A profiling system for the assessment of individual needs for rehabilitation with hearing aids

WOUTER DRESCHLER* AND INGE BRONS

Academic Medical Center, Department of Clinical & Experimental Audiology, Amsterdam, The Netherlands

Despite the huge number of hearing aids and the different options in terms of functionality, there is lack of a systematic approach how to select specific hearing aid models, or at least functionalities that may contribute to an optimal compensation of the hearing loss. If we can design such a systematic approach, this can not only be supportive for hearing aid selection, but also for a well-structured evaluation of the hearing aid benefits. If applied in a large-scale approach, this will yield practice-based evidence that will compensate for the lack of evidence-based practice in hearing aid selection.

INTRODUCTION

Although diagnostic data from pure tone audiometry and speech audiometry are essential for fitting a selected hearing aid, their role in the selection of a hearing aid itself is limited. We propose to design a systematic approach for hearing aid selection with focus on signal-processing functionalities rather than on features and operational issues like volume controls, connectivity, or options for tinnitus masking and (bi)CROS-units. For this purpose, additional information is required about the limitations experienced by the hearing-impaired client in daily life without or with their old hearing aids (pre-fitting), and how this changes with new hearing aid use (post-fitting). Therefore, it is useful to draw up an inventory of both the disabilities experienced by the hearing-impaired listener and the individual objectives for rehabilitation (fitting targets).

Kramer *et al.* (1995) developed a questionnaire to assess hearing impairment in daily life, the Amsterdam Inventory for Auditory Disability and Handicap (AIADH), which was shown to have good reliability and validity (Meijer *et al.*, 2003). For the disability profile used in this study, the AIADH was slightly adapted to the AVAB (in Dutch: Amsterdam Questionnaire for Auditory Disabilities): We only used the disability-related questions, added three questions, and rearranged the questions into six dimensions or factors: detection of sounds, speech in quiet, speech in noise, auditory localization, focus, and noise tolerance (see Table 1). Such a profile might be useful in tailoring a hearing aid to the specific needs of a patient, as well as in evaluating the benefit of a hearing aid for an individual with respect to the six different aspects of auditory functioning (see also Fuente *et al.*, 2012). An important

*Corresponding author: w.a.dreschler@amc.uva.nl

Proceedings of ISAAR 2015: Individual Hearing Loss – Characterization, Modelling, Compensation Strategies. 5th symposium on Auditory and Audiological Research. August 2015, Nyborg, Denmark. Edited by S. Santurette, T. Dau, J. C. Dalsgaard, L. Tranebjærg, and T. Andersen. ISBN: 978-87-990013-5-4. The Danavox Jubilee Foundation, 2015.

disadvantage of a questionnaire like the AVAB is that it evaluates a fixed list of common listening situations, which are not by definition situations that are relevant for the patient. As an alternative for questionnaires with fixed situations, Dillon *et al.* (1997) proposed the Client Oriented Scale of Improvement (COSI) for the evaluation of hearing aids, in which patients are asked to define their own targets for rehabilitation. Although the COSI is very useful for individual patients, the major disadvantage is that the individualization complicates the comparison of needs or benefits for groups of patients. This makes the COSI still useful for clinical practice, but of low value for research purposes and evaluation of hearing aid types or functions over groups of patients. In order to improve comparability between patients, Dillon *et al.* (1997) proposed to categorize each individual target into a set of sixteen predefined categories. Zelski (2000) concluded that the intra-observer agreement was high, but that the number of categories could be reduced. On the other hand, there is for instance no category for 'localization of sounds', despite the potential importance of this aspect in hearing aid selection and fitting.

As an alternative for the sixteen categories proposed by Dillon *et al.* (1997), the six dimensions of the AVAB might be useful. If this approach proves to be applicable, individual hearing disabilities and individual compensation targets can be compared along the same dimensions and can be taken together in a six-dimensional human-related-intended-use profile. These dimensions cover a broad range of important auditory functionalities and might be related to hearing aid functions. An advantage of using the same dimensions for AVAB and COSI is that, when using both AVAB and COSI, the COSI can help the interpretation and weighting of the AVAB results. If categorization of the COSI targets can be done in a reproducible way, COSI is a valuable tool in the hearing aid prescription and evaluation process, both for clinical practice and research purposes, by being individual and general at the same time.

The goal of this study was to determine whether the six categories defined by the AVAB disability profile are appropriate to also categorize individual COSI targets. The main two aspects of this question are (1) whether the inter-observer agreement between clinicians is sufficiently high, and (2) whether categories are regarded as missing or superfluous.

METHODS

Fitting targets from hearing aid candidates and hearing aid users

The COSI targets used in this study were administered during regular clinical practice in the Academic Medical Center. A total number of 533 COSI targets were collected from 151 consecutive patients who visited the clinic in fall 2014 and early 2015 for hearing aid fitting. During the first visit pure-tone audiometry, speech audiometry, AVAB questionnaire, and COSI questionnaire were all administered and documented. 103 patients were new hearing aid users and 48 patients already had a hearing aid. Data were gathered retrospectively from the database, thus patients and clinicians were not aware of the purpose of this study during administration of the targets. Personal information was removed to make the data anonymous.

Observers and procedure

Eight professional audiologists (six clinical physicists in audiology and two hearing-aid dispensers) participated in this study. There was a wide range in experience administering the AVAB and COSI. For the purpose of this study, this was regarded as an advantage. If inter-observer correspondence is not dependent on the level of experience, we may assume that the categorization of COSI targets is robust.

Participating audiologists received a file with the 533 COSI targets and a user interface for categorization, accompanied by written instructions. In order to make sure that they understood what was meant by the six categories (Table 1), they first got the possibility to read all AVAB questions sorted by category. After they confirmed that they understood the categories, they started the categorization procedure.

A user interface showed one target at the time and presented 3 questions to be answered for each of the targets:

1. The first question was which AVAB category describes the COSI target best. Only one category could be assigned, and observers were forced to make a choice. However, apart from the six categories, there was an option ‘not possible to categorize’ for targets that did not fit well in one of the categories.
2. The second question was if additional categories were required to describe the COSI-target. Observers were allowed here to add one or more categories, if this was judged to be relevant for the categorization of the COSI target.
3. The third question was whether the COSI target was formulated in a sufficiently specific way. Possible answers were yes or no.

Audiologists were allowed to stop at each moment and continue at a later moment from the point they stopped. After categorizing all 533 targets, the audiologist had the possibility to indicate whether they found the classification feasible, or whether they missed categories or perceived categories as superfluous. Finally, they had the possibility to give additional remarks.

AVAB: Profile of “general” disabilities	
Det	Detection
SiQ	Speech in Quiet
SiN	Speech in Noise
Tol	Noise Tolerance
Foc	Focus / Discrimination
Loc	Localization / spatial hearing

Table 1: List of dimensions that are derived from the AVAB questionnaire to inventory “general” disabilities.

RESULTS

The primary dimension

Figure 1 indicates the distribution of all judgments (8 observers times 533 COSI targets) regarding the primary dimension. Speech perception in noise and in quiet and detection were the dimensions mostly used as primary dimensions. In about 15% of the cases the audiologists chose for the option ‘not possible to categorize’ (indicated as “rest”). Some examples of COSI targets that did not match the six dimensions were: “To reduce the hinder from my tinnitus” or “Less problems with feedback”. COSI targets could also be categorized as “rest”, if the target was not specified in enough detail, e.g., “Communication with others”, “Safety in my job”, or “Less miscommunication at home”. Figure 1 also indicates that the distributions for new users (gray bars) and experienced users (black bars) are very similar.

We analysed the numbers of COSI targets that were classified identically. In 389 out of 533 COSI targets, the primary dimension was the same for 8 audiologists (55%) or 7 audiologists (18%). This indicates a good agreement between observers. We also calculated Cohen’s kappa as a metric for inter-observer correspondence (Cohen, 1960). If we include all dimensions into the analysis, Cohen’s Kappa was 0.81. This may be considered as a substantial (or even almost perfect) agreement (Landis and Koch, 1977). Other measures for inter-observer agreement (Fleiss’ kappa and Gwet’s Agreement Coefficient 1) gave comparable results, both for the analysis of all dimensions and for sub-analyses for separate dimensions. The analyses of the individual dimensions revealed that the correspondence between audiologists in the categorization of focus/discrimination is only weak to fair (kappa value of 0.3).

The use of additional dimensions

As indicated, additional dimensions could be used to categorize the COSI target. Figure 2 shows that some of the audiologists used only the primary dimensions in the majority of cases (e.g., observers 2, 3, 4, and 8), while others frequently used 2, 3, or even more dimensions. Further analysis indicated that the combinations of dimensions that occurred most frequently were:

- Speech in quiet and speech in noise (for 38% of the cases where speech in quiet was chosen as primary dimension, speech in noise was chosen as additional dimension, and for 35% of the cases where speech in noise was chosen primarily, speech in noise was added as secondary dimension).
- Detection and localization (for 25% of the cases where detection was chosen as primary dimension, localization was chosen as additional dimension, and for 38% of the cases where localization was chosen primarily, detection was added as secondary dimension).
- Detection and focus (for 15% of the cases where detection was chosen as primary dimension, focus was chosen as additional dimension, and for 38% of the cases where detection was chosen primarily, focus was added as secondary dimension).

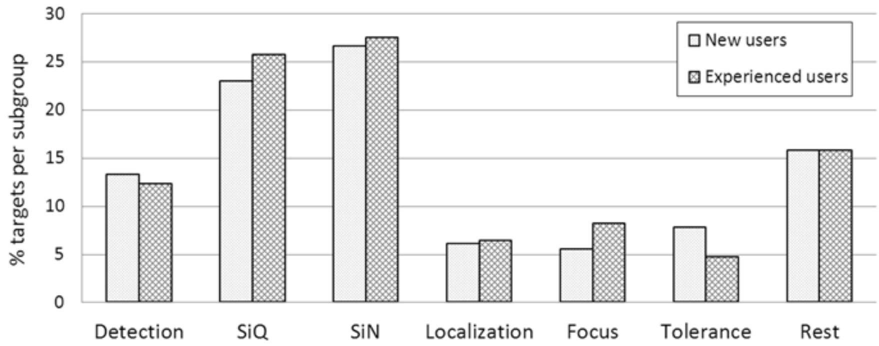

Fig. 1: Distribution of categories for the primary dimension, split for new users (gray bars; n=103) and experienced users (black bars; n=48). COSI targets that didn't match one of the 6 dimensions were categorized as "rest".

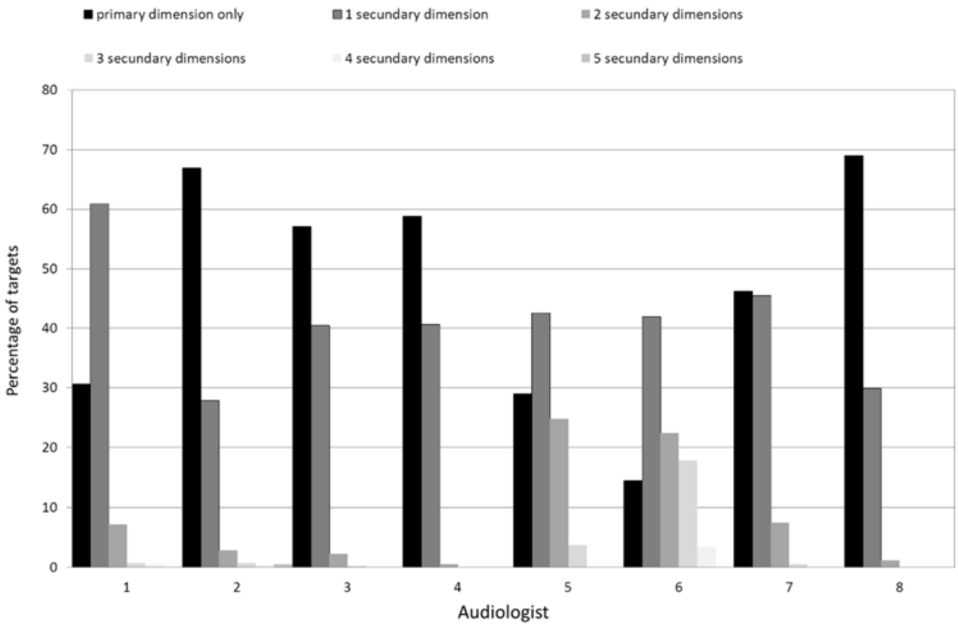

Fig. 2: Distributions of the number of dimensions used to categorize the 533 COSI targets by the 8 audiologists.

Missing dimensions

At the end of the session the audiologists answered some overall questions. The classification in six dimensions was regarded as feasible, but some categories were indicated as missing. Tinnitus was mentioned as a missing dimension by 5 out of 8 audiologists. Other dimensions that were missing were related to speech from a distance, listening effort, music and sound quality, and the perception of loud sounds. On the other hand, focus/discrimination was indicated to be more or less superfluous and was not often used.

DISCUSSION

In this study, we found a good agreement between eight audiologists in the categorization of COSI goals into the six AVAB dimensions. The agreement was very high given the fact that the observers reported that some targets are not specific enough, some targets do not fit well into the six dimensions, and some targets can easily be categorized differently, for instance: “To hear someone coming from behind, speaking”. The study yielded some suggestions to combine dimensions and add new ones. Future research is needed to design a new set of “optimal” dimensions. But, despite the possible improvements in the future, this study indicates that COSI targets can be expressed reasonably well along the same dimensions as the disability profile defined by AVAB. This allows the following two steps:

From categorized COSI targets to a target profile

COSI can now be used to define a target profile in the same six dimensions as used in the AVAB-based profile of disabilities. The purpose of the hearing aid selection and fitting is then to improve the AVAB results by using a hearing aid until the clients meet the target profile resulting from COSI. As a starting point, for instance, we use a score of 3 for each of the six dimensions, thus 18 points overall. Based on the dimensions chosen for the COSI goals, these points can be re-divided over the dimensions, with more weight for dimensions for which COSI goals were formulated than for the other dimensions.

This can be done in different ways. But as a starting point, we implemented the following weighting:

- Each fitting target was assigned to one or more dimensions. We decided not to discriminate between primary and secondary/tertiary dimensions.
- The subject’s priority was an important component of the weighting. The assignments were weighted according to the priority of the fitting target.
- The sum scores of the weighted assignments determined the relative importance of each dimension.

This way, the “18-points” are distributed according to their relative importance, indicated by the user, into an individually shaped target profile. For some subjects the resulting pattern was rather general (the points were more or less equally distributed across the six dimensions). In other subjects focused profiles were found, in which specific dimensions were much more important than others.

Combining the profiles into a profile of compensation needs

Given the finding that auditory disabilities and fitting targets can be expressed reasonably well along the same dimensions, they can be combined in a compensation profile. Of course, this can be implemented in different forms, but this section illustrates the choices that have been made in the BRIDGE program, that has been introduced recently in the Netherlands.

Figure 3 illustrates the way that disability profiles (assessed with the AVAB questionnaire) and target profiles (assessed with the COSI approach discussed above) can be combined in one profile for "compensation needs". The profile of disability is the starting point. For severe cases, the scores are closer to the centre (a severe disability gives a low score). The target profile is around 3, but may be focused as discussed above. Figure 3 shows a hypothetical but unusual example that speech in quiet is the top priority target. The difference between these two profiles is indicative of the compensation needs for an individual user and may be applied in the selection process for a hearing aid model/type and/or specific hearing aid features.

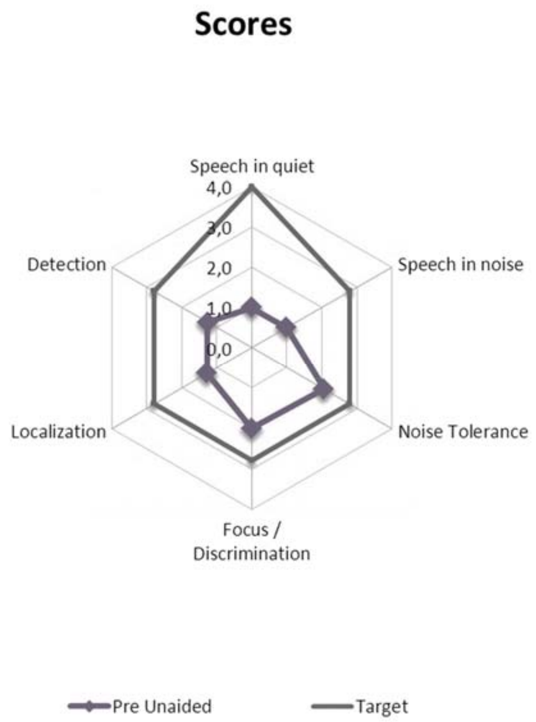

Fig. 3: Illustration of the combination of profiles. The compensation profile is composed of the difference between profile of disabilities (the starting point from AVAB) and the target profile (the user needs from COSI).

APPLICATIONS

There are three major areas where our approach of a disability profile and a target profile along the same dimensions, combined in a compensation profile, can be supportive:

1. The compensation profile is a means that can be helpful in the selection of hearing aids and/or hearing aid functionalities. The overall degree of compensation needs should be related to the minimum level of technology that is required for an adequate compensation. In addition, the profile of the compensation needs along the six dimensions indicates which aspects deserve special attention in the selection process. A possible outcome can be that a person with relatively modest compensation needs nevertheless should be fitted with a high-end hearing aid, because his/her main problems are in the "focus" dimension that is hard to compensate with low-end hearing aids.

2. The profiles provides a well-structured basis for the evaluation of the post-fitting situation. The AVAB questionnaire can be used for pre-post comparisons and the post-fitting results should – in principle – meet the targets along each of the dimensions, because these were defined as the fitting targets. It should be realized that this is not always feasible (e.g., restoration of localization in one-sided deaf subjects), but in that case clear argumentation is required that helps to interpret the post-fitting outcome measures. In addition the COSI questions about the "degree of change" and the "final ability" will be used. Both components of evaluation form a good combination by being individual (COSI) and general (AVAB) at the same time.
3. If applied on a large scale, a system like BRIDGE is able to collect knowledge for better hearing aid selection. The system can be used to collect practice-based evidence and this data can be used to learn the clinicians more about reference values and the potential for beneficial effects of hearing aids. This knowledge can partly be used to update the system in the future.

CONCLUSIONS

This study shows a way to translate individual patterns of user needs into more general dimensions derived from a disability questionnaire. Now we are able to calculate a qualitative indication of the compensation power required in six dimensions, based on the degree of disability and the individual user needs. This categorization is a starting point in hearing aid selection. Also this approach offers a systematic approach for the evaluation of the post-fitting results. Finally, the approach is able to collect practice-based evidence, if applied on a large scale.

REFERENCES

Cohen, J. (**1960**). "A coefficient of agreement for nominal scales," Educ. Psychol. Meas., **20**, 37-46.

Dillon, H., James, A., and Ginis, J. (**1997**). "Client Oriented Scale of Improvement (COSI) and its relationship to several other measures of benefit and satisfaction provided by hearing aids," J. Am. Ac. Audiol., **8**, 27-43.

Fuente, A., McPherson, B., Kramer, S.E., Hormazábal, X., and Hickson, L. (**2012**). "Adaptation of the Amsterdam Inventory for Auditory Disability and Handicap into Spanish," Disabil. Rehabil., **34**, 2076-2084.

Kramer, S.E., Kapteyn, T.S., Festen, J.M., and Tobi, H. (**1995**). "Factors in subjective hearing disability," Int. J. Audiol., **34**, 311-320.

Landis, J.R. and Koch, G.G. (**1977**). "The measurement of observer agreement for categorical data," Biometrics, **33**, 159-174.

Meijer, A.G.W., Wit, H.P., Tenvergert, E.M., Albers, F.W.J., and Kobold, J.P.M. (**2003**). "Reliability and validity of the (modified) Amsterdam Inventory for Auditory Disability and Handicap," Int. J. Audiol., **42**, 220-226.

Zelski, R.F. (**2000**). *Use of the Client Oriented Scale of Improvement as a Clinical Outcome Measure in the Veterans Affairs National Hearing Aid Program.* Graduate Theses and Dissertations, University of South Florida.