income of 3,000 DM (about $2,100) or higher was reported by 45.3% of the sample. Functional impairments were low (a listing of 16 impaired activities of daily living resulted in an average score of 1.3, SD = 2.3). Respondents reported on the average 2.5 comorbid diseases (SD = 2.0) and 1.8 medications (SD = 1.9). No subject failed a Mini-Mental State Exam screening for dementia (MMSE; Folstein, Folstein, & McHugh, 1975). Results of univariate tests show that there are no significant group differences in sociodemographic and health characteristics as shown in Table 1 except for two variables (years of education, F[2,134] = 12.00, p < .01, and MMSE scores, F[2,137] = 5.56, p < .01). Scheffe tests revealed that the approximately normal-hearing group had more years of education than the two hearing-impaired groups, and that the approximately normal-hearing group had lower MMSE scores than the group of hearing-impaired respondents with hearing aids. Summarizing, one can state that, despite different recruitment methods, the two hearing-impaired groups are similar regarding sociodemographic and health characteristics.

Instruments

Audiometry. — Hearing ability was tested by an experienced audiometry assistant in the audiology department of a Berlin hospital after respondents had been examined by an ENT physician. German standard procedures in hearing aid prescription and fitting were followed using a Dorn AT 300
audiometer (Lehnhardt, 1987). Pure-tone audiometry (PTA) consisted of measuring air- and bone-conduction thresholds. Air-conduction thresholds were measured separately for each ear using headphones. Measurements included the frequencies 0.25, 0.5, 1, 2, 3, 4, and 6 kHz and started with 1 kHz in the better ear, testing first the higher and then the lower frequencies. Bone-conduction thresholds were measured in the frequencies 0.5, 1, 2, 3, 4, and 6 kHz separately for each ear. For speech audiometry, hearing thresholds for speech were tested and lists of phonetically balanced monosyllabic (PB) words were presented at 60, 80 and — if not too loud — 100 dB separately for each ear. Aurally rehabilitated respondents were presented PB words at 65 dB with and without hearing aids under free-field conditions (words were presented in a noiseless chamber over a loudspeaker at a distance of 1 m from the respondent).

**Hearing diary.** — Following the first and the last testing session, subjects kept a standardized hearing diary (returned by mail). The hearing diary form was developed within this study. The average number of diary entries at baseline was 44.1 and at follow-up 8.7. In the diaries respondents rated 44.1 and at follow-up 8.7. In the diaries respondents rated positive and negative affect, described duration of selected social activities, and reported on hearing problems. In addition, subjects with hearing aids reported on hearing aid use, satisfaction, and problems with the hearing aid. Satisfaction with hearing aids was measured using a 5-point scale (1 = low satisfaction and 5 = high satisfaction). From the diaries, average hearing aid use, satisfaction with hearing aid(s) and social activities (time spent with other people) at baseline and follow-up were calculated when there were at least seven diary entries.

**Communication problems.** — A German translation of the Hearing Handicap Inventory for the Elderly (HHIE) was used to measure self-perceived hearing handicap (Ventry & Weinstein, 1982). The HHIE is widely used in auditory rehabilitation research and consists of two scales measuring social and emotional problems associated with hearing handicap.

**Social activities.** — Social activities were measured using two instruments. First, a list of 14 leisure activities involving social partners was presented (e.g., going out with others, visiting friends, going for a walk with another person). Respondents indicated if they had performed these leisure activities during the last month and how important the activities were to them, resulting in unweighted and weighted leisure activity counts. This instrument was developed for the present study. Internal consistency of the scale is moderate (Cronbach's alpha = .63 and .65, Guttman split-half reliability r = .69 and .70 for the unweighted and weighted scores, respectively). Since analyses with both unweighted and weighted scores show converging results, only analyses concerning unweighted activity counts are reported. Second, as described above, average daily time spent with others was calculated from the diaries.

**Satisfaction with social relations.** — Satisfaction with social relations was measured using two instruments. A German version of the UCLA loneliness scale was used (Quast, 1986; Russell, Peplau, & Cutrona, 1980). Satisfaction with social support was measured using a subscale of a German social support scale (F-SOZU, Sommer & Fydrich, 1991).

**Psychosomatic well-being.** — Psychosomatic well-being was measured using three scales. First, for measuring emotional well-being the Positive Affect Negative Affect Scale (PANAS) was used (Watson, Clark, & Tellegen, 1988). In the present study the PANAS was used to measure emotional state “during the last weeks” at baseline and follow-up. The difference between positive and negative affect was taken to indicate affect balance. Second, depressive symptomatology was measured using a German 15-item version of the Center
for Epidemiological Studies–Depression Scale (CES–D; Hautzinger & Bailer, 1993; Radloff, 1977). Third, somatic well-being was measured using a German symptoms list (Zerssen, 1976).

Cognition. — Three domains of intellectual abilities were measured using five tests: speed (digit symbol substitution, digit letter), fluency (animals, letter ‘s’) and vocabulary (spot-a-word). Modified versions of tests developed for the Berlin Aging Study were used (Lindenberger, Mayr, & Kliegl, 1993). In the digit symbol substitution test respondents had to transcribe symbols according to a digit-symbol template (Lindenberger et al., 1993). In the digit letter test respondents had to name letters according to a digit-letter mapping template (Lindenberger et al., 1993). In the animals test and letter ‘s’ test respondents had to name as many different animals and words starting with the letter ‘s’, respectively, as possible (Lindenberger et al., 1993). In the spot-a-word test items containing one word and four pronounceable nonwords were presented; the task of the subject was to name the word (Lehrl, 1977). In the two fluency tasks responses were scored distinguishing correct responses and incorrect responses (morphological variants, repetitions, wrong category). Scores from correct responses only were used in data analysis. Coding of cognitive tests was done by a highly experienced test coder.

Factor structure of instruments. — To analyze the relationships between dependent variables, a principal component analysis with varimax rotation was performed. The five-factor solution (73.7% explained variance) classified dependent variables as expected: communication problems (self-perceived hearing handicap), social activities (leisure activities, time spent with others), satisfaction with social relations (loneliness, satisfaction with close relationships), psychosomatic well-being (affect-balance, depressive symptomatology, psychosomatic symptoms), and cognition (digit-symbol, digit-letter, letter ‘s,’ naming animals). For all variables, substantial factor loadings were greater than $a = .65$, side-loadings on other factors were less than $a = .40$, and communalities were higher than $h^2 = .60$. Only the cognition variable spot-a-word had double loadings of $a = .68$ on the factor communication problems and $a = .48$ on the factor cognition.

RESULTS

Statistical analyses were performed using SPSS (Norusis, 1990). Missing data in the psychological variables were estimated from scale means. In PTA, missing data were estimated from the lower frequency next to the missing frequency.

Hearing Capacity and Hearing Aid Use

In all pure-tone and speech audiometric measures the groups differed: The aural rehabilitation group showed more severe hearing loss than the hearing-impaired control group, which in turn differed significantly from the approximately normal-hearing controls (Table 2). This was true for PTA in the speech frequencies 0.5, 1, and 2 kHz ($F[2,137] = 81.39, p < .01$), PTA in high frequencies 1, 2, and 4 kHz ($F[2,137] = 107.24, p < .01$), hearing threshold for speech ($F[2,135] = 37.31, p < .01$), and correctly named PB words at 60 dB ($F[2,132] = 44.09, p < .01$). In all analyses, Scheffé tests revealed significant differences among the three groups. Most respondents showed symmetric hearing capacity (difference between ears in PTA average in 0.5, 1, and 2 kHz smaller than 30 dB) and air-bone gaps less than 10 dB in the better ear, implying that hearing impairment was mainly due to sensorineural hearing loss. All respondents in the hearing-impaired groups were entitled to a hearing aid; their hearing loss can be characterized as mild to moderate (mean PTA in the frequencies 0.5, 1, and 2 kHz in the aural rehabilitation group 36.0 dB, $SD = 9.0$, in the hearing-impaired control group 25.8 dB, $SD = 8.7$; mean high frequency PTA in 1, 2, and 4 kHz 47.3 dB, $SD = 10.4$, and 37.8 dB, $SD = 9.6$, respectively). The aural rehabilitation group showed the strongest hearing loss of all three groups. Average hearing loss in the hearing-impaired control group was smaller. Respondents in the approximately normal-hearing control group were in no need of hearing aids: their average hearing level was almost comparable to younger adults (mean PTA in 0.5, 1, and 2 kHz 11.6 dB, $SD = 4.2$, mean high frequency PTA in 1, 2, and 4 kHz 16.4 dB, $SD = 5.6$).

Most of the respondents in the hearing aid group were fitted with only one hearing aid (73.8%). About half of the hearing aids were in-the-ear hearing aids (50.8%). German public health insurance companies pay about 1000 DM Table 2. Information Regarding Hearing Capacity

<table>
<thead>
<tr>
<th>Pure-tone audiometry</th>
<th>Aural Rehabilitation Group</th>
<th>Hearing-Impaired Control Group</th>
<th>Normal-Hearing Control Group</th>
<th>Differences Between Groups</th>
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</thead>
<tbody>
<tr>
<td>PTA (0.5, 1, 2 kHz) in dB ($SD$)</td>
<td>36.0 (9.0)</td>
<td>25.8 (8.7)</td>
<td>11.6 (4.2)</td>
<td>**</td>
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<tr>
<td>PTA (1, 2, 4 kHz) in dB ($SD$)</td>
<td>47.3 (10.4)</td>
<td>37.8 (9.6)</td>
<td>16.4 (5.6)</td>
<td>**</td>
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<tr>
<td>Difference between ears $&lt; 30$ dB, %</td>
<td>92.9</td>
<td>97.6</td>
<td>100.0</td>
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<tr>
<td>Air-bone gap better ear $&lt; 10$ dB, %</td>
<td>92.5</td>
<td>97.6</td>
<td>100.0</td>
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<th>Speech audiometry</th>
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<tbody>
<tr>
<td>Hearing threshold for speech, dB ($SD$)</td>
<td>25.4 (9.2)</td>
<td>19.3 (7.6)</td>
<td>10.0 (4.8)</td>
<td>**</td>
</tr>
<tr>
<td>PB words at 60 dB, % correct ($SD$)</td>
<td>47.9 (27.6)</td>
<td>66.0 (22.6)</td>
<td>97.0 (7.0)</td>
<td>**</td>
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* * $p < .01$.
(about $700) per hearing aid prescribed by an ENT physician; this amount is sufficient for standard behind-the-ear hearing aids. Nevertheless, study respondents fitted with hearing aids paid, on average, an additional amount of 1,200 DM (about $840) for their devices, with a range of 0–5,000 DM ($0–3,500). Hearing aid amplification resulted in a gain in freefield audiometry at 65 dB: The percentage of correctly identified PB words significantly increased on average by 17.6% (SD = 16.5) when respondents used their hearing aids ($t(59) = -8.28, p < .01$). Percentage of correctly identified PB words without hearing aids amounted to 67.4% (SD = 23.5) and with hearing aids to 85.0% (SD = 13.1). Satisfaction with hearing aids was moderate to high. The only exception was one participant whose satisfaction increased from “hardly satisfied” at baseline to “very satisfied” at follow-up. Average satisfaction with hearing aids increased slightly but significantly from baseline to follow-up (average scores at baseline 3.59, at follow-up 3.75, $t(43) = -3.15, p < .01$). There was a high stability in hearing aid satisfaction ($r = .80, p < .01$). There was no significant mean change and high correlational stability in hearing aid use ($r = .82, p < .01$). There was interindividual variation in hearing aid use, which ranged from baseline from a daily average of 36 to 924 minutes (range at follow-up: 26 to 960 min). Correlation between hearing aid use and hearing aid satisfaction was $r = .46 (p < .01)$ at baseline and $r = .32 (p < .05)$ at follow-up. Two aspects of aural rehabilitation were fulfilled satisfyingly in the present sample: Hearing aid users experienced a gain in speech discrimination when using their hearing aids, and satisfaction with their aids was moderate to high.

**Intervention Effects**

As reported above, the two hearing-impaired groups differed in terms of audiometric hearing loss. In addition, significant differences between groups were found in self-perceived hearing handicap at baseline (HHIE, $F[2,137] = 30.71, p < .01$). Hence, comparisons between hearing-impaired quasi-experimental and control groups might be confounded with extent of hearing loss. To overcome this methodological problem, three types of statistical analyses were performed to test the intervention effect of hearing aids. First, mixed design MANOVAs with one between-subjects factor (Group with three levels: aural rehabilitation group, hearing-impaired control group, approximately normal-hearing control group) and one within-subjects factor (Time with two levels: baseline and follow-up) involving all subjects ($N = 140$) were performed to test the differences in change over time among all three groups. An intervention effect would be indicated by a significant Group $\times$ Time interaction. Descriptive statistics for all dependent variables are shown in Table 3 ($N = 140$). At baseline groups were similar in all but two dependent variables. Significant differences among groups were found in self-perceived hearing handicap (see above) and the cognitive test spot-a-word ($F[2,137] = 6.26, p < .01$). Scheffé tests revealed that mean values of the aural rehabilitation group were higher in self-perceived hearing handicap and lower in the cognitive test compared with both control groups.

Second, group comparisons (MANOVAs) were replicated with two matched subsamples of the aural rehabilitation group and the hearing-impaired control group. Participants in these subsamples were matched on audiometric hearing loss and self-perceived hearing handicap at baseline ($N = 50$). For both members of a pair, differences in

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<th>Table 3. Descriptive Statistics in Dependent Variables for Three Groups Between Baseline and 6-Month Follow-up: Means and Standard Deviations (in Parentheses)</th>
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<tr>
<td>Communication problems</td>
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<td>Hearing handicap (HHIE)</td>
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<td>Social activities</td>
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<td>Satisfaction with social support</td>
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<td>Loneliness (UCLA)</td>
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<td>Psychosomatic well-being</td>
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<td>Affect balance (PANAS)</td>
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<td>Depressive symptomatology (CES-D)</td>
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<td>Spot-a-word</td>
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<td>Letter &quot;s&quot;</td>
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<td>Naming animals</td>
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averaged audiometric hearing loss in the speech frequencies (0.5, 1, and 2 kHz) were smaller than 10 dB, and differences between self-perceived hearing handicap (HHIE) were smaller than 15 points. There were no statistically significant differences between the matched groups of aurally rehabilitated participants and hearing-impaired participants without hearing aids regarding audiometric hearing loss and self-perceived hearing handicap (audiometric hearing loss: aural rehabilitation group, mean 30.9 dB [SD 8.5]; hearing-impaired control group, mean 28.5 dB [SD 8.4], F[1,48] = 0.007, n.s.; self-perceived hearing handicap: aural rehabilitation group, mean 13.8 [SD 8.2]; hearing-impaired control group, mean 13.6 [SD 7.8], F[1,48] = 0.94, n.s.). Third, hierarchical regression analyses were performed predicting dependent variables measured at follow-up by scores from baseline. Baseline measures included the dependent variable, self-perceived hearing handicap, hearing loss, and the dummy-coded variable, hearing aid use. Results will be interpreted when all three analyses converge (level of significance \( p < .05 \)). In a second set of analyses, all MANOVAs and hierarchical multiple regression analyses were replicated, controlling for demographic and health variables (using age, years of education, functional impairment scores, and Mini-Mental State scores as covariates). Since results do not differ, only the first set of analyses will be reported.

**Communication problems.** — An intervention effect of hearing aids was found in the indicator of communication problems in all three analyses. Self-perceived hearing handicap (HHIE) dropped for the aural rehabilitation group between baseline and follow-up, while the means of the two control groups remained stable (\( N = 140 \)). The Group \( \times \) Time interaction was significant (Group \( \times \) Time interaction  \( F[2,126] = 24.56, p < .01 \)). This finding was replicated in the matched samples (\( N = 50 \)). The Group \( \times \) Time interaction term was significant also in the reduced sample \( (F[1,48] = 14.81, p < .01) \). Means and standard deviations (in brackets) of the HHIE in the reduced sample were as follows: aural rehabilitation group at baseline 13.8 (8.2), at follow-up 8.0 (7.6); hearing-impaired control group at baseline 13.6 (7.8), at follow-up 15.2 (10.4). Figures 2A and 2B depict the results of these analyses.

In the stepwise multiple regression analysis, three variables were used to predict self-perceived hearing handicap measured at follow-up: self-perceived hearing handicap measured at baseline, hearing loss in the speech frequencies, and hearing aid use (dummy-coded, 1 = hearing aid, 2 = no hearing aid). Predictors were entered in the regression model in the same order as listed here. As can be seen in Table 4, stability in self-perceived hearing handicap is moderate \( (R^2 = .23) \). In the second step, the variable hearing loss is entered in the regression model, which does not add significantly explained variance. Finally, the dummy-coded variable, hearing aid use, is entered into the regression model and increases significantly the explained variance \( (R^2_{\text{change}} = .05, \ F = 9.10, p < .01) \). Inspection of the Beta-coefficient shows that self-perceived hearing handicap at follow-up increases when individuals do not use a hearing aid (Beta = .29).

**Social activities.** — In all three statistical analyses, no significant intervention effects (Group \( \times \) Time interaction term) were found in the variables measuring social activities (leisure activities, time spent with others).
Satisfaction with social relationships. — Regarding indicators of loneliness and satisfaction with social support, the multivariate analysis of the reduced sample \((N = 50)\) revealed a significant Group × Time effect (Pillai's criterion = .2160, \(F[2,46] = 6.34, p < .01\)). In univariate analyses only the intervention effect for the loneliness score was significant \((F[1,47] = 12.67, p < .01)\). In the full sample \((N = 140)\) the multivariate Group × Time interaction was not significant, although in univariate analyses an intervention effect in the loneliness scores \((UCLA)\) was found \((F[1,124] = 3.29, p < .05)\). In the multiple regression analyses loneliness scores at follow-up were predicted by loneliness scores at baseline only \((R^2_{adj} = .70, F = 303.13, p < .01)\). The other predictors did not add significantly explained variance in the criterion variable.

Psychosomatic well-being. — In all three statistical analyses, no significant intervention effects (Group × Time interaction term) were found regarding indicators of psychosomatic well-being (affect balance, depressive symptomatology, psychosomatic symptoms).

Cognition. — In all three statistical analyses, no significant intervention effects (Group × Time interaction term) were found regarding indicators of cognitive functioning (digit-symbol test, digit-letter test, spot-a-word, letter “s,” naming animals).

Cross-Lag Panel Analysis
Group comparisons as reported so far could be problematic because hearing aid use varied widely within the aural rehabilitation group (possible violation of internal validity). It might be useful to focus on the aural rehabilitation group only and analyze the effects of hearing aid use directly. Therefore, the extent to which hearing aid use (as measured via hearing diaries) was related to dependent variables over time was examined. Hence, cross-lag panel analyses were executed, relating extent of hearing aid use at baseline to dependent variables at follow-up ("cross-lag correlations"). Since autocorrelations influence longitudinal cross-lag correlations, partial correlations were calculated, correcting cross-lag correlations for scores of dependent variables at baseline. Table 5 shows cross-lag correlations between hearing aid use at baseline and dependent variables at follow-up, and partial cross-lag correlations between hearing aid use at baseline and dependent variables at follow-up (controlled for dependent variable at baseline). Note that only data from the aural rehabilitation group entered into this analysis. Due to missing diary data, maximal sample size for these analyses is \(n = 47\).

There are two significant cross-lag correlations between hearing aid use at baseline and dependent variables at follow-up. High hearing aid use at baseline is correlated with low self-perceived hearing handicap \((r = -.37, p < .01)\) and low depressive symptomatology \((r = -.29, p < .05)\) at follow-up. Only one of these correlations remains significant when controlling for baseline scores of dependent variables: high hearing aid use at baseline is correlated with low self-perceived hearing handicap at follow-up \((r = -.39, p < .05)\). Note that reversed cross-lag correlations predicting hearing aid use at follow-up from dependent variables at baseline were not significantly different from zero in most dependent variables (both uncorrected and partial cross-lag correlations).

**DISCUSSION**

The present study is a planned follow-up intervention trial consisting of a quasi-experimental aural rehabilitation group and two control groups: one consisting of hearing-impaired elders without hearing aids, the other consisting of approximately normal-hearing elderly respondents. Based on a literature review, the areas of communication problems, social activity, satisfaction with social relations, well-being, and cognition were identified as domains of psychological functioning potentially positively affected by hearing aid use. Group comparisons revealed that hearing aid use has positive effects on self-perceived hearing handicap only. It remains to be tested whether this decrease in self-perceived hearing handicap corresponds to a decrease of actual communication problems as rated by observers. There were no robust significant effects in indicators of social activity, satisfaction with social relations, well-being, and cognitive capacity. Since hearing aid use varied widely in the aural rehabilitation group, cross-lag panel analyses were performed. These analyses revealed that high hearing aid use at
baseline reliably leads to lower self-perceived hearing handicap at follow-up. Combining the results of group comparisons and cross-lag analysis, one can say that positive intervention effects of hearing aid use could be shown reliably in self-perceived hearing handicap. The results of the present study are consistent with other intervention studies in this area (Malinoff & Weinstein, 1989; Newman & Weinstein, 1988; Weinstein, 1991). It has to be acknowledged, however, that positive changes in depressive symptomatology found by Mulrow and colleagues (Mulrow et al., 1990a; Mulrow, Tuley, & Aguilar, 1992) were not replicated in the present study (a significant zero-order correlation between hearing aid use at baseline and depressive symptomatology at follow-up was not stable in cross-lag analysis). It should be emphasized that hearing impairment in the present sample was mild to moderate. It could be that in populations with more severe hearing handicap the intervention effect of hearing aid use might be different, possibly more positive and influencing more domains of functioning.

Methodological Considerations

Before considering theoretical and practical implications of the results, two methodological limitations of the present study should be pointed out. First, the hearing-impaired groups (aural rehabilitation and hearing-impaired control) differed in terms of hearing capacity and subjective hearing problems at baseline. Hearing loss and self-perceived hearing handicap were higher in the aural rehabilitation group compared with the hearing-impaired control group. This baseline group difference could lead to a "regression towards the mean" effect, thus artifically inflating the intervention effect found in self-perceived hearing handicap. Since the intervention effect in the total sample \((N = 140)\) could be replicated within matched subgroups \((N = 50)\) and by multiple regression analysis, one could carefully interpret the decrease in self-perceived hearing handicap as intervention effect. Still, the design of the current study was quasi-experimental (nonrandom assignment of participants to experimental conditions). It seems advisable to replicate the current study with a true experimental design.

Second, there was no control over hearing aid fitting within this study. Aural rehabilitation was performed by registered hearing aid acousticians under the supervision of ENT physicians according to the German standards of hearing aid fitting. Results regarding satisfaction with hearing aids and improved speech discrimination indicate that hearing aid fitting in the present study complies with the general goals of aural rehabilitation. All subjects but one were at least moderately satisfied with their hearing aids at baseline. There was also a significant increase in speech discrimination (hearing aid gain) with and without using hearing aids. Hence, fitting of hearing aids might be considered as satisfying. Still, most of the individuals in the current study got only one hearing aid (monaural rehabilitation), although all participants should have been fitted with two hearing aids because of symmetric hearing loss (Hellbrück, 1993). Since monaural rehabilitation for elderly hearing-impaired individuals is not atypical (Hermann, 1990), the results of the present study do not reflect the effects of "ideal aural rehabilitation," but rather the current practices in the German aural rehabilitation model. Summarizing, one might conclude that despite methodological limitations the results of the present study point to positive intervention effects in the domain of self-perceived communication problems.

Theoretical Considerations

Hearing aids support elderly hearing-impaired persons in communication and social interaction. In the present study, no reliable influence could be found on indicators of social activity, satisfaction with social relations, well-being, and cognition. Why do hearing-impaired elders on the one hand experience a subjective improvement in communication ability through their hearing aids, but do not benefit from their devices in other domains of psychological functioning, although hearing loss affects these areas negatively? To answer this question, it might be useful to speculate about the relationship between impairments of the auditory system and psychological functioning in the domains of social activity and cognition.

Although even mild to moderate hearing impairment might heavily disturb social interactions, one has to emphasize that many social activities performed by older adults take place in a social convoy that has developed over the life span (Antonacci, 1990). The social convoy of a person might be rather unaffected by mild to moderate hearing loss. On the other hand, chronically increasing hearing problems might slowly and undetectably change social habits (not changing the social convoy). These slow changes in social habits might occur without awareness of communication problems in the aging person. It may take some time before that person detects (or acknowledges) subjective communication problems. Hence, although hearing aids influence the subjective perception of communication problems within short periods of time (weeks, months), social activity patterns adapted to chronic hearing problems might not be changed as promptly. It should be emphasized, however, that this could be quite different for more severe hearing impairments.

Another causal nexus might apply to the relationship between hearing capacity and cognitive abilities. Two hypotheses have been discussed to explain the substantial correlations between hearing ability and cognitive capacity in old age. The "common cause hypothesis" argues that decreases in central cognitive processing affect simultaneously sensory and cognitive functioning (Lindnerberger & Baltes, 1994). The "cascade hypothesis," on the other hand, claims that decreases in hearing ability over extended periods of time (years) affect cognitive functioning because of sensory underload (Sekuler & Blake, 1987). Regarding the use of hearing aids, these hypotheses make different predictions. Under the common cause hypothesis, hearing aids should have no positive effect on cognitive functioning at all, since the underlying central aging mechanism is not affected by acoustic amplification. Although the cascade hypothesis would predict positive changes in cognitive functioning due to compensation for sensory loss, these changes would not necessarily be swift. Positive effects of hearing aid use are contingent on the duration of rehabilitation and the extent of hearing aid use (Gelfand, Silman, & Ross, 1987). At the worst, prolonged understimulation of the
The cognitive system might even lead to irretrievable losses. Hence, in this case aural rehabilitation might produce no effects in cognitive functioning. Since in the present study hearing aid use over a period of 6 months only was analyzed, no definite conclusion can be drawn with respect to common cause and cascade hypothesis. Nevertheless, the temporal dimension (onset and duration of hearing aid use) might be a crucial variable in hearing aid rehabilitation.

Consequences for Intervention

Implications of the present study for practical interventions give rise to a tempered optimism: Hearing aid use is helpful in communication; the extent of actual hearing aid use reduces self-perceived communication problems. Since hearing aids are intended to enhance hearing capability and reduce hearing problems, this result might be interpreted optimistically in terms of rehabilitation success. Two other practical findings of this study should be emphasized, however. First, hearing aid use varies widely. Within this study, daily average hearing aid use varied between 30 minutes per day to 16 hours per day. This finding is consistent with other studies that have found high interindividual variability in hearing aid use (Grünes Kreuz, 1985; Hermann, 1990; Mulrow et al., 1990a). Second, hearing aid use is highly stable over 6 months: Those persons who use their hearing aid(s) only very little in the first weeks will use their devices also at a low rate 6 months later. High stability has been found for satisfaction with hearing aids, too. Since it has been shown that intention to use the hearing aid (measured prior to hearing aid fitting) predicts actual hearing aid use (Wiesner & Tesch-Romer, 1996), it seems important to improve the circumstances of hearing aid prescription and fitting. Audiologic counseling before hearing aid fitting could improve intention to use hearing aids, and psychosocial support in the first weeks of hearing aid use could lead to increased actual hearing aid use. It should be emphasized, however, that even aurally rehabilitated hearing-impaired individuals have to cope with hearing and understanding problems (Tesch-Römer & Nowak, 1995). The use of technological devices, however, is a necessary condition to strengthen communication capability of elderly individuals with hearing loss and to enable their participation in social interactions.

Acknowledgments

This study was supported by the German Research Foundation (Te 2011/2). Michael Marsiske, Reinhold Kliegl, Andreas Kruse, Marion Nowak, Eric Schmitt, and five anonymous reviewers made thoughtful comments to earlier versions of the manuscript. I am grateful to Hans-Rudolf Nitze and Margret Baltes for their help during planning and realization of this study. Anely Frogosa-Steudel was responsible for ENT examinations and audiometric measurements. Finally, I would like to thank Astrid Boekstegers, Margit Wiesner, and Andrea Wegner-Deiss for data collection.

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Received April 1, 1996
Accepted November 27, 1996

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