Are hearing aids the better rehabilitative choice when compared to PSAPs? On speech-intelligibility and sound-quality, the answer is yes.

Filip M. Rønne[12] & Rikke Rossing[1]

[1] Eriksholm Research Centre, Rørtangvej 20, 3070 Snekkersten, Denmark

[2] Corresponding author: fimr@eriksholm.com

Filip M. Rønne, PhD, has for 6 years been working as a research engineer at Eriksholm Research Centre, a part of one of the leading hearing aid manufacturers, Oticon A/S. His main research interests revolves around improving the spatial hearing of hearing aid users, and developing new test methods for investigating user benefit of advanced algorithms.

Rikke Rossing, AuD, is a research clinician at Eriksholm Research Centre.

In recent years, a new category of hearing amplification devices has been introduced. Personal Sound Amplification Products (PSAPs) offer a cheaper alternative to hearing aids, and some studies have concluded that they, in selected audiological domains, offered the same benefits as regular hearing aids for people with mild-to-moderate hearing losses. However, very few of the published studies that have compared the two product types have ensured proper test-subject blinding, and none have ensured test-subject blinding and individualized fit of the hearing devices.

Most PSAPs are being marketed and sold as over-the-counter devices, typically via an online shop. Some devices are fitted by the end-user at home, and some devices are not fitted at all. Thus, a major factor contributing to the lower retail price of PSAPs is, that the end-user does not have to pay for the service of a hearing care professional. One disadvantage of this is an often imprecise fit of the device to the individual hearing loss (Reed et al, 2015). Despite this and the less advanced technology basis of the PSAPs, it has been argued at conferences, that for people with mild to moderate hearing losses, some PSAPs can in specific domains offer an audiological performance similar to traditional hearing aids (Xu et al, 2015; Reed et al, 2015; Kim et al, 2016). However, when one considers the amount of time usually spent on fitting and fine-tuning regular hearing aids, and the amount of resources required for the development of advanced, conventional hearing aids, these findings are quite surprising.

This study set out to investigate whether it is really true that there are no difference in the audiological performance of PSAPs compared to HAs, when both are fitted as standardized as possible, and further when the experimenters ensures that the participants are properly blinded to the device they are listening to.

Laboratory tests

This study evaluated two premium PSAPs, Perfect Choice HD (PC) and Sound World Solutions CS50+ (SWS), against the Oticon Alta2 Pro (Alta2) hearing aid. Both are amongst the premium PSAPs, priced in the high-end of the market. Furthermore, SWS got good reviews by Mamo et al. (2016) and were reported to produce good listening performance by Reed et al. (2015). Consequently, these two products were chosen as representatives of some of the best PSAPs in terms of audiology in a very widespread field of marketed products in the category.

The test setup

A sketch of the used test setup can be seen in Figure 1. Experiments took place inside and outside an anechoic room. An artificial head (Klangfinder HS8 Pro) with four pairs of “ear canals” was placed inside the anechoic room. The artificial head was wearing a pair of all three devices (see Figure 2). The participant sat outside the anechoic room and listened through headphones. That way, all three sets of devices were playing all the time,

and a simple switch could be made between which of the three pairs of devices the participant would be listening to. This setup ensured that the participants were blinded to which device they were listening through, thus avoiding potential placebo effects. Further, it allowed for a smooth and quick switch between devices, which is particularly important when comparing sound quality.

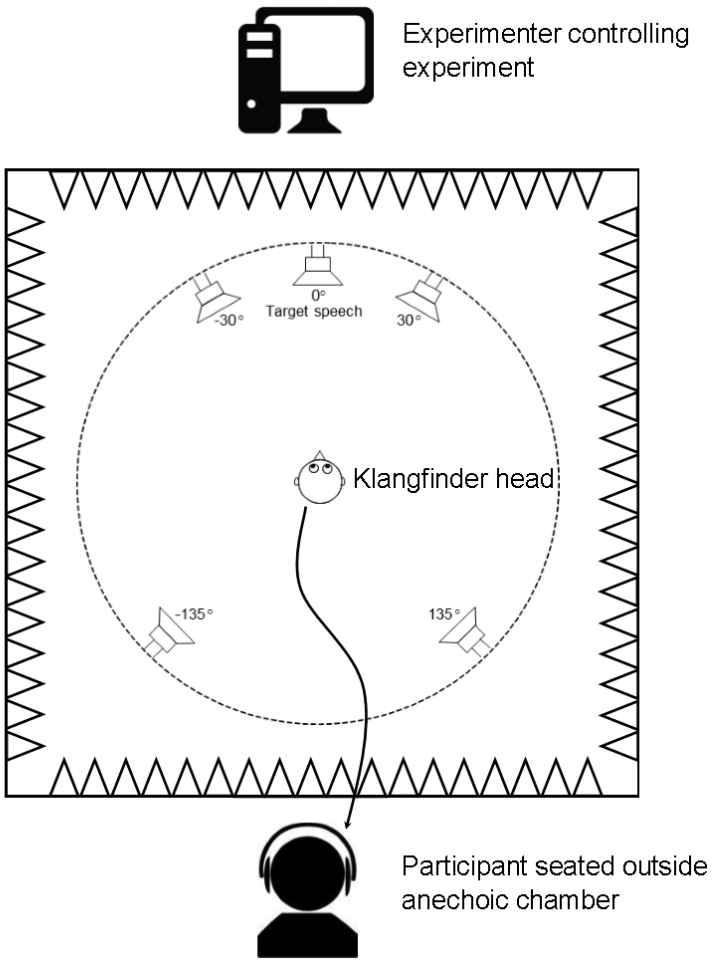

Figure 1: The participants were seated outside an anechoic room wearing headphones. Inside the room an artificial head was placed, wearing all three devices bilaterally.

Figure 2: The Klangfinder HS8 Pro artificial head wearing all three devices.

Fitting of the hearing devices

An important decision when designing an experiment aimed to compare the performance of two different hearing devices, is how they should be fitted to the individual participant. This study chose to aim at fitting all hearing devices as consistent and simple as possible. This meant that the hearing aid, the Alta2, was fitted in prescribed mode (VAC+, one program) with no fine-tuning and no REM verification allowed. This choice was made to mimic the very least possible fit in real life practice. The choice of not using fine tuning and verification was taken to avoid being accused of creating a hearing-aid biased study.

For the PSAPs, the same fitting strategy meant that the PSAPs were fitted based on the best possible tool available to an end-user ordering the devices online. For the SWS the programming was based on a ‘prescribed’ setting obtained by running the custom-made hearing test available in the accompanying app, and by selecting the supposedly most generally used program: Program 1 (“Everyday”). The PC does not come with a hearing test, and selection of the program number (out of three) is the only way to influence the frequency response. Again the supposedly most generally used program, Program 1 (“Speech”) was selected.

Speech intelligibility

In two separate experiments (called A and B), the speech intelligibility in noise of 10 (A) and 11 (B) mild-to-moderately hearing impaired participants were tested using the Danish Hearing-In-Noise-Test (HINT, Nielsen & Dau, 2011). This was done in four different spatial setups. The target speaker was always placed in front (0°), whereas the position and type of the maskers varied (see summary in Table *1*).

The results of the speech intelligibility experiments are shown in *Figure 3*. Experiment A revealed that the hearing aid was significantly better than both PSAPs in the standardized 0° HINT, and in the more natural ±30° and ±135° (one-talker) conditions. Contrary to experiment A, the results at 0° in Experiment B showed no significant difference between Alta2 and SWS. Since, the trend of Alta2 performing better than SWS was similar to experiment A, the insignificant result of experiment B is likely the consequence of the relatively small number of test subjects included in the experiments. If the results had been pooled across experiment A and B the difference would have been clearly significant. In the ±135° four-talker configuration the hearing aid performed much better than the SWS. The reason for this is the adaptive directionality of the HAs, which was automatically activated for some (but not all) participants in this HINT configuration.

Overall, these findings showed that the hearing aid produced much better speech intelligibility in all the non-standard spatial configurations. Further, even in the standard HINT a significant performance difference was observed between the hearing aid and PC and between the hearing aid and SWS in experiment A, but not in B. Further, in the restaurant scene (±135°, 4-talker) where adaptive directionality kicks in for some of the subjects (only for those performing below 0dB SNR), an even larger difference in performance is observed between the hearing aid and the best performing PSAP.

Experiment A (Alta2 vs SWS vs PC)

Real life situation	target	maskers	masker type
"Standard HINT"	0°	0°	noise
"Dinner table"	0°	±30°	1-talker
"People talking behind you"	0°	±135°	1-talker

Experiment B (Alta2 vs SWS)

Real life situation	target	maskers	masker type
"Standard HINT"	0°	0°	noise
"Restaurant scene"	0°	±135°	4-talker

Table 1: Summary of HINT conditions tested. "±30°" refers to two maskers, placed at hence 30° to the left and 30° to the right of the target loudspeaker.

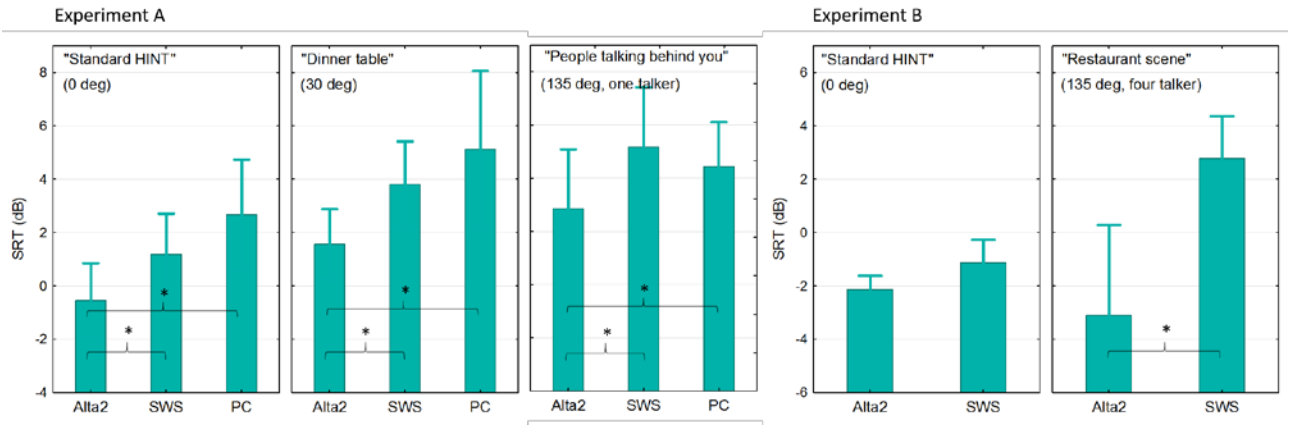

Figure 3: HINT results. In Experiment A, the hearing aid (Alta2) performs significantly better than the PSAPs in the three tested configurations (0°, ±30°, ±135° one talker). In experiment B, the hearing aid also performed better than the PSAP in the ±135° four-talker configuration, whereas no significant performance difference were observed in the 0° configuration. Bars show across-subject averages, error bars show 95% confidence intervals and "" indicates significant differences (based on a mixed model Analysis of Variance, ANOVA) between hearing aid and PSAP scores.*

Sound quality

Sound Quality was also assessed in both Experiment A and B, however the sound samples were changed between the two visits. In Experiment A the subjects listened to three different pieces of music (classical, rock, jazz) and two types of speech (speech in quiet, dialogue in canteen), whereas the subjects in experiment B listened to two types of music (classical, jazz), three types of speech (speech in quiet, dialogue in traffic, dialogue in canteen), and finally to a soft signal of the chirping of a bird in a forest scene. The classical and jazz sound samples were not the same in the two experiments.

The results of the sound quality experiments are shown in *Figure 4*. In experiment A the results were summed across all 10 subjects, 5 sound samples, 5 repetitions and three between-devices comparisons (all in all 750 comparisons). Experiment B had 11 subjects, 6 sound samples, 4 repetitions and one between-devices comparison (all in all 264 comparisons). Experiment A showed that the subjects preferred listening through Alta2 and SWS over PC, with no significant difference between Alta2 and SWS. Experiment B (using a different set of sound samples) showed that Alta2 was significantly preferred over SWS.

The reason that the sound quality was similar between the hearing aid and SWS in experiment A and highly different in experiment B, is likely due to the audiogram-based fitting of the hearing aid which prescribes much more high frequency amplification than both PSAPs. In experiment A, a jazz sound sample was selected that had much high frequency content, and some participants described the sound of the hearing aid in this condition as sharp or shrill, whereas for the more regular wide band jazz sample selected in experiment B, the participants described the sound of the hearing aid as clear and crisp. It could be speculated that the hearing aid suffers from the lack of fine tuning that would have been offered in a regular fitting situation.

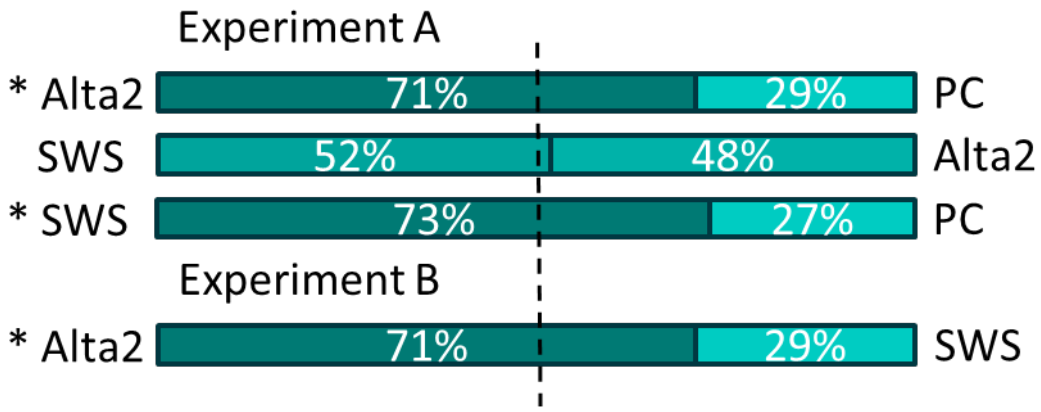

Figure 4: Preference across all participants, sound samples, and repetitions in experiment A and B. The figure shows the preferences in percent of how many times the device shown in the left was preferred over the device to the right. "" denotes a statistically significant difference.*

Summary and Conclusion

In this study, the performance of two PSAPs were evaluated against the performance of a hearing aid for listeners with mild-moderate hearing losses. On the most important domain, speech intelligibility, it was shown that the hearing aid performed significantly better than both PSAPs. Sound quality wise, the hearing aid was also on average preferred over both PSAPs, although one PSAP (SWS) was preferred equally often as the hearing aid on a subset of sound samples. Thus, it seems fair to conclude that on speech intelligibility and sound quality, the hearing aid is the better rehabilitative choice.

Literature

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