

SOUND QUALITY AND COMFORT WITH INSTANT EAR-TIPS: FROM THE LAB TO REAL LIFE

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The professional hearing aid fitting has always been central to the unique sound of Widex hearing aids, with innovations such as the Sensogram and TruAcoustics™ allowing hearing care professionals to optimize the fitting for each individual user. With this, the fitting goes beyond just accounting for the individual's hearing loss by also taking into account the anatomy of the individual's ear canal, possible inaccuracies in the audiometric thresholds measured, and the effects of placing the hearing aid in the ear. Widex Moment Sheer™ represents another step in the journey towards optimized individual fittings for all by introducing a new range of instant ear-tips and updating the individualized ear-tip recommendations in Compass™ GPS. Three new ear-tips have been added to the portfolio: The Round open, which is more closed than the original Open instant ear-tip but still suitable for milder hearing losses; the Sleeve vented for sloping hearing losses; and the Sleeve power for the most closed instant fit. Along with the familiar Open and Round 1-vent, these make up the recommended ear-tips in Compass GPS 4.4, as illustrated in Figure 1. The rest of the familiar portfolio of Widex instant ear-tips also remains compatible, providing the hearing care professional (HCP) with maximum flexibility.

An important prerequisite for the optimized individual fit is careful research into the effects of the different key elements. Therefore, it is important to investigate the new ear-tips and recommendations in both laboratory and real-life settings. The laboratory measurements are the starting point, but the real-life experiences of HCPs and end users are crucial and should also be investigated. In this article, we report the outcomes of both lab and real-life studies of the new ear-tips.

REAL-EAR MEASUREMENTS FOR THE NEW EAR-TIPS

The key insight behind the development of TruAcoustics was the fact that the same ear-tip has substantially different acoustic properties in different ears. This was shown in a large-scale study of instant ear-tips in 58 ears (Balling et al., 2019; Caporali et al., 2020; Cubick et al., 2022). Based on this insight, TruAcoustics was created to adjust the gain of the hearing aid to the way the specific ear-tip fits in the specific user's individual ear canal, with transparency and leakage estimated based on the feedback test. For the new ear-tips, the same acoustic properties were measured, and TruAcoustics and the ear-tip recommendations in Compass GPS were adjusted accordingly.



Figure 1: Recommended ear-tips in Compass GPS 4.4: (a) Open; (b) Round open; (c) Round 1-vent; (d) Sleeve vented; (e) Sleeve power.

METHOD

The measurements were very similar to the study done with the previous Widex instant ear-tips, and they focused on two aspects: transparency and leakage. Transparency refers to how much the presence of the ear-tip in the ear canal affects the sound coming into the ear. The less the presence of the ear-tip affects the sound, the more transparent the fitting. Transparency is measured as the real-ear occluded insertion gain (REOIG): the difference between real-ear unaided response (REUR) and real-ear occluded response (REOR) – the response when the ear-tip is in the ear, but the hearing aid is turned off.

Leakage is used as a general term for how low-frequency amplified sound leaks out from the ear through the vent and any leakage around the ear-tip. Leakage is quantified by the vent effect (VE), which is the difference in real-ear response to a streamed signal between a setup with the ear-tip in the ear (normal fitting) and a setup with the ear-tip in the ear while the ear is occluded with impression material (occluded).

The study included measurements of REUR, REOR, and streaming response with and without impression material for the three new ear-tips in the portfolio. Measurements were done twice per participant for each ear-tip.

The study included 24 participants (6 female, 18 male), with an average age of 53 years (range 29 to 69). Participants were selected so that they had different sizes of ear canal. Hearing loss and hearing aid experience were not prerequisites.

Since the aim of the study was to measure transparency and leakage of different couplings, the hearing aids were not programmed to any specific hearing loss, but instead programmed to give 10dB linear gain in all bands. The hearing aids used were Widex Moment 440 RIC312.

RESULTS

Figure 2 shows the vent-effect measurements for the three new ear-tips in conjunction with parallel measurements for the two other recommended ear-tips (Balling et al., 2019; Caporali et al., 2020), which

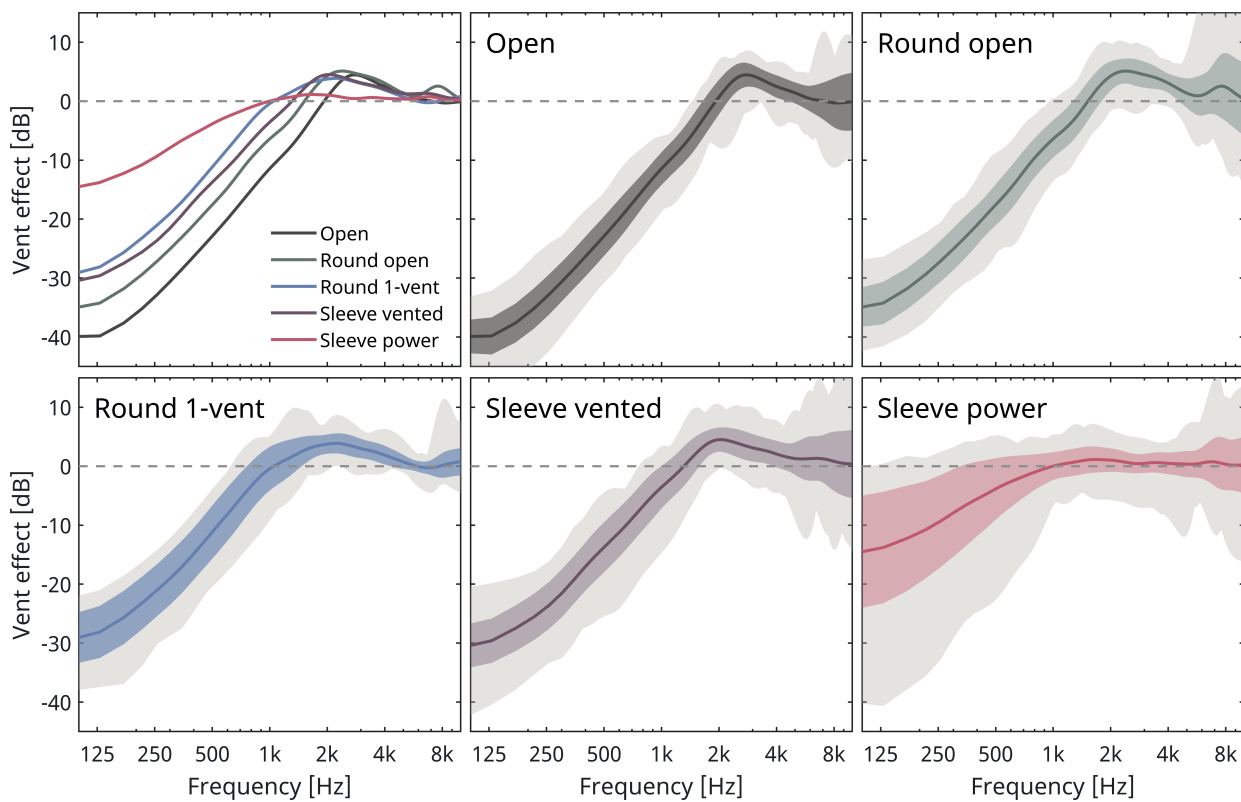


Figure 2: Vent effect measurements, with mean values for all ear-tips shown in the top left panel. The remaining panels show the mean vent effect with the solid line, +/- 1 standard deviation with the colour-shaded areas, and the range between minimum and maximum vent effect in the grey-shaded areas. The measurements for Round open, Sleeve vented, and Sleeve power are from the current study, while measurements for Open and Round 1-vent are from the study reported by Balling et al. (2019) and Caporali et al. (2020), based on parallel measurements on 58 ears.

have been in the instant ear-tip portfolio for some time. The top left panel summarizes the mean vent effect for the different ear-tips, with the Sleeve power being the most closed and the Open ear-tip the most open. The remaining panels of Figure 2 show the results for one ear-tip each, with the solid line representing the mean, the colour-shaded area +/- 1 standard deviation around the mean, and the grey-shaded area the full range of measurements for that ear-tip.

A key thing to notice in the figure is that the Sleeve power is considerably more closed than the other recommended ear-tips in the previous portfolio, as well as the Double dome ear-tip often chosen by HPCs for a close fit (see Balling et al., 2019). Therefore, the new Sleeve power gives HPCs the option to use instant ear-tips for heavier hearing losses than was possible with the previous portfolio. Another important result is that there is substantial variation in the vent effect for the same ear-tip used in different

people's ears. This variation is smaller for the more open ear-tips and larger for the more closed.

The same pattern is observed for transparency, measured as real-ear occluded insertion gain (REOIG), as shown in Figure 3. This shows the Open ear-tip as completely transparent, while the presence of the remaining ear-tips in the ear allows less direct sound to enter the ear. As seen for the vent effect measurements, the Sleeve Power is the most closed option.

These results show that it remains crucial to do the feedback test, based on which TruAcoustics estimates the vent effect and real-ear occluded insertion gain for the individual ear and adjusts gain accordingly – in other words, tailoring the gain to the individual hearing aid user. Although the measurements were conducted only on Widex ear-tips, the variation is overwhelmingly likely to be the same for ear-tips from other manufacturers.

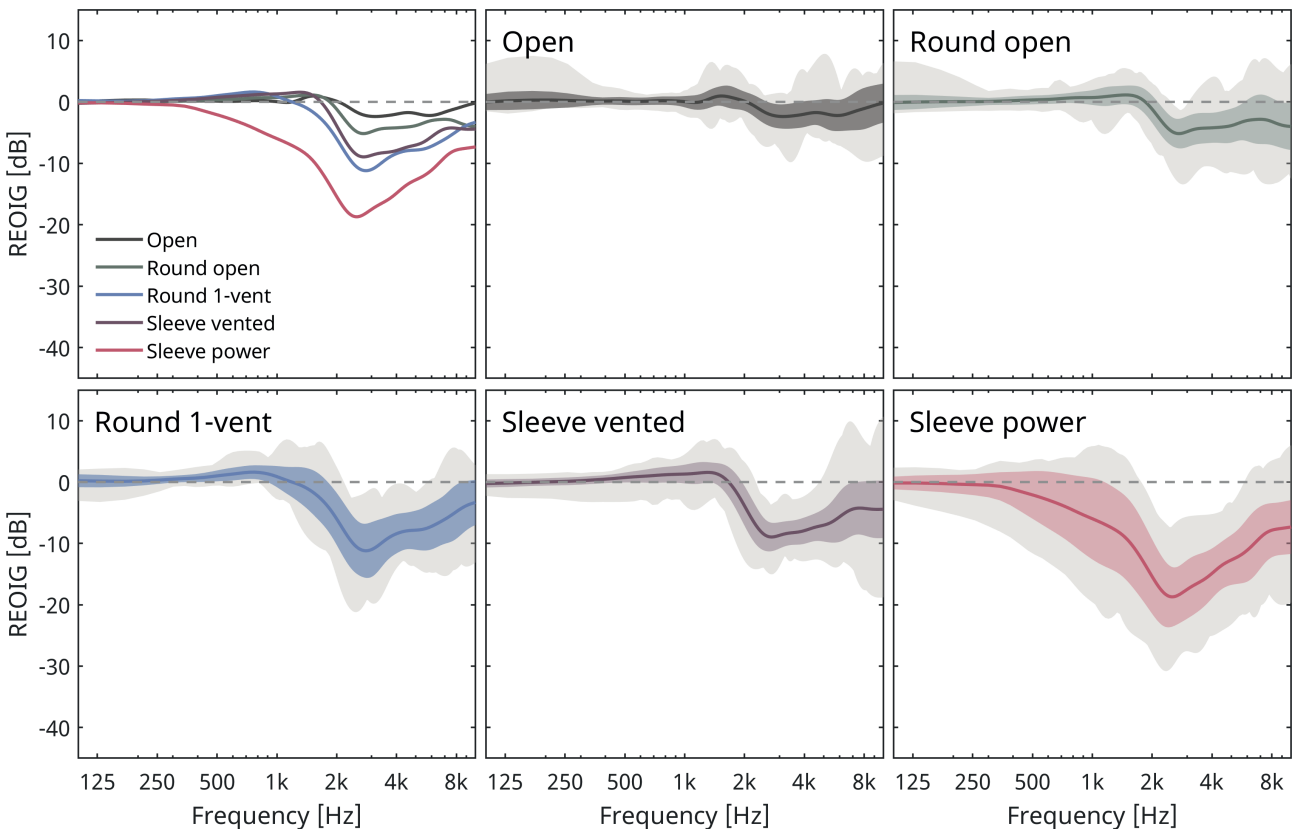


Figure 3: Real-ear Occluded Insertion Gain (REOIG), with mean values for all ear-tips shown in the top left panel. The remaining panels show mean REOIG with the solid line, +/- 1 standard deviation with the colour-shaded areas, and the range between minimum and maximum vent effect in the grey-shaded areas. The measurements for Round open, Sleeve vented, and Sleeve power are from the current study, while measurements for Open and Round 1-vent are from the study reported by Balling et al. (2019) and Caporali et al. (2020), based on parallel measurements on 58 ears.

REAL-LIFE EXPERIENCES WITH THE NEW EAR-TIPS

The measurements reported above are an important baseline for selecting and fitting the new ear-tips, but it remains crucial also to test them in real-life clinical practice, with a focus on both HCP and end-user experiences. The survey reported below investigates this based on answers from 15 HCPs and 41 end users.

METHOD

The end-user participants in the survey were customers in the Danish hearing aid chain *Din Hørespecialist*. They were experienced hearing aid users who were upgrading to a new hearing aid, buying Widex MOMENT RICs in the price points 220 to 440. Forty-one end users who fitted the criteria participated in the survey. They were fitted following the new ear-tip recommendations, with 22 (54%) fitted with Sleeve vented, 13 (32%) with Sleeve power, four (10%) with Round open, and two (5%) with different ear-tips on the left and right ears.

The HCPs were hearing care professionals working for *Din Hørespecialist* who fitted these end users. Apart from one recently trained HCP, they all had at least one and a half years of experience working as HCPs, with a mean experience of 10 years. They were also mostly very experienced with fitting Widex hearing aids, with a mean experience of nine years. Each HCP fitted between one and 11 end users with the new ear-tips, with a mean of three fittings per HCP.

The survey included questionnaires for both end users and HCPs. The HCPs answered one short questionnaire about their experience immediately after each fitting, with questions about ease of fitting, fit to target, and overall satisfaction with the individual fitting. At the end of the survey, they answered similar questions about their general experience with the new ear-tips, as well as additional absolute and comparative questions about their experiences. Most of the questions were answered using seven-point satisfaction scales, in line with previous surveys (e.g., Balling & Townend, 2021).

The end users received a questionnaire immediately after the first fitting, with questions focusing on sound quality and comfort, rated on visual-analogue scales going from 0 to 10. They answered a second

questionnaire after a trial period of a minimum of seven days, including the same questions as in the initial questionnaire as well as additional questions on ease of handling and degree of feedback.

The survey used the standard fitting flow of *Din Hørespecialist*, which proceeds as follows: The first step is a hearing test, followed by a discussion with the patient about their hearing needs, based on which a hearing aid model is selected and subsequently ordered.

At the next appointment, the hearing aids are fitted with the ear-tip recommended by Compass GPS and using the Widex best-practice fitting flow with feedback test and Sensogram, following the Widex Fitting Rationale. After the first fit, real-ear measurements (REM) are taken, and the gain for normal, soft, and loud levels is adjusted to a DHS proprietary fitting rationale that combines elements of the DSL and NAL-NL2 generic rationales. After the REM, the patient's initial reaction to the sound is gauged, based on listening to the hearing care professional's voice, the jangling of keys, and ambient noise when opening the door, asking them to evaluate the loudness and tonal balance. Then, a speech test (Dantale, Elberling et al., 1989) is administered and gain is adjusted if this is deemed necessary. Following this, special listening programs are created depending on the patient's needs; often, the differences between programs are enhanced. Finally, the hearing care professional and the patient go outside the clinic so the patient can listen with the hearing aids, including any special listening programs, in the street. Follow-up happens within one week of the first fitting, typically remotely.

RESULTS: HEARING CARE PROFESSIONALS

HCPs were asked three questions about each fitting, which they answered immediately after the fitting. The questions were about overall satisfaction, satisfaction with fit to target and headroom, and satisfaction with ease of use. The same questions were also asked in the final questionnaire, summarizing the experience across all patients fitted for each HCP. The results are displayed in Figure 4, with the per-fitting responses in the top row and the general responses in the bottom row. Following the practice of the MarkeTrak surveys

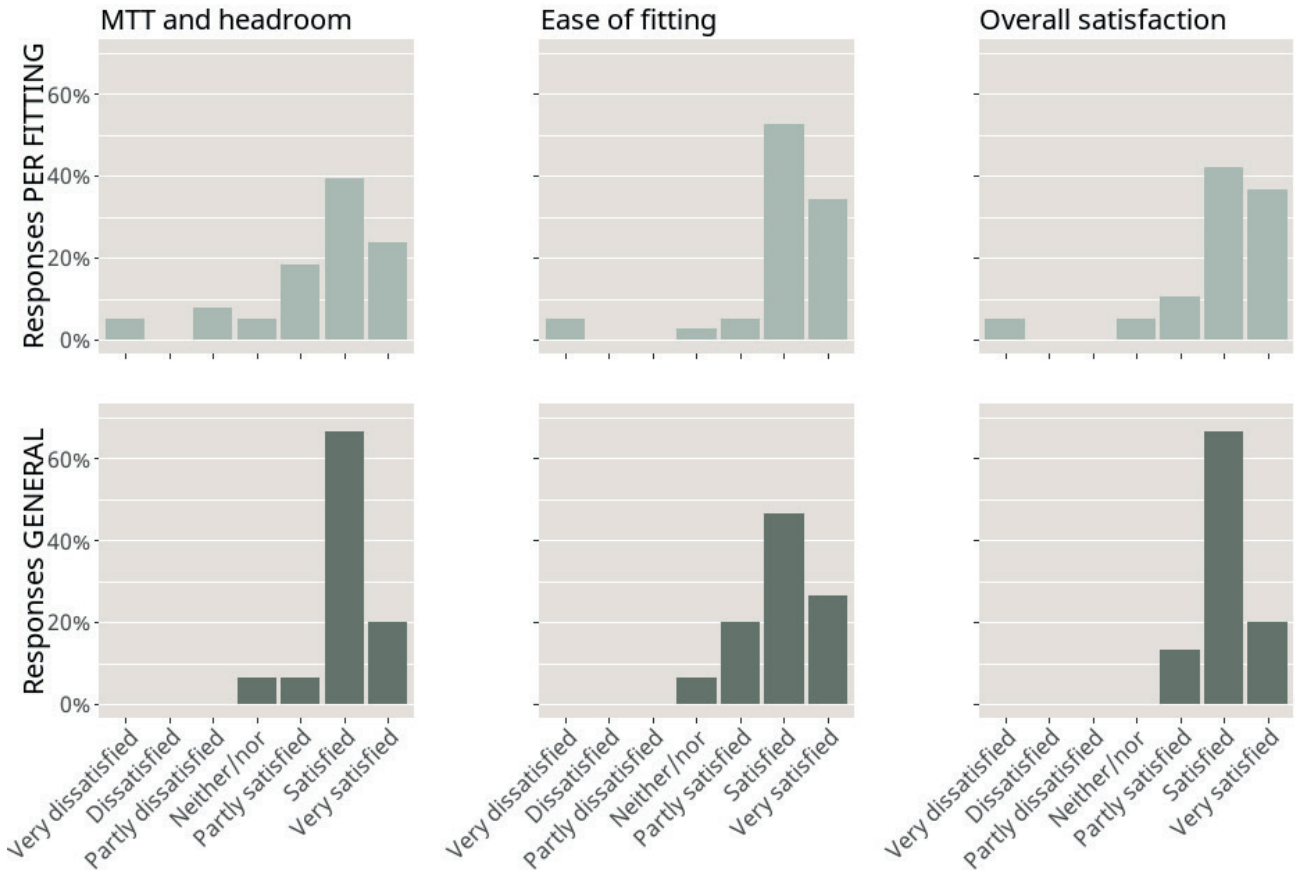


Figure 4: Survey responses from participating HCPs, with per-fitting responses in the upper row and general responses in the lower row. Ratings of match to target (MTT) and headroom are shown in the left panels, ease of fitting ratings in the middle panels, and general satisfaction ratings in the right panels. Overall, satisfaction ratings are high, with the post-survey general responses being the highest.

(e.g., Powers & Rogin, 2019), the three most positive responses on the scale are categorized as “Satisfied”.

For the per-fitting responses in the top row, satisfaction ratings are high, with 82% being satisfied with match to target and headroom, 92% being satisfied with ease of fitting, and 89% satisfied overall. We also see two ratings of “Very dissatisfied” across the three panels; these come from the same two fittings, one of which was a client who used different ear-tips on the two ears, which may complicate matters. Importantly, these two ratings only represent 5% of fittings. Given that the recommendations are based on the hearing loss only, while the evaluation of the physical fit is left to the HCP, it is perhaps not surprising that there is a small minority of situations where the recommendation is not ideal, and the HCP needs to make other choices.

For the general responses from the end of the survey period, displayed in the bottom row of

Figure 4, the results are even more positive, with no one being dissatisfied and only a single HCP landing in the “neither/nor” category for two of the questions. Otherwise, the HCPs indicate a high level of satisfaction with match to target and headroom (95%), ease of fitting (95%), and overall (100%).

In short, the HCP responses indicate a very high level of satisfaction with the new ear-tips, both per fitting and generally. Another interesting question is of course how HCPs perceive the ear-tip recommendations in terms of achieving the best fit. This was addressed with the question “To what extent do the new ear-tips help you get the best fitting for each customer?” The answers to this question are displayed in Figure 5, where all HCPs indicate that the ear-tips help to some degree, and for most respondents to a high degree.

Finally, it is important to investigate HCPs’ attitudes to the new ear-tip portfolio and recommendations

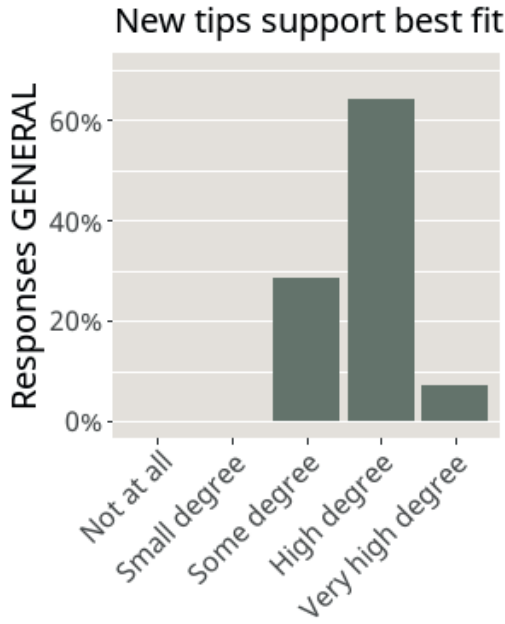


Figure 5: Responses from final survey showing that the new ear-tips help the HCPs achieve the best fit.

compared to the previous portfolio. This was done in the final survey, where HCPs answered questions on the possibility of fitting with instant instead of custom; on which hearing losses can be fitted with instant; and on their overall satisfaction on seven-point answer scales going from “Old portfolio much better” to “New portfolio much better”. The responses displayed in Figure 6 show that virtually everyone prefers the new selection, with the most frequent rating being “Better with the new selection”. In line with the real-

ear measurements shown above (Figure 2), HCPs find that the new selection allows for a better possibility of fitting with instant instead of custom ear-tips (left panel) and more hearing losses being fittable with instant instead of custom ear-tips (middle panel). These ratings also match the very high level of general satisfaction seen in the right panel of Figure 6.

RESULTS: END USERS

The end users answered questions about their experience both immediately after the fitting and after a trial period of at least one week. To understand how the ear-tips work for the end users in real life, the post-trial period answers are the most interesting and therefore in focus in the following. However, it is interesting to note that the answers are quite consistent across the two questionnaires, with a slight fall in the post-trial ratings of around half a point. This suggests that the user’s experience immediately following the fitting will generally also represent their longer-term experience, at least in the context of a careful fitting process like the one used for this survey.

The results from the end-user surveys fall in two clusters: one with questions on comfort and placement, and one with questions on sound quality in a broad sense. These clusters are both a priori meaningful and confirmed in clustering analyses of the answers. Interestingly, feedback ratings cluster more with comfort and placement variables than with sound quality. This makes sense in terms of audible

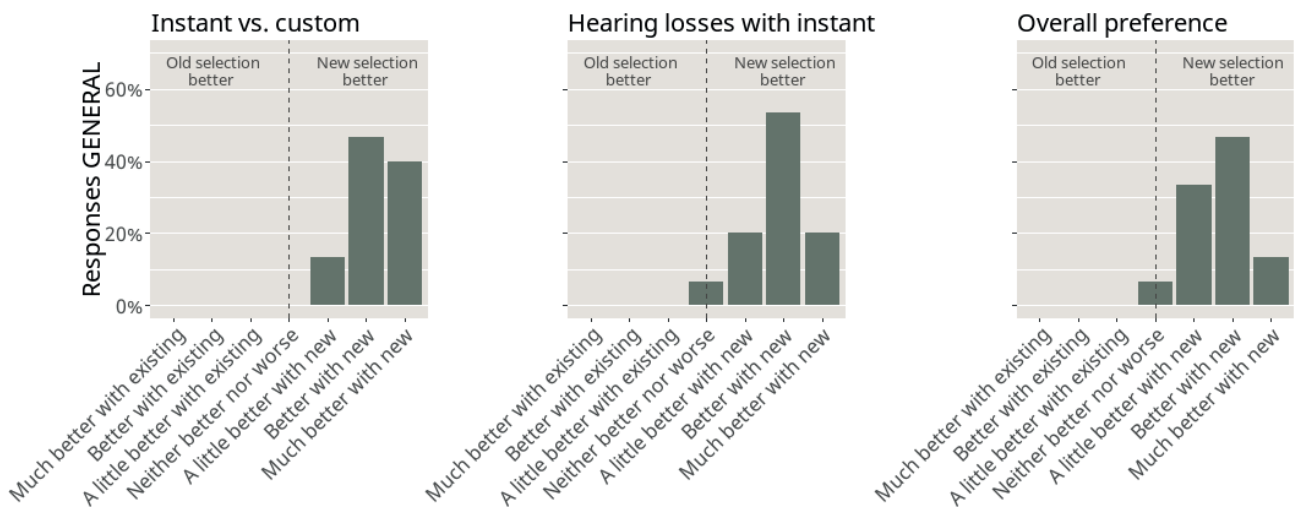


Figure 6: Comparative questions from the final questionnaire on the possibility of fitting with instant instead of custom (left), on which hearing losses can be fitted with instant (middle), and overall satisfaction (right). Overall, the new portfolio is perceived as superior.

feedback partly depending on how the ear-tip sits in the ear, but it also shows that sound quality may be rated relatively independently of any experience of feedback.

In accordance with internal studies on end-user experience, these questionnaires used visual-analogue scales (VAS) for the answers, with negative anchors at 0 and positive anchors at 10, and the option for the end users to place their rating anywhere on the scale. This means that the answers are on a more truly numerical scale, which it makes sense to summarize using the mean (represented by filled circles in Figure 7) and standard deviation (+/- 1 standard deviation represented by the whiskers in Figure 7).

Figure 7 displays the comfort and placement variables in the left panel and the sound quality variables in the right panel. For both these aspects of end-user experience, the responses are solidly in the high end of scale, with mean ratings of around 8 for all variables, which is excellent on a 10-point scale. There is a little more variation in the answers for the comfort cluster than for the sound quality cluster, which makes

sense in that all patients were fitted with the ear-tip which the fitting software recommended for them based on their hearing loss. Although this is often also a good physical fit, some variation is to be expected.

CONCLUSIONS

Being able to fit hearing aids using instant ear-tips represents a large step forward for the ease of fit, comfort, and immediate start of better hearing for many patients. However, as the current vent effect measurements (Figure 2) and other research show, instant ear-tips are quite variable in terms of their acoustic effects, making it crucial to adjust the fitting to the specific ear-tip in the specific ear. This can be done with the in-situ tailoring of the sound that is a key part of a Widex fitting, using TruAcoustics to correct for vent effect and ear-canal resonances, and the Sensogram to establish the hearing thresholds with the hearing aid in the ear. With such tailoring, and our new, carefully selected range of recommended ear-tips, the real-life survey data show very high satisfaction among both the professionals working with the ear-tips and the end users wearing them.

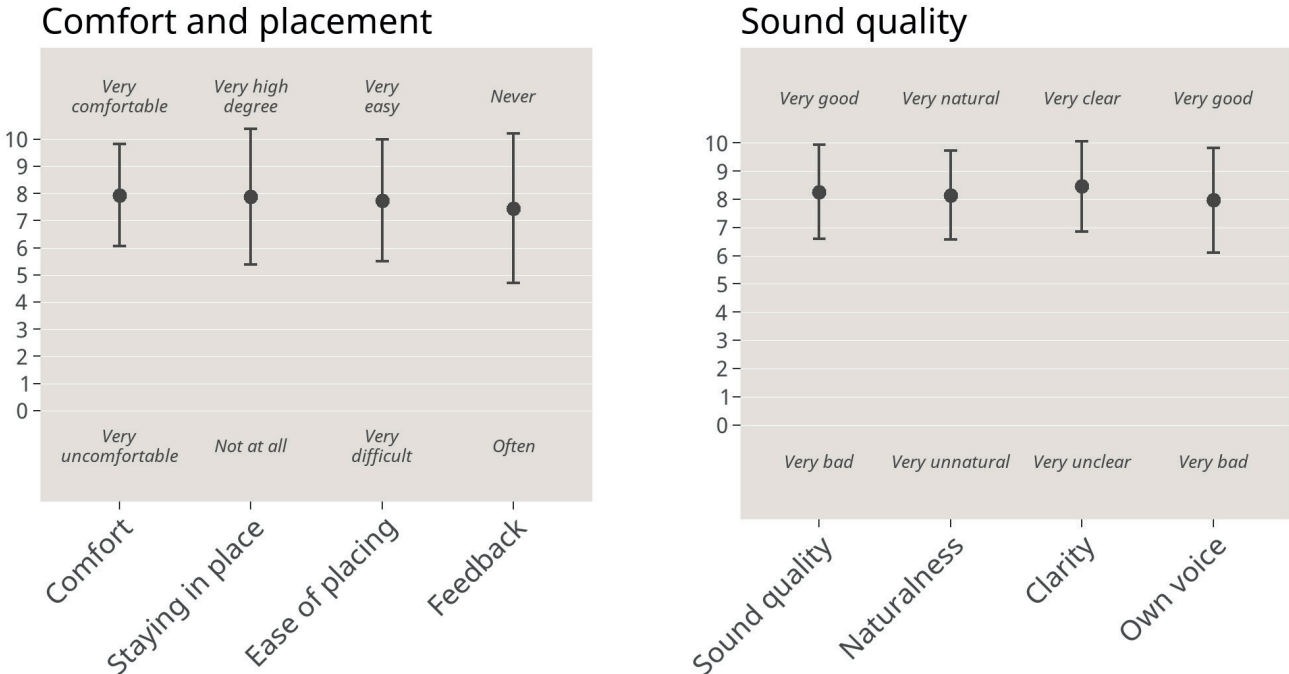


Figure 7: Ratings from the end users after their trial period with the new ear-tips. The filled circles represent the mean, while the whiskers show +/- 1 standard deviation. The different anchors used for the different questions are indicated in the graph. Mean ratings are all around 8, which is excellent on a 10-point scale.

REFERENCES

- Balling, L. W., Jensen, N. S., Caporali, S., Cubick, J., & Switalski, W. (2019). Challenges of Instant-Fit Ear Tips: What Happens at the Eardrum? *Hearing Review*, 26(12), 12-15.
- Balling, L. W., & Townend, O. (2021). Asking the Experts: Hearing Care Professionals' View of Widex. *WidexPress*, 46.
- Caporali, S. A., Cubick, J., Catic, J., Damsgaard, A., & Schmidt, E. (2020). The vent effect in instant ear tips and its impact on the fitting of modern hearing aids. *Proceedings of the International Symposium on Auditory and Audiological Research*, 7, 205-212.
- Cubick, J., Caporali, S., Lelic, D., Catic, J., Damsgaard, A. V., Rose, S., Ives, T., & Schmidt, E. (2022). *The Acoustics of Instant Ear Tips and Their Implications for Hearing-Aid Fitting*. <https://doi.org/10.1097/AUD.0000000000001239>
- Elberling, C., Ludvigsen, C., & Lyregaard, P. E. (1989). Dantale: A New Danish Speech Material. *Scandinavian Audiology*, 18(3), 169-175. <https://doi.org/10.3109/01050398909070742>
- Powers, T. A., & Rogin, C. M. (2019). MarkeTrak 10: Hearing aids in an era of disruption and DTC/OTC devices. *Hearing Review*, 26(8), 12-20.