COMMON CONCEPTIONS ABOUT FIRST-TIME VERSUS EXPERIENCED HEARING AID USERS: FACTS OR FICTION?

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ABSTRACT

This paper describes a collaborative study between Videnscenter for Specialpædagogik (ViSP) in Storstrøms County, Denmark, and Oticon research centre, Eriksholm (ERH). Differences between first-time (FT) users and experienced (EXP) users of hearing aids were investigated by means of a specially developed questionnaire, which was issued to a total of 254 test subjects. An extensive battery of objective data was collected about the test subjects and used in the statistical analyses.

A mixture of surprising and expected results was obtained. E.g., contrary to the common conception, no difference was found between the two groups with respect to own voice and occlusion issues, whereas it was strongly confirmed that FT users tend to report that soft sounds are overly loud when amplified by the hearing aid.

The strengths and weaknesses of using self-report questionnaires as a research tool are discussed.

1 INTRODUCTION

In the hearing aid community, there appears to be a set of conceptions about how FT users of hearing aids behave compared to EXP users. Thus, most people in the industry and the world of auditory rehabilitation will probably agree to statements such as:

1. FT users are more bothered about occlusion problems and issues related to own voice than EXP users.
2. FT users find that soft sounds are too loud when amplified by the hearing aid. This is much less pronounced for EXP users.
3. FT users generally dislike amplification of high-frequency sounds. Again, this is much less pronounced for EXP users.
4. FT users are less aware of the complexities of every-day sound environments and less aware of the compromises involved in using a hearing aid, compared to EXP users.

It is, however, surprising how little support these conceptions have in the published literature.

With respect to conception #1 on occlusion and own voice issues, the lack of literature became painfully clear during the first and third authors' participation in the preparation of the Carle et al. (2002) article. Incidentally, Carle et al. did not find any differences between FT and EXP users regarding occlusion problems. While the existence of conceptions #2 and #3 is recognised by Arlinger et al. (2000), a survey of the literature for solid scientific evidence regarding the differences between FT and EXP users, which was performed at the outset of this study, was again disappointing (note that Arlinger et al. studied only FT users). During the course of this study, however, a couple of highly relevant references have appeared (Smeds, 2004; Marriage et al., 2004; Convery et al., 2005). These will be discussed later in the paper.

Conception #2 on loudness of soft sounds could possibly be related to the concept of *softness imperception*, as proposed by Florentine & Buus (2002). It is well known that the near-threshold loudness growth in impaired hearing is steeper than in normal hearing. On top of that, Florentine & Buus argued that the lowest loudness levels do not exist at all in impaired hearing. Thus, a sound which is just above threshold would have a higher loudness according to a hearing impaired listener than the loudness reported by a normally hearing listener – if the sound in question was just above the normal threshold. If this is true, one would certainly expect that it could take some time to get used to hearing soft sounds again, since their loudness in the aided condition would be greater than they used to be when hearing was normal. Thus, the concept of softness imperception seems to agree well with the anecdotal clinical evidence from which conception #2 is built. It should be noted, though, that doubt recently has been raised about the validity of softness imperception (Moore, 2004). Thus, another – and perhaps more straightforward – explanation of conception #2 is the mere audibility of the soft sounds, which the hearing aid provides; soft sounds that the FT hearing aid user has not heard for a long time.

A similar kind of reasoning could be applied to conception #3. Since the most common hearing loss slopes towards the high frequencies, there will in general be more new high-frequency sounds to get used to for the FT users, which may explain why they tend to particularly dislike amplification at high frequencies. Along these lines, appreciation of amplification of high-frequency sounds, and obtaining the benefits from it, requires a phase of acclimatisation (Vestergaard, 2004) during which the FT hearing aid user becomes an EXP user.

While perhaps being less established in the general hearing aid community, the concept of *sound awareness* (#4 above) was of particular interest in this study; spawned by previous work on *user preference fitting* (Elberling & Vejlby Hansen, 1999; Elberling & Sivertsen, 2000; Behrens et al., 2002) and *auditory ecology* of hearing aid users (Søgaard Jensen & Nielsen, 2005). In these studies, observations were made in groups of either FT or EXP users, but a direct comparison between the two user groups was not performed.

Thus, there is an obvious lack of solid scientific evidence regarding the four common conceptions listed above in particular, and the differences between FT and EXP users of hearing aids in general. The aim of the present study is to provide some of this evidence, and specifically to either confirm or reject the conceptions outlined above.

1.1 Initial considerations

Studying FT users of hearing aids is difficult, because they naturally become EXP in a relatively short period of time. Hence, conducting research with FT users requires a constant in-flow of newly fitted hearing aid users, which was readily available from the second author's facility. Another difficulty is that subjecting FT users to intense experimentation in the laboratory may bias them into becoming prematurely experienced. Since that would defy the purpose of the study, a more glancing approach was chosen, with which FT users could be studied with minimal bias. Thus, the study was conducted as a self-report survey with relatively short questionnaires issued by mail to a large number of hearing aid users, both FT and EXP.

Hearing aid users are, however, potentially different in many other respects than their amount of hearing aid experience – examples are: age, gender, aetiology, audiometric profiles, and hearing aid fitting. Systematic differences between FT and EXP groups on any of these variables may have an effect on the outcomes of a questionnaire and confound those differences between the groups of FT and EXP users, which are in fact due to the difference in hearing aid experience. This potential problem can e.g. be minimised by making the groups of FT and EXP users similar in all other aspects than hearing aid experience. This was, however, considered intractable for the present study. Instead, the statistical analysis of the data will take into account variations in the aforementioned *predictor variables*, which were collected in the study.

The local Research Ethics Committee was asked whether or not a formal application was necessary regarding the present project. The Committee determined that the present project could be carried out without applying for a formal approval.

2 MATERIAL

2.1 Questionnaire

Despite the problems related to the development of new a questionnaire (Cox, 2003), the very specific nature of the present study demanded a specially designed questionnaire. Considerations of response rate and previous experience with the user group at ViSP (see e.g. Vestergaard, 2000) suggested limiting the questionnaire to two A4 pages and a maximum of 20 questions. Furthermore, it was decided to use a categorical set of possible responses rather than a visual analog scale, also in consideration of the return rate, and in order to keep missing data to a minimum.

The questions fall in five groups: one for each of the four common conceptions outlined above, and a group of general questions regarding satisfaction and use of the hearing aids – this final group of general questions is not considered further in this paper due to space limitations. An English translation of the complete questionnaire is included in the appendix. The original questionnaires were obviously prepared in Danish, with separate versions for monaural and binaural hearing aid users. Finally, the questionnaire included a designated space for filling in the date of completion by the test subject. Below, individual questionnaire items will be referred to as Q2 for question 2, etc.

2.2 Test subjects

The clients that were invited to become test subjects in the study were basically randomly selected from the Audit database used at ViSP, with the following exceptions. All test subjects had their first hearing aid fitted at the same clinic, all were native Danes, and anyone with indications of dementia, aphasia, or other problems were disregarded. Otherwise, the primary FT/EXP group criteria were as follows.

- FT: fitted with his/her first hearing aid between 3 and 5 weeks ago. This is a compromise between the test subjects having obtained a reasonable amount of experience with the new hearing aids while still being in the initial phase of getting used to hearing aids (McLeod & Upfold, 2003).
- EXP: have used hearing aid(s) for at least 3 years and have used their current hearing aid(s) for 1 year ±1 month. The last requirement is introduced because clinical evidence shows that even EXP hearing aid users go through a period of acclimatisation after being fitted with new hearing aids, and during this period they can to some extent be considered as FT users again (Gatehouse, 1998). At the other end, the upper limit of 13 months post-fitting was introduced to make sure that the hearing aid fitting was still reasonably fresh.

An a priori estimate of how many test subjects would be required to achieve results with substantial statistical power was established. Taking also into account the expected return rate of 65%, the target was to send out questionnaires to 150 FT and 150 EXP hearing aid users.

2.3 Protocol

In accordance with the above selection criteria, questionnaires were sent out to FT users 21 or 22 days post-fitting. It was decided that questionnaires returned within 5 weeks of being sent out, and completed within 2 weeks according to the test subject's own note, were to be included in the study. Similarly, questionnaires for the EXP users were sent out 12 months (±1 month) after fitting of the current hearing aid, and were to be included if returned within 5 weeks. The inclusion criteria were met in almost all cases, and with such minor irregularities that it was decided to include all returned questionnaires in the analysis. The total amount of questionnaires sent out and the resulting return rates are shown in table 1. Thus, the target of 150+150 was not quite achieved, but was compensated by the higher-than-expected return rates.

	FT	EXP	Whole population
Sent out, valid	129	125	254
Returned	90	106	196
Return rate	70%	85%	77%

Table 1. *Overview of return rates.*

After receiving the questionnaire, the relevant screenshots from the Audit database were printed, anonymised, and filed together with the questionnaire and a cover sheet. As the Audit database was the only tractable way of collecting additional information about the test subjects, the contents of this database effectively determined the available selection of predictor variables; even though other less tangible variables such as personality type (Cox, 2003) and cognitive abilities (Lunner, 2003) are known to affect hearing aid benefit and questionnaire outcomes.

2.4 Data preparation

First, the issue of how data from monaural and binaural hearing aid users could be pooled needed to be addressed. The approach used was to identify one ear of each binaural user, which was representative for as many issues as possible. Thus, by using only these *first-ear* data of the binaural users, pooling with the monaural users became straightforward. First-ear candidacy for the binaural users was determined according to the criteria listed in table 2.

Priority	Criterion	Reasoning
1	Maximum time of use	It is expected that the most used ear/hearing-aid is the most important in determining questionnaire outcome
2	Minimum low-frequency hearing loss (average of available HTL values from 250 to 1000 Hz)	Many questions in the study are related to occlusion, and the perception of occlusion problems will be governed by the *worst ear* (Nielsen & Laugesen, 2000; Kiessling et al., 2005). Occlusion problems are more likely to occur in the ear with the least low-frequency hearing loss (Dillon, 2001)
3	Minimum discrimination loss (DL%)	It is expected that the aided ear that contributes most to speech understanding is the most important
4	Random draw	

Table 2. *Hierarchy of criteria for determining the first ear of the binaural users.*

The process of preparing the available raw data for a statistical analysis involved a number of transformations and simplifications. A few examples need to be mentioned.

- Outcome data were numerically coded 1, 2, 3, 4, 5, left to right, see also appendix.
- Instead of discarding out-of-range audiometric data these were replaced by numbers 5 dB larger than the stated limit. Thus >110 would be replaced by 115, etc.
- The elaborate classification system used at ViSP for audiological diagnoses was reduced to three categories: Sensorineural (S), Mixed (M) or Conductive (C).
- Data for different vent configurations (Parallel, Stepped, Collection, etc.) were transformed into equivalent parallel vent size (see e.g. Carle et al., 2002).

Gathering vent data was considered very important because of common conception #1 on occlusion and own voice, but these data were compromised by many missing data in the Audit database. This turned out only to consider ITE hearing aids, and was related to the fact that often the vent size ordered for an ITE is changed by the manufacturer because of lack of physical space in the hearing aid shell. Hence, the ITE vent data are either not entered at all or are not updated with the vent size actually produced. Consequently, all pertinent manufacturers were approached about providing vent information for the ITE hearing aids used in this study, based on serial numbers; and all agreed to participate. For later reference, the complete list of predictor variables used in the analysis below is shown in table 3 together with brief explanations.

Predictor	Description
FT/EXP	FT or EXP user. Binary variable.
GENDER	Male or Female. Binary variable.
AGE	Measured in years.
BIN/MON	Binaural or monaural hearing aid user. Binary variable.
*HL_TYPE*_1	Type of hearing loss on first ear: S, M, C.
HL_TYPE_aided	Type of hearing loss across aided ears: S, M, C.
*AvLF_HTL*_1	Average of available HTL values from 125 to 1000 Hz at first ear. Characterises hearing loss with respect to occlusion.
*PTA*_1	Average of available HTL values from 500 to 4000 Hz at first ear. Characterises the hearing loss in general.
PTA_aided	Average of available HTL values from 500 to 4000 Hz across aided ears. Characterises the hearing loss in general.
*HA_STYLE*_1	BTE, ITE, ITC, MIC or CIC fitted to first ear.
*SC*_1	Static compliance on first ear. Strong predictor of own-voice/occlusion problems according to Carle et al. (2002).
*effVENT*_1	Effective vent diameter on first ear. Strongly influences the objectively measurable occlusion effect (Dillon, 2001).

Table 3. *List of predictor variables used in the analysis below.*

2.5 Preliminary evaluation of data

Distributions of age, gender, hearing aid fitting status, aetiology, and hearing thresholds in the two groups of FT and EXP users are shown in figure 1, table 4 and figure 2. These data show – as expected – that the FT users tend to have less hearing loss than the EXP. It is perhaps surprising that the mean ages in the two groups are very similar, but this actually agrees with the increase in age of the average FT user observed by Brunenberg et al. (2004). It is also observed that in the EXP group there are more binaural fittings (possibly because some FT users start out with a single hearing aid and become binaurally fitted later), more BTE hearing aids (either due to the greater hearing losses found in this group, or simply because the ITE hearing aid style have become more common in recent years), and more hearing losses with a conductive component (M and C aetiologies) relative to the FT user group. The gender distributions in the two groups are very similar, but there are considerably more men than women in general. An examination of the hearing aids used by the test subjects showed that the vast majority were fitted with modern digital hearing aids; without strikingly different patterns in the two user groups.

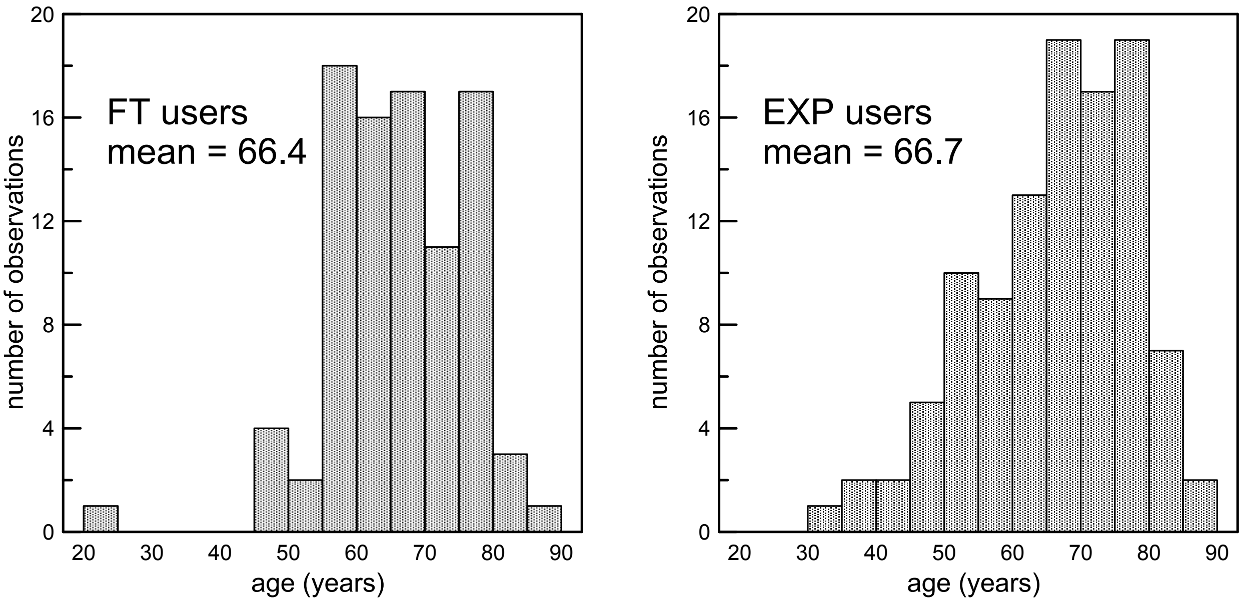

Figure 1. *Histograms of age in the two user groups.*

	FT	EXP	Whole population
Male / Female	53 / 37 59% / 41%	61 / 45 58% / 42%	114 / 82 58% / 42%
Binaural / Monaural	68 / 22 76% / 24%	93 / 13 88% / 12%	161 / 35 82% / 18%
BTE/ITE	26 / 61 30% / 70%	43 / 63 41% / 59%	69 / 124 36% / 64%
Aetiology: S / M / C	78 / 9 / 1 89% / 10% / 1%	85 / 14 / 5 82% / 13% / 5%	163 / 23 / 6 85% / 12% / 3%

Table 4. *Summary data (test subject counts and percentages) regarding gender, hearing aid fitting and aetiology.*

Factor analysis was performed on the outcome data and while the results were not very strong, the factor structure obtained with normalised quartimax rotation did indeed correspond quite well with the four common conceptions that dominated the questionnaire. Thus, the factor analysis broadly speaking suggests that the questionnaire produced sensible results. However, since this study has been designed with a strong emphasis on predictor variables and the factor analyses ignores the fact that the different items in factors or subscales may be related differently to the predictors, the analysis is continued by primarily examining individual questions.

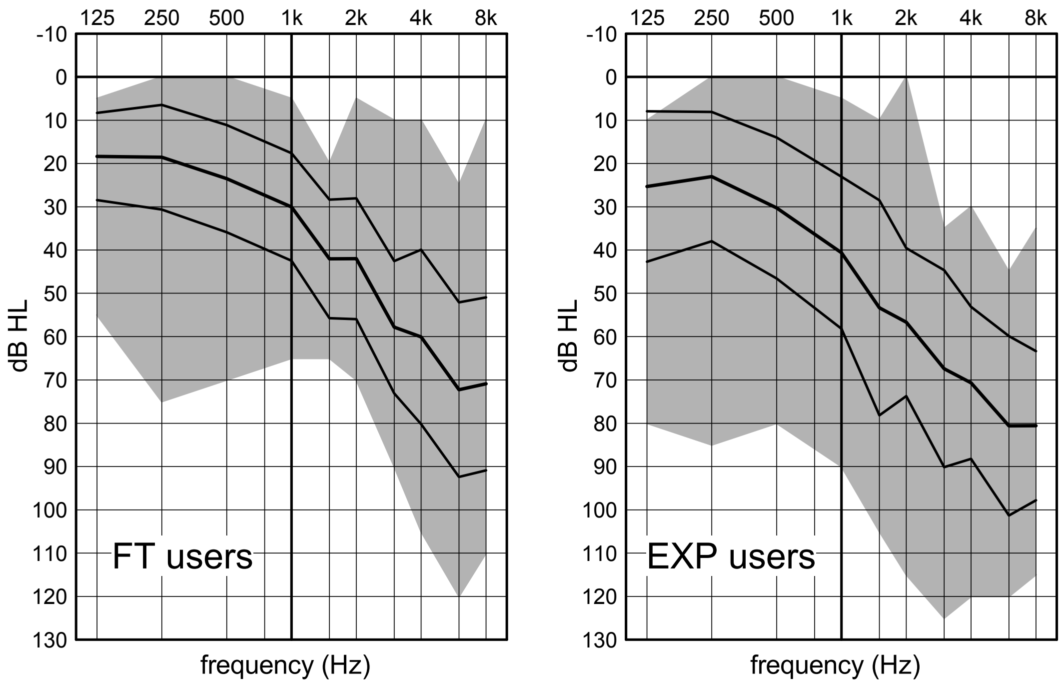

Figure 2. *Overview of audiometric data for the two user groups. Shown are the mean (bold line,) mean ±1 standard deviation (thin lines), and range (grey area) of hearing thresholds. Only first-ear data (see section 2.4) of responding test subjects are used – thus all ears included are aided.*

2.6 Analytic approach

Due to the categorical nature of the outcome data, the basic statistical tools are the Mann-Whitney U-test of group differences and Spearman rank-order correlations. Once significant predictor/outcome correlations have been established, traditional regression analyses will be used even if assumptions regarding normal distribution of data may be violated. Hence, interpretation of the results from these analyses will be done cautiously.

3 MAIN RESULTS – THE FOUR COMMON CONCEPTIONS

3.1 Own voice and occlusion issues

According to this conception, FT users are more bothered by occlusion and issues about own voice than the EXP users, who allegedly have become used to it. There are six questions that probe into issues about own voice and occlusion; see table 5.

Item	Wording	Mean FT	Mean EXP	*p*-level
Q4	How often are you asked to repeat yourself?	4.18	4.03	0.32
Q7	How is the sound quality of your own voice?	3.23	3.38	0.35
Q9	How is your feeling for the level of your own voice when you speak?	3.31	3.39	0.69
Q10	If your speaking partner interrupts you, can you hear what he/she is saying?	3.65	3.26	0.001*
Q11	Do you experience problems with a sensation of being shut in or plugged up when you speak?	3.51	3.77	0.10
Q12	Do you experience problems about hearing what other people are saying when you eat?	3.33	3.22	0.50

Table 5. *Basic results regarding the questions related to own voice and occlusion: mean scores and the results of Mann-Whitney U-tests (adjusted for ties). Results marked with * are significant at p<0.05.*

Out of these, Q7, Q11 and Q12 are "traditional" questions mainly related to occlusion, whereas Q4, Q9 and Q10 also relate to the signal processing of the hearing aid (Nielsen & Laugesen, 2004). Table 5 also shows the results of Mann-Whitney U-tests of differences between the groups of FT and EXP users. Because of the crude five-point scale used for the outcomes there are many ties in the data; hence *p*-values adjusted for ties are given (Siegel, 1956). The results show that only with regard to Q10 is there a statistically significant difference between the two groups. In contradiction to the common conception, the FT users report doing *better* than the EXP users regarding being able to hear when interrupted. The next step is then to look for predictor variables that might explain these surprising observations. Thus, Spearman correlations have been computed between the six outcome variables from table 5 and a list of potential predictor variables from table 3. The results are shown in table 6 and although some of these correlations come out as being significant, they rarely exceed a numerical value of 0.2, which corresponds to explaining only 4% of the variance in outcome. Inspired by the observations of Vestergaard (2004), predictor/outcome correlations were also calculated independently for the groups of FT and EXP users, with only marginally higher correlations as the result.

Outcome / Predictor	Q4	Q7	Q9	Q10	Q11	Q12
FT/EXP	0.072	-0.067	-0.028	0.236*	-0.118	0.049
GENDER	-0.116	0.076	0.124	-0.055	0.119	-0.152*
AGE	0.014	0.003	0.076	-0.091	0.052	-0.039
BIN/MON	0.143*	0.015	-0.032	0.011	0.020	0.077
*HL_TYPE*_1	-0.003	0.092	0.018	-0.020	0.059	0.094
*AvLF_HTL*_1	0.062	-0.095	-0.098	-0.078	0.030	0.148*
*PTA*_1	-0.027	-0.018	-0.012	-0.176*	0.147*	0.077
*HA_STYLE*_1	0.069	-0.122	-0.083	0.102	-0.161*	-0.122
*SC*_1	0.137	0.034	0.124	0.058	0.087	0.101
*effVENT*_1	0.133	0.125	0.046	0.147	-0.025	0.056

Table 6. *Spearman rank-order correlations between potential predictor variables and outcomes of the questions on occlusion and own voice. Results marked with * are significant at p<0.05. Predictor variables are explained in table 3.*

Even so, this vein of analysis is advanced one more step regarding the surprising observation on Q10 from above. Thus, a multiple regression model is formulated using the two predictor values that were significant according to table 6. The result is given in table 7, and shows that in the combined regression model, both hearing loss (in terms of *PTA*_1) hearing aid experience (*FT/EXP*) are marginally significant predictors, but the sign of the slope, β, for *FT/EXP* indicates that the FT users maintain their self-reported advantage over the EXP users even when hearing loss is controlled for. The whole model in table 7, however, explains as little as 6% of the total variance in the outcome of Q10. It is clear that formulating linear models in which the individual predictors explain so little variance is of no practical relevance.

Regression summary, R^2 = 0.064, adjusted R^2 = 0.054, whole model p < 0.002		
Predictor	Slope, β	*p*-level
FT/EXP	0.15	0.052
*PTA*_1	–0.15	0.053

Table 7. *Summary results of the regression analysis of Q10.*

As an alternative, the following approach has been taken. The factor analysis mentioned in section 2.5 suggested that five of the outcomes on occlusion and own voice co-vary considerably. Hence, a subscale was formed from these outcomes (Q7, Q9, Q10, Q11, Q12), denoted OVO_5. Next, the test subjects were divided into three groups as follows.

- *low*30_{OVO5}; those whose OVO_5 rating is less than the 30 percentile. These are expected to be the complainers; those who – in the clinic – come across as being particularly concerned about own voice and occlusion issues.
- *mid*40_{OVO5}; those whose OVO_5 rating is in the middle.
- *high*30_{OVO5}; those whose OVO_5 rating is at or above the 70 percentile. These are expected to be the non-complainers.

The idea is then to look for significant differences between the *low*30_{OVO5} and the *high*30_{OVO5} groups, in terms of relevant predictor variables. For the continuous predictor variables this has been done by t-tests (table 8) and for the categorical predictors by Mann-Whitney U-tests (table 9). The only marginally notable difference appears in table 8 and regards the *effVENT*_1 variable. The group difference has the expected direction; the vents tend to be larger in the *high*30_{OVO5} group.

Predictor	**Mean** *low*30_{OVO5}	**Mean** *high*30_{OVO5}	***p*-level**
AGE	67.7	68.6	0.63
*AvLF_HTL*_1	28.7 dB	28.8 dB	0.97
*PTA*_1	47.0 dB	45.2 dB	0.40
*SC*_1	0.83 ml	1.01 ml	0.15
*effVENT*_1	1.83 mm	2.37 mm	0.08

Table 8. *Summary results of t-tests regarding differences in means of the continuous predictor variables in the low*30_{OVO5} *and high*30_{OVO5} *groups. Predictor variables are explained in table 3.*

Predictor	***p*-level**
FT/EXP	0.52
GENDER	0.82
BIN/MON	0.35
*HL_TYPE*_1	0.21
*HA_STYLE*_1	0.17

Table 9. *Summary results of Mann-Whitney U-tests (adjusted for ties) regarding the categorical predictor variables in the low*30_{OVO5} *and high*30_{OVO5} *groups.*

Otherwise, the key observation is the complete lack of difference with respect to the *FT/EXP* variable. If the conception had been true – that FT users are more bothered by issues about own voice and occlusion than EXP users – one would surely have expected to see a significant preponderance of FT users in the *low*30_{OVO5} group considered above. A similar analysis of the final question (Q4) gave very similar results, which finally leads to the conclusion that there is no evidence of support for the common conception about own-voice/occlusion in these data – it is a myth. However, the myth is still there and probably for a good reason. The above results suggest that it is not true that EXP users "will get used to it". Rather, it would seem that EXP users accept the problems they experience with own-voice/occlusion issues and stop complaining about them in the clinic – even though the problems are still there.

Another interesting non-result is also worth a brief note. There exists another common sub-conception regarding smaller hearing aids creating worse occlusion problems. However, the hearing aid style variable *HA_STYLE*_1 did not come out as significant in table 6 in any case. This indicates that the conception is not related to hearing aid type as such. More likely, the hearing aid type to some extent dictates the maximal possible size of the vent, and vent size is probably driving the observed outcome with respect to occlusion problems – recall that the vent size variable turned out to be at least marginally significant in table 8.

3.2 Loudness of soft sounds

According to this common conception, FT users should find soft sounds overly loud when using amplification, whereas the EXP users have become used to amplification and thus have re-calibrated their internal loudness scale. Two questions aim at exploring this issue by probing into the loudness of normal speech and soft everyday sounds, respectively. Wording and summary results of Mann-Whitney U-tests regarding differences between FT and EXP users are shown in table 10. These results show that there are highly significant differences between the FT and EXP users in the outcomes of both questions. The mean values in the two groups show the expected tendencies:

- The loudness of normal speech (Q5) is close to the median rating 3 (loudness as expected), whereas the loudness of soft sounds (Q6) is rated towards the strong side.
- The EXP users are closer to the median rating 3 than the FT users who tend to state that loudness is stronger than expected. This applies to both questions, but particularly to Q6 on soft sounds.

These observations are in good agreement with the supposition. It is reassuring to observe that the average ratings of Q5 in both groups are very close to “As expected”, since a major objective of prescribing hearing aids is to make normal speech audible and comfortably loud.

Item	Wording	Mean FT	Mean EXP	*p*-level
Q5	How do you experience the loudness of normal speech in quiet surroundings?	2.81	3.07	0.0007*
Q6	How do you experience the loudness of the soft sounds of everyday life (e.g. the rustle of the newspaper, the creaking of the floor, the hum of the refrigerator)?	2.20	2.85	0.000001*

Table 10. *Basic results regarding the questions related to loudness of soft sounds.*

There is, of course, the possibility that the differences found in table 10 in fact are due to other things than FT/EXP status of the test subjects. Hence, Spearman correlations were again computed between the outcomes in Q5 and Q6 and a list of potential predictors: *FT/EXP*, *AGE*, *GENDER*, *BIN/MON*, *HL_TYPE_aided*, and *PTA_aided*, see table 3 for explanations. For each question the significantly correlated predictors were used to form regression models, with the results shown in tables 11 and 12. The results of these regression analyses show that the variations in the outcomes, which are due to the *FT/EXP* variable, remain even when the other significantly correlated predictor variables are included in the model.

Regression summary, R^2 = 0.066, adjusted R^2 = 0.056, whole model p < 0.001		
Predictor	Slope, β	*p*-level
FT/EXP	–0.18	0.02*
PTA_aided	0.12	0.12

Table 11. *Summary results of the regression analysis of Q5.*

Regression summary, R^2 = 0.18, adjusted R^2 = 0.17, whole model p < 0.00000002		
Predictor	Slope, β	*p*-level
FT/EXP	-0.33	0.00001*
HL_TYPE_aided	0.23	0.0006*
PTA_aided	0.07	0.32

Table 12. *Summary results of the regression analysis of Q6.*

The *PTA_aided* variable is not a significant predictor in any of the two cases, which suggests that the significant Spearman correlations mentioned above are in fact due to predictor inter-correlations. Indeed, it does seem reasonable that degree of hearing loss is correlated to FT/EXP status. Other than that it is interesting that *HL_TYPE_aided* appears to be a highly significant predictor of Q6 – even if the amount of variance explained is small (5%). The trend is illustrated in figure 3: with a purely sensorineural hearing loss the loudness of soft sounds is rated as stronger than expected, whereas the ratings move towards – and even beyond – “As expected” as the conductive component to the hearing loss becomes more dominant. This is supposedly because that in conductive hearing loss there is less recruitment and hence less tendency to find that soft sounds have become overly loud.

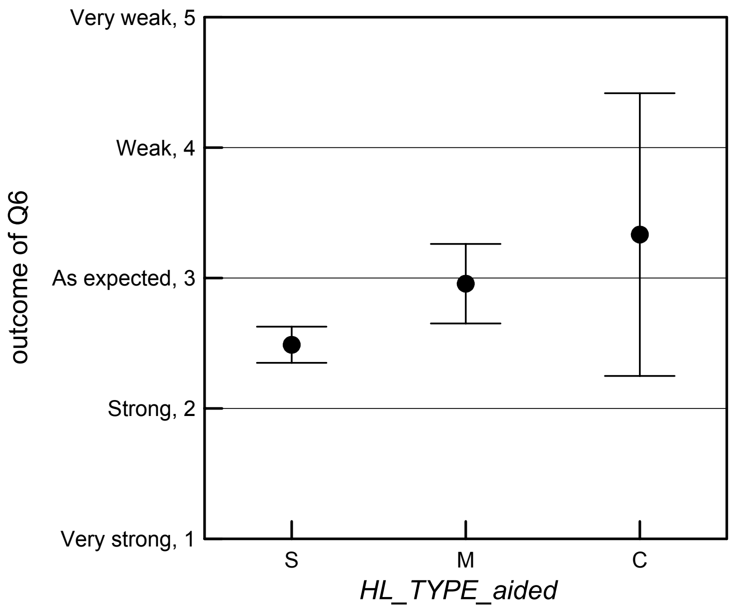

Figure 3. *Mean values (dots) and 95% confidence intervals (bars) of outcomes of Q6 across the three categories of the HL_TYPE_aided variable.*

In conclusion, the data presented above strongly confirm the common conception that FT users tend to perceive soft sounds as being overly loud. This is actually in contradiction to the conclusion drawn by Convery et al. (2005) who reviewed a long list of studies of closely related issues. However, in very few of the studies reviewed, a direct comparison was made between groups of FT and EXP users. Thus, it is noteworthy that Marriage et al. (2004) investigated the adjustments necessary to make prescribed hearing aid amplification acceptable by both FT and EXP users and found that the FT users needed significantly more gain reduction than the EXP users, although this effect was similar at both low and high input levels. Equivalent results were found by Smeds (2004): a group of FT test subjects generally preferred a hearing aid setting that provided less gain than typical prescribed settings, both at low and high input levels. An interesting exception was found with *speech* at low levels, for which higher gain was preferred – gain as would be typical for a prescribed setting. This agrees well with the observations from the current study, where the FT users rated the loudness of normal speech as being close to “As expected”, whereas the soft (non-speech) sounds were rated as louder than expected by the FT users.

3.3 High-frequency amplification

Only a single item specifically probes into the supposition that FT users are disinclined towards high-frequency amplification, see table 13, which also shows the test result regarding FT/EXP group difference. This shows no significant difference between FT and EXP users regarding Q17, although the trend is in the expected direction; FT users tend to agree more to Q17 than EXP users. Arlinger et al. (2000) found similar results, that is, a group of FT hearing aid users rated a hearing aid setting with reduced gain as less sharp than another setting with nominal gain. However, the difference observed by Arlinger et al. was not statistically significant and similarly, a difference in preference between the two settings was not observed.

Item	Wording	Mean FT	Mean EXP	*p*-level
Q17	The sound in my hearing aids is unnecessarily sharp	2.94	2.80	0.43

Table 13. *Basic results related to high-frequency amplification.*

As above, potential predictor variables were sought for by means of Spearman correlations, but none of the tested variables came out as being significant. Hence, the low30, mid40, high30 approach was brought into play again, with a similar lack of significant differences as a result. In conclusion, there is no support found in these data regarding the supposition that FT users are more disinclined towards high-frequency amplification than EXP users. It is noteworthy that Marriage et al. (2004) did indeed observe acclimatisation to high-frequency amplification, which is also a part of this common conception about FT users, but found equal amounts of acclimatisation in the groups of FT and EXP hearing aid users.

3.4 Sound awareness

The six items on sound awareness and compromises involved in using hearing aids (all rated on Disagree – Agree scales) are shown in table 14, along with usual FT/EXP group test results. It turns out that these group differences remain after controlling for the predictor variables that come out as significant from the Spearman correlation analysis.

Item	Wording	Mean FT	Mean EXP	*p*-level
Q13	My hearing aids alleviate conversation problems with one or more people in quiet surroundings	3.98	3.90	0.45
Q14	My hearing aids enable me to hear many sounds I did not hear before I got hearing aids	4.42	4.28	0.19
Q15	When using my hearing aids I am often surprised by new sounds	4.20	3.69	0.0002*
Q16	My hearing aids alleviate conversation problems with one or more people in noisy surroundings	3.27	2.63	0.0002*
Q18	With my hearing aids I can easily recognise voices and sounds that appear in my daily life	4.08	3.94	0.31
Q19	I accept the drawbacks of the hearing aids in order to achieve the benefits they bring me	4.35	4.14	0.33

Table 14. *Basic results related to sound awareness.*

Thus there are several interesting observations to make from table 14, some are mentioned here.

- New sounds. It is no surprise that FT and EXP users agree to similar degrees that the hearing aid(s) help them hear new sounds (Q14), while the FT users tend to find these new sounds more surprising (Q15).
- Benefit of hearing aids. It was expected that FT and EXP users gave similar ratings about benefit regarding conversation in quiet (Q13), whereas it was indeed surprising that the FT users reported getting more benefit in noise than the EXP users (Q16). Here, the common conception would be that FT users are overwhelmed by the amplified background noise and hence dissatisfied with this aspect of using hearing aids. Consequently, it was hypothesised that learning to appreciate that the hearing aids actually help in noisy surroundings would take time – the time it takes to become an EXP user. However, the present data indicates a statistically significant trend in the opposite direction.
- Recognising voices and sounds. While the data show equal ratings on this issue (Q18), it was expected that the allegedly more sound aware EXP users would report to agree more on this statement than the FT users.
- Accept drawbacks. A similar observation as above is made regarding Q19, with the additional comment that the overall rating is exceptionally high – it seems that this population is generally very much willing to compromise in order to obtain the benefits of hearing aids.

In conclusion, these data do not suggest that FT users are less sound aware than EXP users.

4 DISCUSSION

4.1 Potential bias problems

Several surprising results have been reported above; mainly to the effect that FT users report better performance and higher satisfaction with their hearing aids than expected, when compared to the EXP users. Several possible explanations have been examined. Firstly, in some studies of how hearing aid benefit evolves over time (acclimatisation), it has been observed that self-reported benefit may be large at about three weeks post-fitting, whereupon a decrease is observed – a phenomenon termed *halo effect* or *rebound effect* (Munro & Lutman, 2004). The evidence is mixed, though (Turner et al., 1996; McLeod & Upfold, 2003; Munro & Lutman, 2004). If a halo effect has been at play in the present study, it could have influenced the FT users' ratings in the observed positive direction. Secondly, a bias might have been inflicted by differences in the hearing aids fitted to the two user groups; if for instance a large part of the FT users had been fitted with a new and much improved product. However, as noted previously there were no striking indications of such a difference between the FT and EXP users in the study.

4.2 Obtained statistical power

In section 2.2, it was mentioned that the number of test subjects to include in the study was determined through an a priori power analysis. Below, the statistical power actually achieved in the study is examined by looking at three example results, see table 15. All examples consider FT/EXP comparisons in outcome variables. For these calculations it had to be assumed that the group mean differences were tested by means of t-tests, although Mann-Whitney U-tests were actually used. Furthermore, in each case a common standard deviation, σ, was computed as a weighted average across both groups; an F-test had in all cases indicated that it could be assumed that the variances in both groups were equal. The results in table 15 show some variation in the obtained statistical power, but it is particularly encouraging that the important results regarding Q6 and Q16 are associated with levels of statistical power that are well above the standard target value of 0.80 (Montgomery, 2001). Also, all values of statistical power shown in table 15 are well above

	Q6, *FT/EXP*	**Q10,** *FT/EXP*	**Q16,** *FT/EXP*
Source	Table 10	Table 5	Table 14
μ_1	2.20	3.65	3.27
μ_2	2.85	3.26	2.63
N_1	90	88	88
N_2	106	104	105
p-level	0.000001	0.001	0.0002
σ	0.85	0.89	1.17
α	5%	5%	5%
Power	0.9996	0.84	0.96

Table 15. *Input data and resulting statistical power. Here, μ_i are the group mean values, N_i the number of valid data points in each group, σ the common standard deviation, and α the significance level entered into the power analysis.*

4.3 On the statistical quality of self-report outcome data

In the above, a number of regression models were formed during the analysis. The one that regards Q5 is studied in a little more detail here in order to discuss the quality of these regression models and the outcome data. Thus, table 16 shows the corresponding variance breakdown. Recall from table 11 that the whole model explained as little as 6% of the total variance in the outcome of Q5, which perhaps is a surprisingly small amount compared to the strong whole-model *p*-level of 0.001. The problem is the very large residual sum-of-squares; although the residual mean-squares value becomes relatively small because of the many residual degrees of freedom (191, compared the 2 parameters estimated in the model). The question is whether it would have been possible to explain more of the variance if additional predictor variables had been available, or if this residual variance simply is to be expected in the present kind of study?

Effect	**Sums of squares**	**Degrees of freedom**	**Mean squares**	**F**	***p*-level**
Regression	3.9	2	1.96	6.76	0.001*
Residual	55.6	191	0.29		
Total	59.5				

Table 16. *Breakdown of sums of squares corresponding to the multiple regression model for Q5, also considered in table 11.*

Hence, the literature has been consulted regarding studies in which self-reported outcome of hearing aid use has been held up against a number of objective predictor variables. There is a reasonably rich selection of seemingly similar studies (e.g. Gatehouse et al., 2003; Vestergaard, 2004; Behrens et al., 2004), which – at a second glance – turn out to consider a different kind of outcome; typically the results of well-controlled speech tests (e.g. DanTale II, FAAF). In these studies the amount of outcome variance explained by the predictors is typically much higher than in the present study – in the 50% ballpark. Thus it has only been possible to find a single example (Gatehouse et al., 1999), which is in fact moderately similar to the present study. Not surprisingly, the amount of variance explained in that study is smaller – although values as high as 32% were found. In conclusion, it could be hypothesised that the data obtained by self-report questionnaires generally are infected with a large baseline variance due to the way in which data is collected (questionnaire administered by mail, no personal interaction, no calibration of the test subjects' use of the scales, no means of quality control, etc.). This view was further supported by comparing with the baseline variance found in other internal self-report studies carried out with very homogeneous groups of test subjects. In comparison, the data obtained in laboratory speech tests are of much higher quality (close personal interaction, unambiguous yardstick, quality control possible) and the baseline variance accordingly smaller.

5 CONCLUSIONS

The main conclusions regarding the four specific common conceptions about FT versus EXP users of hearing aids may be summarised as follows.

- Regarding problems with own voice and occlusion, the present data have generally speaking shown no difference between FT and EXP users. This is in opposition to the myth, which has it that FT users are more bothered by own-voice/occlusion issues than EXP users. Possibly, though, FT users speak up more about these issues in the clinic than EXP users. As a side issue, it was found that contrary to common beliefs, a smaller hearing aid style does not, as such, lead to worse occlusion problems.
- The data have strongly verified that FT users of amplification tend to perceive soft sounds as being overly loud, as compared to EXP users.
- Nothing in the present data supports the supposition that FT users are more disinclined towards high-frequency amplification than EXP users.
- With respect to sound awareness and consciousness about hearing aid benefits and disadvantages, it was expected that the EXP users generally would be more aware of their auditory surroundings, and in particular more appreciative of their hearing aids in difficult listening situations. These hypotheses were not confirmed by the data.

With respect to the research methods used in the present study it has been revealing – and sometimes rather frustrating – to observe the limits of what can be achieved from self-reported data obtained from questionnaires issued by mail. In particular, the value of gathering the rather large supplementary battery of predictor variables was disappointing; predictor-outcome correlations have generally been very small. Hence, it is not surprising that leading researchers in the hearing aid-scientific community (Gatehouse & Noble, 2004) propose to move into more controlled ways of measuring hearing aid benefit, e.g. by means of the Speech, Spatial and Qualities of Hearing Scale (SSQ) questionnaire. In the SSQ, the outcomes are determined through interviews with the test subjects, which allows for much better controlled answers than when a questionnaire is simply issued by mail without any personal interaction between the test subject and the experimenter. On the other hand, there is a much higher risk of inflicting bias with the SSQ approach compared to the more glancing method used in the present study.

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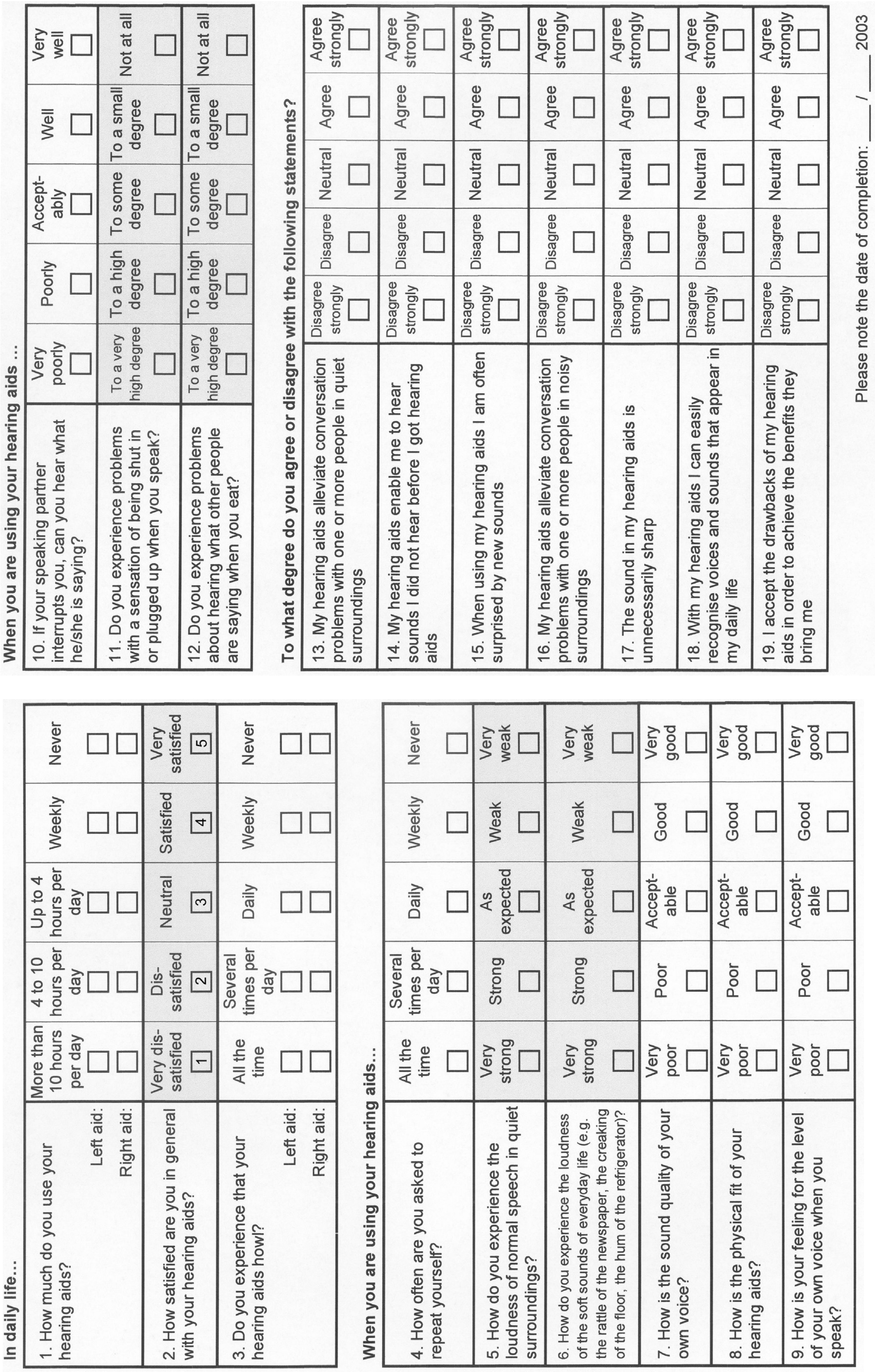
APPENDIX

Figure 4 below shows an English translation of the complete questionnaire. The version shown was for the binaurally fitted test subjects; an alternative version was used for the monaurally fitted users, in which Q1 and Q3 were not left/right-specific. Numerical coding values are indicated at Q2.



In daily life…

1. How much do you use your hearing aids?	More than 10 hours per day	4 to 10 hours per day	Up to 4 hours per day	Weekly	Never
Left aid:	☐	☐	☐	☐	☐
Right aid:	☐	☐	☐	☐	☐
2. How satisfied are you in general with your hearing aids?	Very dis-satisfied 1	Dis-satisfied 2	Neutral 3	Satisfied 4	Very satisfied 5
3. Do you experience that your hearing aids howl?	All the time	Several times per day	Daily	Weekly	Never
Left aid:	☐	☐	☐	☐	☐
Right aid:	☐	☐	☐	☐	☐

When you are using your hearing aids…

4. How often are you asked to repeat yourself?	All the time ☐	Several times per day ☐	Daily ☐	Weekly ☐	Never ☐
5. How do you experience the loudness of normal speech in quiet surroundings?	Very strong ☐	Strong ☐	As expected ☐	Weak ☐	Very weak ☐
6. How do you experience the loudness of the soft sounds of everyday life (e.g. the rattle of the newspaper, the creaking of the floor, the hum of the refrigerator)?	Very strong ☐	Strong ☐	As expected ☐	Weak ☐	Very weak ☐
7. How is the sound quality of your own voice?	Very poor ☐	Poor ☐	Accept-able ☐	Good ☐	Very good ☐
8. How is the physical fit of your hearing aids?	Very poor ☐	Poor ☐	Accept-able ☐	Good ☐	Very good ☐
9. How is your feeling for the level of your own voice when you speak?	Very poor ☐	Poor ☐	Accept-able ☐	Good ☐	Very good ☐

When you are using your hearing aids …

10. If your speaking partner interrupts you, can you hear what he/she is saying?	Very poorly ☐	Poorly ☐	Accept-ably ☐	Well ☐	Very well ☐
11. Do you experience problems with a sensation of being shut in or plugged up when you speak?	To a very high degree ☐	To a high degree ☐	To some degree ☐	To a small degree ☐	Not at all ☐
12. Do you experience problems about hearing what other people are saying when you eat?	To a very high degree ☐	To a high degree ☐	To some degree ☐	To a small degree ☐	Not at all ☐

To what degree do you agree or disagree with the following statements?

13. My hearing aids alleviate conversation problems with one or more people in quiet surroundings	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
14. My hearing aids enable me to hear sounds I did not hear before I got hearing aids	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
15. When using my hearing aids I am often surprised by new sounds	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
16. My hearing aids alleviate conversation problems with one or more people in noisy surroundings	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
17. The sound in my hearing aids is unnecessarily sharp	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
18. With my hearing aids I can easily recognise voices and sounds that appear in my daily life	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐
19. I accept the drawbacks of my hearing aids in order to achieve the benefits they bring me	Disagree strongly ☐	Disagree ☐	Neutral ☐	Agree ☐	Agree strongly ☐

Please note the date of completion: ____ / ____ 2003

Figure 4. *English translation of the questionnaire used for the binaural hearing aid users. The numerical values used for coding of data are exemplified at question 2 (Q2).*

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