Phonak Venture Music program benchmark

Subjectively rated closest to the ideal profile

This study was conducted at DELTA SenseLab in Denmark. It compared the Phonak Venture music program, with the music programs of three competitor devices. Of all music programs tested, none was rated closer to the ideal for music listening than the Phonak Venture music program.

Introduction

New and experienced hearing aid users often describe listening to music as difficult and unnatural. In order to provide the most natural listening experience while listening to music, hearing aid manufacturers continue to develop and refine dedicated music programs. The effects of hearing instrument processing on musical signals and on music perception have received very little attention in research (Wessel, Fitz, Battenberg, Schmeder, & Edwards. 2007). People with hearing loss are no less interested in music than normal hearing people. Therefore, it is not surprising that hearing aid users wish to be able to enjoy listening to music while wearing their hearing aids, rather than removing them, due to reduced sound quality (Chasin & Russo, 2004). Listening to music enhances a person's quality of life, provides a medium for human interaction and models social structures and social competence (Cross, 2006). With these thoughts in mind, the Phonak Venture platform aims to address the many needs of today's countless challenging listening environments, paying close attention to the unique characteristics of music. To evaluate the effectiveness of the Phonak Venture music program, an adaption of the ideal profile method (IPM), developed by Worch and colleagues (2013, 2014) has been employed.

The primary objective of this study was to investigate the Phonak Venture platform music program. The second objective was to perform a benchmark study with competitive hearing aids. For this purpose, an "ideal profile" has been developed, which describes the ideal ratings according to several attributes relevant for investigating the performance of hearing aids when listening to music. Examples of attributes typically encountered in hearing aid music perception can be found in Legarth and colleagues (2012).

Methodology

Thirteen subjects (9 males and 4 females, from 65 – 81 years) with moderate hearing loss (N3 hearing profile (+/-10 dB) as defined by IEC 60118-15 [Bisgaard, Vlaming & Dahlquist, 2010]) (see figure 1) participated in this study. All participants were experienced hearing aid users and trained on subjective assessments of acoustical demonstrations, as part of their work in evaluating acoustic systems. The methodology was designed, executed, analyzed and interpreted by DELTA SenseLab, who specializes in subjective testing of audio and visual stimuli by perceptually evaluating a broad spectrum of systems.

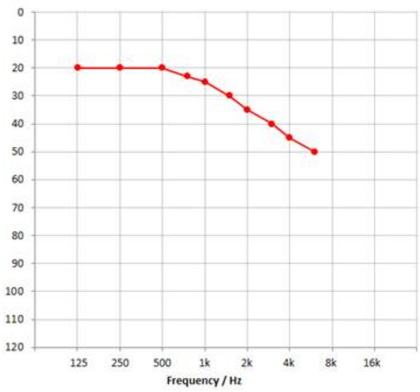

Figure 1. N3 hearing profile as defined by IEC 60118-15 (Bisgaard, Vlaming & Dahlquist, 2010)

The study consisted of two parts: the first part identified the sound attributes specific to music that, when optimized, are relevant in acquiring a pleasurable experience with music. The second part was to rate the different test devices, according to the defined attributes from part one and to define an "ideal point." The "ideal point" was defined by using the attributes from part one, to symbolize the rating for each attribute that is most favorable, when listening to music with hearing aids with an N3 hearing loss.

Four different hearing aids/settings (D1, D2, D3, D4) were investigated and programmed, based on the individual's hearing profile and the special music program of the test devices. D4 was the music program from the Phonak Venture device. D1-D3 were music programs from competitor devices. The setting of the Phonak Venture devices was achieved by further developing the music program used in the former hearing aid generation, Phonak Quest.

Hearing aid recordings were made on a Head And Torso Simulator (HATS) placed in the center of a calibrated stereo loudspeaker setup, in a standardized listening room (Figure 2). An experienced fitter placed the hearing aids on the HATS. The acoustical parameters were selected, based on settings most appropriate for the hearing loss and the first fit suggestion of the fitting software (for each device).

A pre-study was performed, allowing a hierarchical cluster analysis, and general profile plots were developed to differentiate product characteristics. This was done in order to identify similarities and differences between products and to identify those music genres, which are primarily relevant. Three different sound samples were utilized, representing different music genres (classical, pop, and jazz).

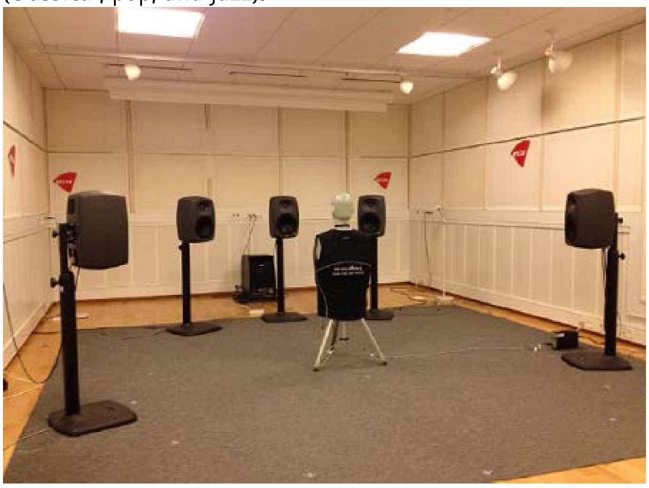

Figure 2. The setup in DELTA's EBU 3276 standardized listening room for the hearing aid recordings.

Participants were firstly asked to define attributes. They were provided with written instructions and they verbally confirmed their understanding of the task, which was to find which attributes of a music sample are relevant for judging different musical samples. Elicited words noted by the test leader were collected to form a working list, that led to the final attribute list used to evaluate the music programs in the various hearing aids used in this study.

The following attributes and their respective description were selected:

Timbre balance (scale from "dark" to "bright"). Timbre balance relates to the general perception of the sound reproduction ranging from dark (bass-heavy and deep) to bright (thin, tenuous, or lacking fullness).

Can-sound (scale from "a little" to "a lot"). Can-sound resembles the sound of old-fashioned phones, or radio broadcasts from the 40's-50's. If the sounds is well balanced and no can-sound is perceived, it should be placed on the far end left side of the scale.

Shrill (scale from "a little" to "a lot"). Shrill is typically perceived in the reproduction of bright tones from violins, flutes, women's voices etc. If the sound has a lot of shrillness it is placed on the right side of the scale. If it does not sound is shrill, it is placed on the far left side of the scale.

Reverberation (scale from "a little" to "a lot"). Reverberation describes whether the sound source is being 'colored' by the room. Does it sound like the music is being played in a bathroom, indoor pool, church, or a more damped room like a bedroom? If no reverberation is present in the sample, it is placed on the far left side of the scale.

Loudness (scale from "soft" to "loud"). The overall perceived loudness of the device.

Dynamics (scale from "flat" to "powerful"). Dynamic describes how lifelike the sound is perceived. Are there differences between soft and loud sounds? The music will sound less present if it has flat dynamics. Powerful dynamics will be perceived as more alive and more realistic.

Source separation (scale from "muddy" to "separated"). Source separation describes whether the instruments (including vocal) can be separated from each other in the overall sound image. If the instruments are perceived as being blended and hard to separate, the sound should be assessed close to muddy on the left hand side of the scale. If there is good source separation and the details are easily perceived, the sample should be assessed towards the right end of the scale (separated).

Treble shadow (scale from "a little" to "a lot"). Treble shadow can be perceived as a whisper or hissing on the brighter musical instruments or the vocal. This sounds like there is a sound shadow after the bright tones making them imprecise and less defined. If the treble is very fuzzy, the sound is placed towards the right end of the scale. If the treble is clean and not fuzzy at all, the sound should be judged as being at the far left end of the scale.

Following two training sessions, subjects then made judgments for all test devices according to the eight attributes (example in Figure 3) identified in the first part of the study by moving a sliding bar towards the corresponding profile on the scale for each device and for each music genre. After performing all ratings, the subjects were asked to mark the preferred profile on the scale for the attribute being assessed, the "ideal profile". The "ideal profile" is a projection of the subjects' desired product characteristics, based on their internal reference and the products currently under evaluation. For determining the "ideal point" no recording was played.

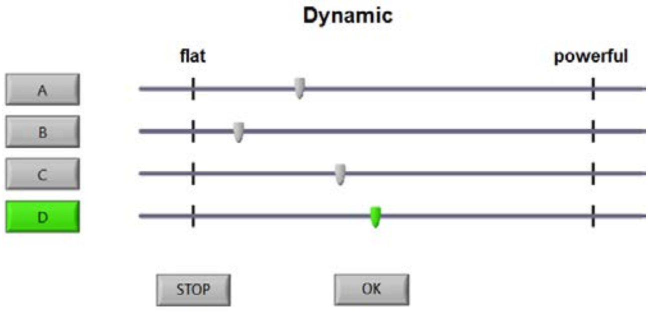

Figure 3. Software screen developed by Delta SenseLab showing the attributes to be rated on the top, a short description of the attribute and the sliders for each test device to be adjusted.

Results

The average ratings and the 95%-confidence interval for the ideal points are presented as a spider plot in Figure 4. This figure illustrates all attributes and each scale in one picture. The characteristics of the "ideal profile" can be described as:

- Timbre balance: giving a slightly dark sound
- Very low can-sound, treble-shadow and shrillness
- Moderate loudness and small reverberation
- High level of source separation and dynamics

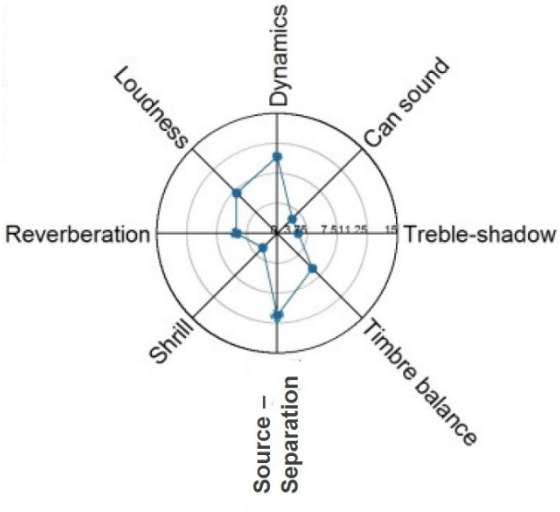

Figure 4. Spider diagram showing the optimal ratings of the subjects when listening to music; this is defined as the "ideal point".

The rating of the different test devices was made relative to the "ideal point" ratings. Almost all devices were rated equally and on a high level. A spider plot has been provided to differentiate the average ratings and the 95% confidence interval to demonstrate the device ratings (Figure 5). Ratings of the test devices can be described as:

- D1: Device has lowest rating on dynamics, loudness, shrill, reverberation and source-separation. Timbre balance is perceived as slightly dark.
- D2: Device has ideal loudness level but with a slightly bright and shrill sound.
- D3: Device shows characteristics close to the "ideal profile" with good source separation and dynamics, low shrillness and can sound and ideal loudness. The timbre balance is slightly brighter than in the "ideal profile".
- D4 (Phonak): Device has similar characteristics as D3 but slightly more treble shadow and shrillness and less source separation, but also less reverberation.

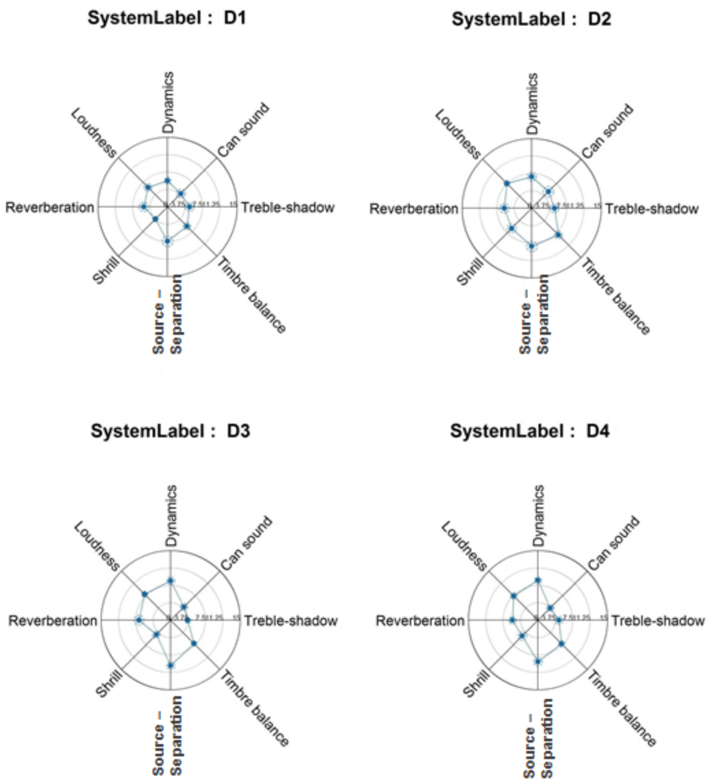

Figure 5. Profile plot of the average ratings of the 4 hearing aids/settings for comparison to the "ideal profile" for all 3 music samples.

When comparing the ideal point (Figure 4) with the spider plots shown in Figure 5 which shows the ratings of the different devices, it is obvious that the ratings of the different attributes for D3 and D4 (Phonak) are closest to the "ideal point". To statistically confirm this observation, a Principle Components Analysis (PCA) was performed, which should provide a complimentary interpretation. The results are shown in Figures 5 through 8. The PCA resulted into three main dimensions, which explain together 65% of the variance. Dimension 1 (29%) is dominated by the attributes shrill, treble shadow, and can sound. Dimension 2 (23%) embraces the attributes loudness and timbre balance (Figure 6) and Dimension 3 (13%) is related to reverberation (Figure 8). Figures 7 and 9 display the area spanned by Dimension 1 and Dimension 2, and by Dimension 2 and Dimension 3, respectively. They show the average values and 95% confidence interval ellipses of the 4 test devices and the "ideal point" and allows an easy interpretation of the data. It can be concluded that all test devices are statistically different from the "ideal point" according to dimension 1 & 2. Consequently, neither receives the desired ratings of the presented dimensions as the confidence intervals of the "ideal point" and all of the test devices do not overlap. Furthermore, the figure provides a clear statement that test device D3 and D4 (Phonak) are closest to the "ideal point", confirming the observation from figure 5, which leads to the conclusion that these devices are rated best. The overlap of the confidence intervals of both devices confirms that their ratings are not significantly different from each other, but are on the same level.

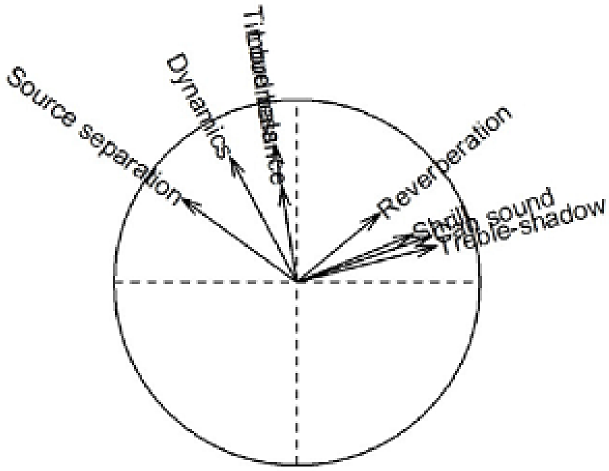

Figure 6. Result of the PCA for all test devices and all sound samples showing the sections of the attributes. Two dimensions were found to combine several attributes with each other. Dimension 1 incorporates the attributes shrill, treble-shadow and can-sound and explains 29% of the variance. Dimension 2 incorporates the attributes loudness and timbre balance, explaining 23% of the variance.

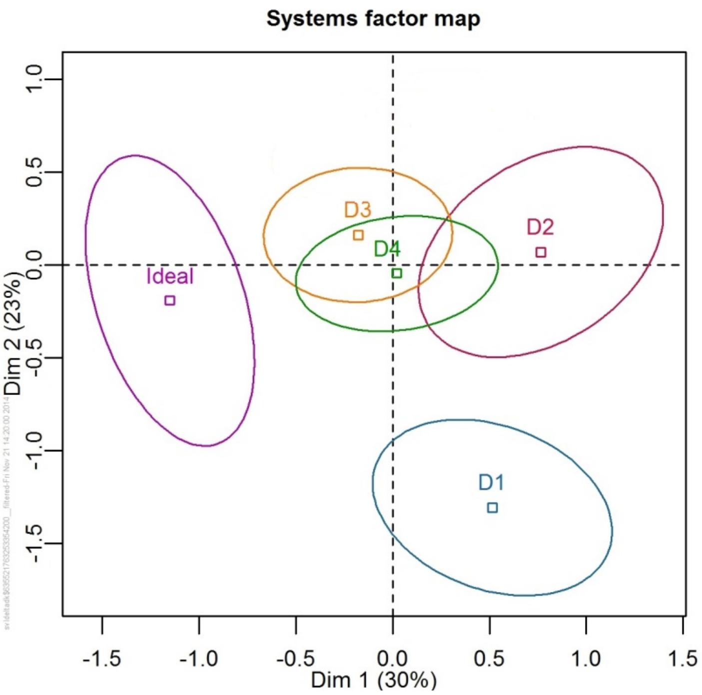

Figure 7. Average and the 95%-confidence intervals of all test devices and the "ideal point". Their arrangement relative to each other according to Dimension 1 and Dimension 2 together explains 52% of the variance.

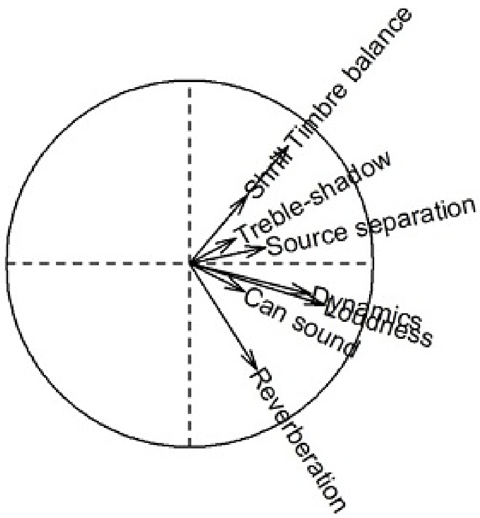

Figure 8. Result of the PCA for all test devices and all sound samples: The picture shows the sections of the attributes. Two dimensions were found to combine several attributes with each other. Dimension 2 loudness and timbre balance explain 23% of the variance. Dimension 3 relates to reverberation, explaining 13% of the variance.

When analyzing dimensions 2 & 3 (figure 9) it can be observed that D3 and D4 (Phonak) are overlapping with the "ideal point" whereas both of the other devices are much further away. This means that D3 and D4 (Phonak) provide the ideal ratings but without statistical difference between each other. However, they are statistically different to the other two test devices.

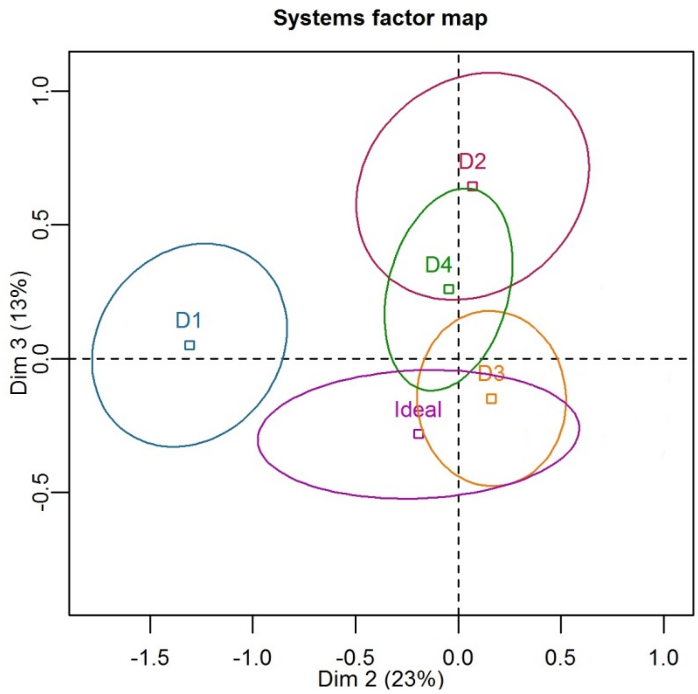

Figure 9. Average and the 95%-confidence intervals of all test devices and the "Ideal Point". Their arrangement relative to each other according to Dimension 2 and Dimension 3 together explains 36% of the variance.

Conclusion

A benchmark test of four hearings aids/settings was conducted using an attribute test, the Ideal profiling method (Worch, Le, Punter, & Pages, 2013; Worch, Crine, Gruel, & Le, 2014) for three different music samples by 13 trained assessors with a diagnosed N3 hearing loss (Bisgaard, Vlaming, & Dahlquist, 2010). The hearing aids were programmed according to the individual's hearing profile and then evaluated with the manufacturer's dedicated music listening program activated. The hearing aids were evaluated on eight different attributes, that were defined over two consensus attribute sessions with a subgroup from the assessors' panel. The results from the hearing aid listening tests were analyzed, to identify the perceived differences in the four products/settings using music samples. The product profiles were also related to the ideal profile, that was defined by the listening panel during the test. The ANOVAs revealed significant system effects for almost all attributes. Test devices D3 and D4 (Phonak) had the closest match to the ideal profile. Therefore, no music program was rated closer to the ideal for music listening than the Phonak Venture music program. For further improvement, it would be constructive if the test devices would reduce the shrillness and the treble shadow to get closer to the ideal profile.

In general, it can be concluded that the ideal profile identified by the subjects in this study, can promote future implementation and refinement of dedicated music programs in hearing aids. Based upon the results of this study, it can be noted that of the four hearing aid music programs assessed, there is a general agreement on what is required to improve the experience of listening to music with hearing aids. Continued improvements and adjustments to current hearing aid music programs utilizing subjective feedback is beneficial and essential, in achieving overall satisfaction of listening to music through hearing aids.

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Authors and investigators

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Søren Vase Legarth graduated from the Technical University of Denmark in 2004 as M.Sc.E.E. with key interest and attention towards Acoustics. He was after graduation employed at the acoustics department in DELTA and in 2007 when SenseLab was started he had the responsibility of setting up a trained test panel, lab facilities and develop test software. In 2011 he became Head of Department.

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Volker Kühnel, PhD, received his degree in Physics in 1995. From 1995 to 1997 he worked in Oldenburg as a post-doc in the group of Medical Physics of Prof. Dr. Dr. B. Kollmeier, Oldenburg, Germany. Since 1998 he has worked at Phonak AG in Switzerland. He is currently in the field of product development and leads the team "Audiological Performance" at the interface between hearing aid algorithms and fitting software.