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Preliminary field and laboratory trials with Senso Diva™

Introduction

The *Senso Diva* hearing aid has been developed in close collaboration with hearing aid users, who have assessed its performance through successive controlled laboratory and field trials to help secure the desired final quality. The finished product has also been tested and evaluated in laboratory trials as well as field trials to ensure that the hearing aid lives up to expectations – both in the laboratory and in real-life situations. These trials have been conducted at Widex' audiological research laboratory in Vaerloese, Denmark, and at the Office of Research in Clinical Amplification (ORCA), which is Widex' research centre in Chicago, Illinois, USA. The primary purpose of the two trials reported in this article was to verify the hearing aid's value in practical use. However, as the results are among the first available, they are undoubtedly of clinical interest.

The design of *Senso Diva* bears evidence of our wish to improve the users' speech intelligibility in noisy environments. Various methods have been tested to determine how improved speech intelligibility in background noise could be achieved without compromising the overall functionality and performance of the hearing aid. The basic principle is that the *Senso Diva* hearing aid should be useful in the wide range of listening situations the users find themselves in each day. This principle has formed the basis for the evaluation of *Senso Diva* covered in this article.

Data from field and laboratory trials carried out at ORCA and in Vaerloese with *Senso Diva* are presented below. The test subjects participating in the ORCA trial were all fitted with *Senso Diva* ITC hearing aids, which are equipped with Diva Locator - an adaptive directional system. This made the ORCA trial particularly well suited for determining the effect of the directional properties in *Senso Diva*.

In the Vaerloese trial, the test subjects evaluated different hearing aid models – BTE, ITC or CIC - in their daily environments. The trial could therefore be used as an indicator of the users' satisfaction with the *Senso Diva* concept in general.

The ORCA test[1]

The distance between the two microphones in the adaptive microphone system of *Senso Diva* ITC's is only 5 mm. Therefore, the two microphones must be completely matched to obtain a satisfactory directional effect. This was achieved with the automatic microphone matching system, OptiMic™ . It was, however, interesting to see whether the directional system would also be effective in practice. Therefore, one of the primary objectives of the ORCA trial was to evaluate the effect of *Senso Diva* ITC's directional properties in a group of experienced and a group of inexperienced hearing aid users. The use of directional microphone systems in hearing aids is recognised as an effective way of improving speech intelligibility in noisy environments. The functionality of a directional system is, however, also affected by external factors, such as the position of the hearing aid in the ear and the size of the vent. Ricketts (2001) has demonstrated that a vent with a diameter of 2 mm can reduce the directivity index (DI) below 500 Hz by up to 2 dB compared to a blocked vent. Therefore, if the results of an evaluation of a directional hearing aid are to be useful, the venting of the test instruments must correspond to the venting used in practice. A comparison was made of the individual test subject's speech intelligibility recorded with the test hearing aids (programmed with different settings) and the results obtained with their own hearing aids and without hearing aids. Two different methods for determining speech intelligibility in different listening situations were used in the trial.

Test subjects

The test group comprised 14 hearing impaired people; 7 experienced and 7 inexperienced hearing aid users. The average age for the group of experienced and inexperienced users was 65 years and 71 years respectively. The average hearing loss at 500, 1000 and 2000 Hz for the experienced test subjects was 46 dB HL for the right ear and 49 dB HL for the left ear. For the group of inexperienced test subjects, the average hearing loss was 25 dB HL for the right ear and 26 dB HL for the left ear. See figure 1. All the test subjects had sensorineural hearing loss, varying in configuration and degree of loss.

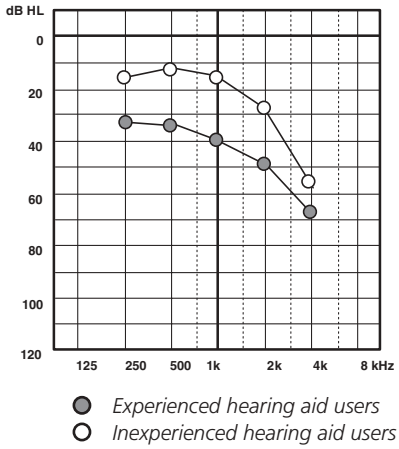


Figure 1. *Average air-conduction thresholds for the test subjects of the ORCA test.*

The experienced hearing aid users had been using hearing aids for a period of minimum three years, and five years on average. 1 test subject used BTE hearing aids, 2 used ITC hearing aids and 4 had CIC hearing aids. All the test subjects were binaurally fitted. 2 test subjects already used digital hearing aids, 2 subjects used digitally programmable hearing aids, and 3 had conventional analogue hearing aids.

Test hearing aids

All test subjects were binaurally fitted with *Senso Diva* ITC hearing aids. Five of the inexperienced hearing aid users were fitted with hearing aids provided with a 2 mm diameter vent, and two with a 1 mm diameter vent. The vents of the experienced users were generally smaller; four test subjects had no vent, one had a 1 mm vent and two had a 2 mm vent.

Measuring speech intelligibility

The test subjects' speech recognition in background noise was assessed by two different tests; the Speech Perception In Noise test (SPIN) and the Hearing In Noise Test (HINT). Both tests were carried out in a sound-treated booth with a reverberation time of approx. 0.1 second in the speech frequency range. Any order effect was counteracted by changing the order of the various tests (*Senso Diva* in omnidirectional and adaptive directional mode) from one test subject to another.

Hearing In Noise Test (HINT)

HINT is a test in which the test subject is asked to repeat short sentences (for example "A boy fell from the window" or "They lost all of their money"). The test consists of 25 lists with 10 sentences each, recorded with a male speaker. During the test, the speech signal level is changed according to the accuracy with which the test subject is able to repeat the previous sentence. The signal presentation level is altered in 4 dB steps for the first four sentences and in 2 dB steps for the following sentences. This way, the signal-to-noise ratio is continuously corrected to achieve 50% correct sentence identification. The noise signal was "Widex party noise" presented continuously and uncorrelated from behind and from either side of the listener (90°, 180° and 270° azimuth). See figure 2. The presentation level for all three noise signals was fixed at a long-term RMS level of 68 dB SPL. The purpose of presenting the noise as a semi-diffuse sound field was to create a listening situation that did not favour a specific directional char-

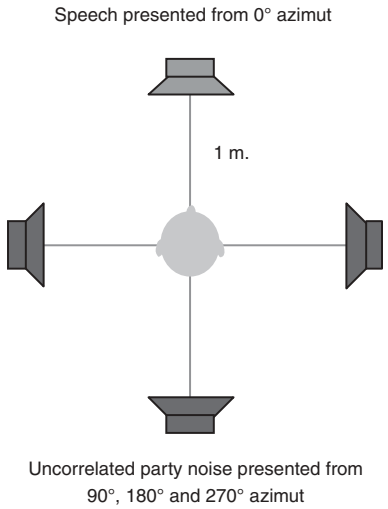


Figure 2. *Loudspeaker setup used for both the SPIN and HINT test*

[1] *The ORCA test is described in greater detail in Kuk et al (2002)*

acteristic. The result of the test is an indication of the average signal-to-noise ratio at which the individual test subject is able to repeat 50% of the sentences correctly.

Speech Perception In Noise (SPIN)

At the SPIN test, the test subject was asked to repeat monosyllabic words. The test words are placed at the end of a sentence (for example: »The boy gave the football a *kick*" or "Miss Brown shouldn't discuss the *sand*"). The test consists of 8 lists with 50 sentences each, recorded with a male speaker. The response options are open, and the test subject received no feedback from the tester. The SPIN test was performed with the hearing aids in omnidirectional mode as well as in adaptive directional mode. The speech signal was presented directly in front of the listener (0°) at a long-term RMS level of 68 dB SPL. The noise signal was "Widex party noise" presented continuously and uncorrelated from 90°, 180° and 270° azimuth. See figure 2. The noise was presented at three levels; 61, 68 and 75 dB SPL respectively, measured as long-term RMS at the listener's position. The signal-to-noise ratio was +7, 0 and –7 dB respectively. The results were calculated as the number of words that each individual test subject was able to repeat correctly, expressed in per cent (%).

Test procedure

The test procedure involved several sessions. At the first session, the test subjects were informed of the test procedure in detail, and an impression was taken of both ear canals. The second session was for evaluating the positioning of the *Senso Diva* ITC instruments in the ear. Then, the hearing aids were fitted to the test subjects. The fitting was based on a basic Sensogram (in-situ threshold measurement at the frequencies 500 Hz, 1 kHz, 2 kHz and 4 kHz), as well as on the prescribed feedback test with feedback cancelling activated. Listening tests were performed with *Senso Diva* in fixed omnidirectional mode and with Diva Locator activated (adaptive directional mode) to allow the test subjects to get used to the sound in the hearing aid. The test subjects were asked to wear the hearing aids for approx. one month to get used to the sound, after which speech recognition tests were repeated and the hearing aids fine tuned if necessary. Then the test subjects were asked to wear the test instruments for another month. The last session comprised the final evaluation of the test hearing aids including SPIN and HINT tests for both omnidirectional and adaptive directional mode. The results stated in this report are all from the last session.

Results

HINT results

The HINT test results are shown in Figure 3, which shows a scatter plot of the signal-to-noise ratios required for the individual test subject to identify 50% of the HINT sentences correctly with the omnidirectional microphone and the directional microphone respectively. The diagonal line indicates equal performance in the omnidirectional and directional mode. The fact that all the data points are below the diagonal line indicates that the signal-to-noise ratio required for 50% correct identification of the sentences was lower with *Senso Diva* in directional mode than with *Senso Diva* in omnidirectional mode.

For the group of experienced hearing aid users, the required SNR varied in omnidirectional mode from -0.24 dB to 16 dB, while the required SNR in adaptive directional mode ranged from -8.0 to 6.8 dB. This resulted in an average SNR of 5.6 dB in omnidirectional and -0.4 dB in adaptive directional mode. This corresponds to an average SNR improvement of 6.0 dB in adaptive directional mode compared to the omnidirectional mode.

For the group of inexperienced hearing aid users, the average difference was somewhat smaller. The required SNR in omnidirectional mode varied from -0.24 dB to 6.6 dB, while the required SNR in adaptive directional mode ranged from -4.5 dB to 1.6 dB. This resulted in an average SNR of 2.76 dB in omnidirectional and -1.14 dB in adaptive directional mode. This corresponds to an average SNR improvement of 3.9 dB in adaptive directional mode compared to the omnidirectional mode.

SPIN test results

The individual SPIN test results are shown in figure 4. The figure compiles the scores obtained with the omnidirectional mode and the adaptive directional mode. The diagonal line indicates the level at which there is no difference between the test subjects' result for omnidirectional and adaptive directional mode. Data points above the diagonal line indicate that a better score was obtained in adaptive directional mode than in omnidirectional mode. The figure shows individual scores for both groups of test subjects at three different signal-to-noise ratios.

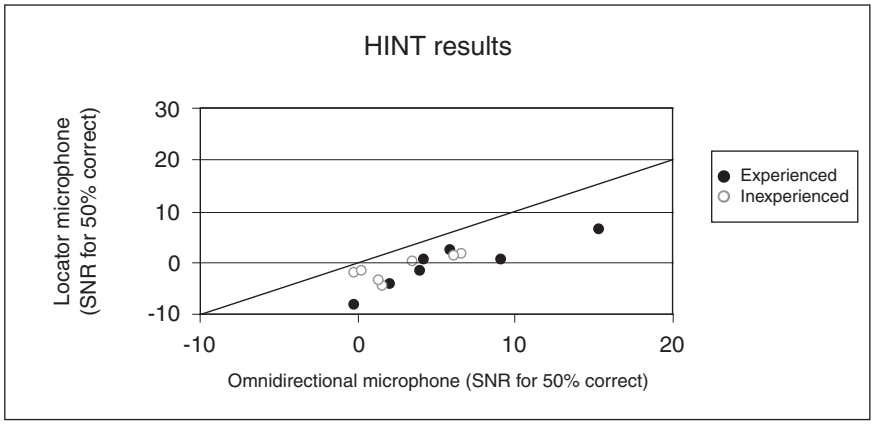


Figure 3. *Scatter plot which shows the SNR for 50% correct sentence recognition for both groups of hearing aid users in the HINT test with a directional and omnidirectional microphone, respectively.*

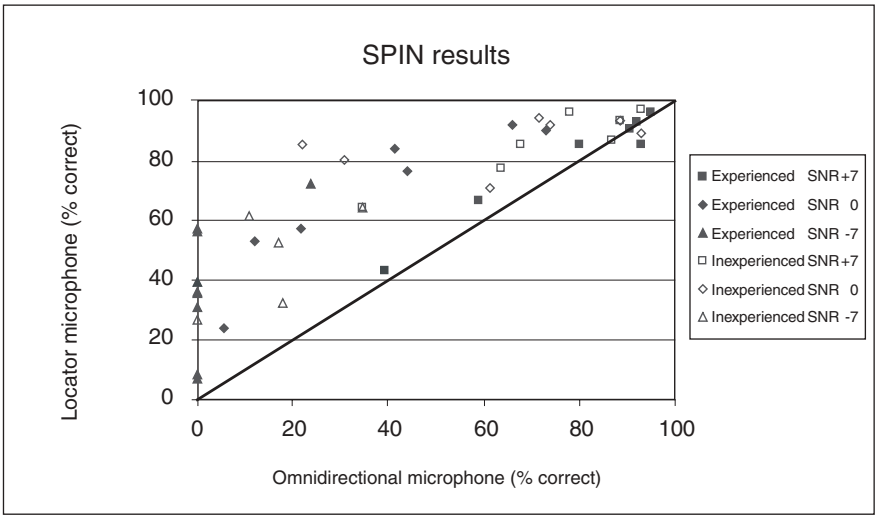


Figure 4. *Scatter plot which shows the SPIN score with a directional microphone and an omnidirectional microphone for both groups of hearing aid users at three signal-to-noise ratios.*

Various conclusions can be drawn from the data:

a. The test subjects obtained a higher score with adaptive directional mode than with omnidirectional mode at all signal-to-noise ratios, except at the best SNR of +7, where a few test subjects benefited equally from both modes.

b. The benefit derived from adaptive directional mode varied significantly in the different test situations. At the best signal-to-noise ratio (+7 dB) only a minor improvement was obtained. At the poorest signal-to-noise ratio (-7 dB) several test subjects obtained a recognition score of 0% in omnidirectional mode. These test subjects generally showed a major improvement in adaptive directional mode.

c. The increase in the scores is generally reduced with an improved signal-to-noise ratio. This can be seen from the average data. For example, the group of inexperienced hearing aid users showed an average improvement with the adaptive directional mode compared to the omnidirectional mode of 8.5% at a SNR of +7 dB, 23% at a SNR of 0 dB and 36% at a SNR of -7 dB. For the group of experienced hearing aid users the average improvement with the adaptive directional mode compared to the omnidirectional mode was 5.5% at a SNR of +7 dB, 31% at a SNR of 0 dB and 29% at a SNR of -7 dB.

d. The average data for the two groups also show that the group of experienced users obtained the maximum effect of the adaptive directional mode at a signal-to-noise ratio of 0 dB. The group of inexperienced users, however, obtained the maximum effect of the adaptive directional mode at a signal-to-noise ratio of -7 dB on average. This indicates that the relation between benefit and input level for these two groups differs.

Discussion

The ORCA test documented that the use of the adaptive directional system is an effective method of improving speech intelligibility in noise despite the very short microphone distance (5 mm), for both inexperienced and experienced hearing aid users. For all the test subjects, an objective improvement was recorded in one or more test situations. The improvement (on average 6 dB) for the experienced group of hearing aid users is of at least the same magnitude as the improvement of 3-4 dB typically reported (Ricketts, 2001). Despite the objective benefit demonstrated for both groups, the extent of the improvement was different for the groups in the HINT test (6 dB for the group of experienced users and 3.9 dB for the group of inexperienced users). There are many possible explanations to account for this difference. One of the explanations could be the difference in the relation between benefit and input level for the two groups as illustrated by the SPIN test, where the two groups achieved their best average scores at different signal-to-noise ratios.

Another possible cause of the reported difference between the two groups could be that the inexperienced users' hearing aids were provided with larger vents. It has previously been documented (Ricketts, 2001) that a 2 mm vent may reduce the DI below 500 Hz by up to 2 dB and result in an overall reduction of the speech weighted directivity index (AI-DI) of more than 0.8 dB compared to with no vent. This may explain the lesser benefit obtained from the directional system by the group of inexperienced hearing aid users. Nevertheless, a considerable directional effect was recorded for both groups of test subjects with ITC hearing aids. It is worth noticing that although the hearing aids were provided with no vent or only a small vent, this did not affect the users' satisfaction with the sound of their own voice through the hearing aid. The reason for this might be the use of many narrow-band compression channels with a small time delay in *Senso Diva*, and the Diva Occlusion Manager option.

Conclusions

The trial shows that the *Senso Diva* directional system with adaptive directional mode and short microphone distance is an effective method for improving speech intelligibility in noise for both experienced and inexperienced hearing aid users. The test also demonstrates that *Senso Diva* can be used with no vent or a moderate vent – also by inexperienced users. This is convenient for achieving the full benefit of the adaptive directional system as well as of other features designed for enhancing speech intelligibility in noise.

The Vaerloese trial

The primary purpose of the Vaerloese trial was to determine user satisfaction with all 3 *Senso Diva* models (CIC, ITC and BTE). The experiment was conducted as a field trial, where a group of satisfied hearing aid users compared *Senso Diva* with their own hearing aids. For this purpose a *Senso Diva*-specific questionnaire as well as two different generic questionnaires were used; the APHAB (Abbreviated Profile of Hearing Aid Benefit) questionnaire and the NSH questionnaire (prepared by the Nordic cooperation on disability). The questionnaires allowed the test subjects to test and evaluate the benefit and satisfaction derived from their test hearing aids in relevant everyday situations.

Test subjects

The test group comprised 19 people (15 men and 4 women) with moderate sensorineural hearing loss. The average age was 61.6 years (range: 46-77 years). The average hearing loss at 500, 1000 and 2000 Hz was 46 dB HL for the right ear and 48 dB HL for the left ear. Figure 5 indicates the average air-conduction thresholds and the grey area the outer limits for ears fitted with hearing aids.

17 of the test subjects were experienced and satisfied hearing aid users.

The average experience of hearing aid use was 11.7 years. 6 test subjects used BTE hearing aids (2 monaural and 4 binaural), 11 used ITE hearing aids (all binaural) and 1 used CIC hearing aids (binaural). 11 had hearing aids with digital signal processing. The other test subjects had hearing aids with analogue signal processing

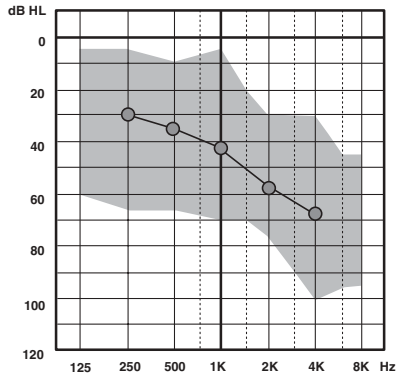


Figure 5. *Average and range of air-conduction thresholds (N = 35).*

(6 of these were digitally programmable). 4 test subjects had hearing aids with a directional microphone, and 3 of these could switch between directional and omnidirectional characteristics. 1 test subject had not worn hearing aids previously and 1 was not satisfied with the performance of his hearing aid.

Test hearing aids

Three different *Senso Diva* models were used as test hearing aids. SD-9M (BTE), SD-XM (ITC) and SD-CIC (CIC). The test subjects were fitted with the *Senso Diva* model considered most appropriate for the individual person. The majority of the test subjects (15) were fitted with the same type as they had used previously. Following consultation with the remaining 4 test subjects it was decided to use a different type of hearing aid (two switched from ITE hearing aids to CIC models, one switched from BTE to ITC hearing aids and one had not used hearing aids prior to participating in the test). 5 test subjects were fitted with SD-9M (BTE), 10 with SD-XM (ITC) and 4 with SD-CIC (CIC). 2 BTE fittings and 1 CIC fitting were monaural (as was the case with their own hearing aids). The other test subjects were binaurally fitted. The venting incorporated into the test hearing aid earmoulds and shells was based on Widex' vent guide. See figure 6.

Test procedure

The *Senso Diva* hearing aids were fitted using a basic Sensogram (in-situ threshold measuring at 500 Hz, 1 kHz, 2 kHz and 4 kHz) as well as a feedback test. Shortly after the fitting, each test subject was interviewed about the sound quality and loudness level of their test hearing aid. Then, they were given the test instruments without any further fine tuning in order to test the recommended gain in familiar surroundings and listening situations. All the test subjects were encouraged to contact Widex in Vaerloese as required. If they did not contact Widex, they were contacted by telephone approx. one week after the fitting. 13 test subjects did not find fine tuning necessary, while 6 subjects did. For the

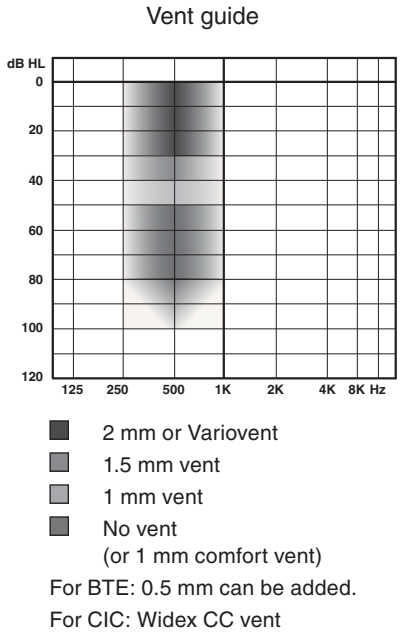


Figure 6. *Recommended vent diameter. Maximum vent diameter is determined on the basis of the hearing loss at 500 Hz.*

6 test subjects whose hearing aids were fine tuned, the maximum deviation from the standard fitting was +5 to –3 dB. All the test subjects were fully instructed in the use of the *Senso Diva* model fitted to them, including the functionality of the adaptive directional system and noise reduction. The 6 test subjects whose hearing aids needed fine tuning had this done at the third session. The test subjects tested the hearing aids for at least 6 weeks. In addition to the test hearing aid, they were also provided with user's instructions and a *Senso Diva*-specific questionnaire to be filled in at home and handed over at the completion of the test. The other questionnaires were completed in consultation with the tester.

Subjective testing of user satisfaction

The test subjects' subjective evaluation was recorded by means of the NSH questionnaire for clinical testing of hearing aids (Hagerman, 1999) and the APHAB questionnaire (Cox, 1995). The part of the two questionnaires concerning the test subject's perception of their own hearing aids was filled in at the first session, and the part concerning their perception of *Senso Diva* was filled in at the last session. The test subjects were also given a special *Senso Diva* questionnaire

after the *Senso Diva* hearing aid fitting to be completed at home and returned at the completion of the test.

Results

APHAB questionnaire results

In all the categories on the APHAB form, a significant difference was recorded in the frequency of problems experienced with own hearing aids and with *Senso Diva* – in *Senso Diva*'s favour. The results generally show that the test subjects – as a whole – were relatively well fitted both with their own hearing aids and *Senso Diva*. The average frequency of problems experienced by the group for the 4 main categories does not exceed the "Half-the-time" (50%) mark, neither with their own nor with the *Senso Diva* instruments. See figure 7. Despite the good results with the subjects' own hearing aids, a significant reduction in "Experienced problems" can be seen. The difference in APHAB scores with *Senso Diva* and with own hearing aids is an indication of the benefit achieved. The benefit is significantly in favour of *Senso Diva* in all 4 main categories. See table 1.

APHAB significance		
	P(T<=t) one-sided	P(T<=t) two-sided
Ease of communication	0.001	0.002
Reverberation	0.002	0.003
Background noise	< 0.0001	< 0.0001
Aversiveness	0.002	0.004

Tabel 1. *Significance levels for each of the 4 main categories in APHAB.*

NSH questionnaire results

18 test subjects filled out the entire NSH questionnaire. One person had not previously been fitted with hearing aids and could therefore only answer the last question, which was whether he preferred to continue without hearing aids or to use the *Senso Diva* hearing aid.

All the test subjects noted an improvement with *Senso Diva* compared to their own hearing aids. 18 out of 21 questions in total showed a significant improvement with *Senso Diva* compared to their own hearing aids, while 3 of the questions did not show any significant difference for either. These 3 questions concerned assessment of the telecoil function, hearing aid positioning and adjustment of the various hearing aid controls. See figure 8. The last question in the NSH questionnaire was about hearing aid preference. 16 test subjects preferred *Senso Diva* over their own hearing aid. When asked how sure they felt about their choice, they scored their certainty 9 on a scale of 10 on average. 2 test subjects preferred their own hearing aids, scoring their certainty 6 out of 10 possible points, and 1 person considered *Senso Diva* and his own hearing aids to be equally good. See figure 9.

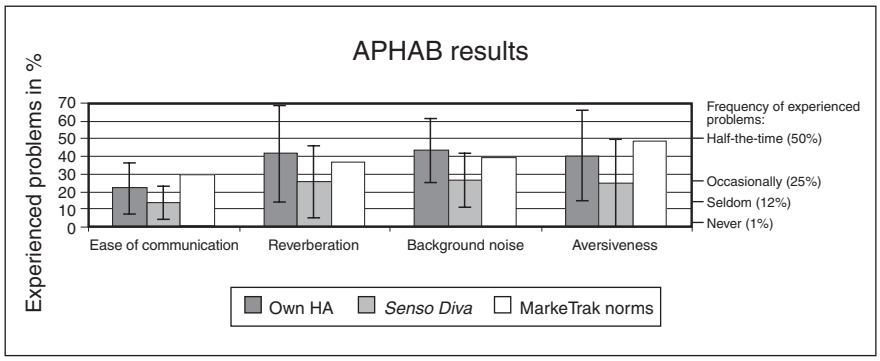


Figure 7. *The frequency of problems experienced with the test subjects' own hearing aids and with Senso Diva respectively. All four main categories are shown as percentage of experienced problems. As a result, the main category "Aversiveness" is the reverse of the usual presentation. The MarkeTrak norms (Kochkin, 1995) are incorporated as reference.*

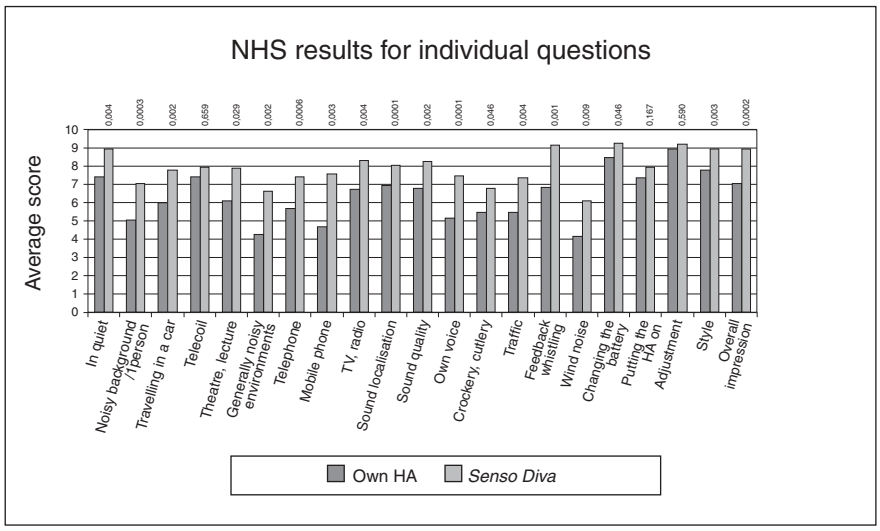


Figure 8. *Average results for all test subjects for individual questions in the NSH questionnaire for clinical testing. The maximum score obtainable for each individual question is 10. The higher the column is, the more positive the test subject's perception of the hearing aid performance was in the specific situation. The figures above the columns indicate the significance level at a P(T< = t) one-sided T test.*

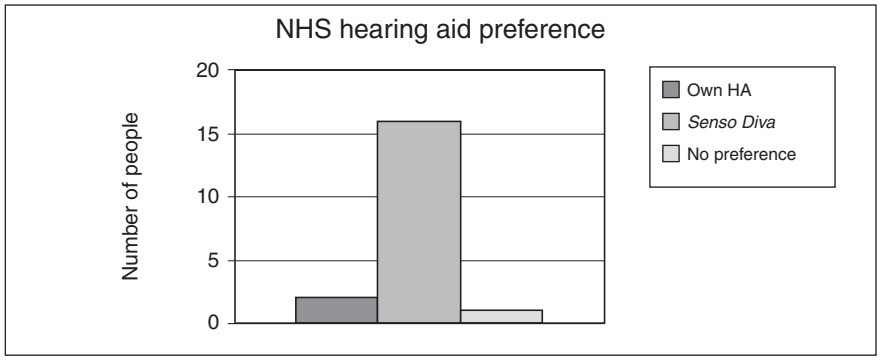


Figure 9: *Please answer the question: Do you prefer hearing aid A (reference hearing aid; your own hearing aids) or hearing aid B (test hearing aid; Senso Diva) ?*

Questionnaire for field test

Listening comfort

The following response options were available for the individual questions about comfort in a number of specific listening situations:

1. Very strenuous. Too much noise - I feel like removing the hearing aid or turning it off.
2. A little strenuous - Noise is a nuisance.
3. Acceptable - The noise is acceptable.
4. Little trouble - Noise is hardly a nuisance.
5. No trouble - I can hear the noise but am not bothered by it.

General for all responses was that the degree of comfort perceived with *Senso Diva* was high – also in very difficult listening situations. On average, the test subjects perceived the highest degree of comfort in quiet rooms, when travelling in a car and in supermarkets. Even in the most noisy situations – for example near noisy machinery and in the street, the comfort was assessed as more than just acceptable. See figure 10.

Speech perception

The test subjects assessed speech reproduction by evaluating how much of the speech they were able to perceive in a number of specific listening situations. The following response options were available for each question:

1. Nothing is perceptible.
2. Only some words are perceptible.
3. Half of the words are perceptible.
4. I understand most of the words, but must concentrate.
5. I understand everything without any special concentration.

As with listening comfort, the appraisal of speech intelligibility with *Senso Diva* was very positive. 7 listening situations in total were evaluated. Among the presented listening situations, the test subjects found it easiest to understand speech in an ordinary living room with 2-3 people speaking, or in a shopping centre or supermarket. Not unexpectedly, the most difficult situations were those with many people present (for example 7-8 people at a table or at large gatherings). In these situations, the test subjects had greater difficulty understanding speech, although they still rated speech intelligibility with *Senso Diva* as good. See figure 11.

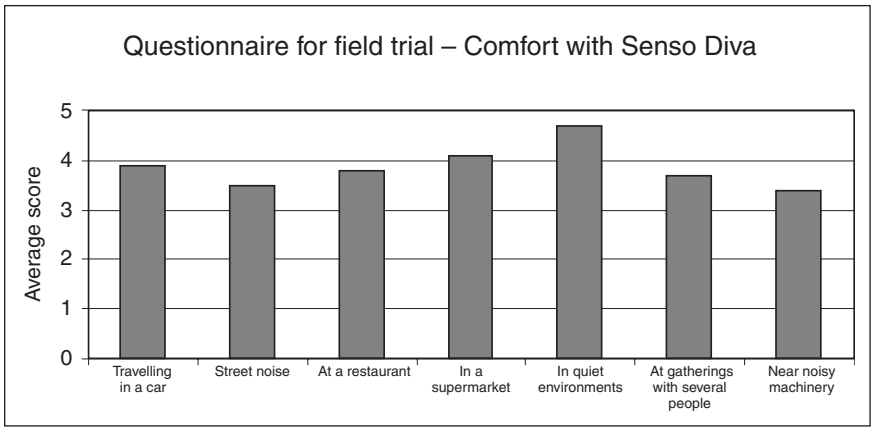


Figure 10. *The test subjects' average score for response to the question regarding comfort. 5 points is the highest score obtainable for an individual question.*

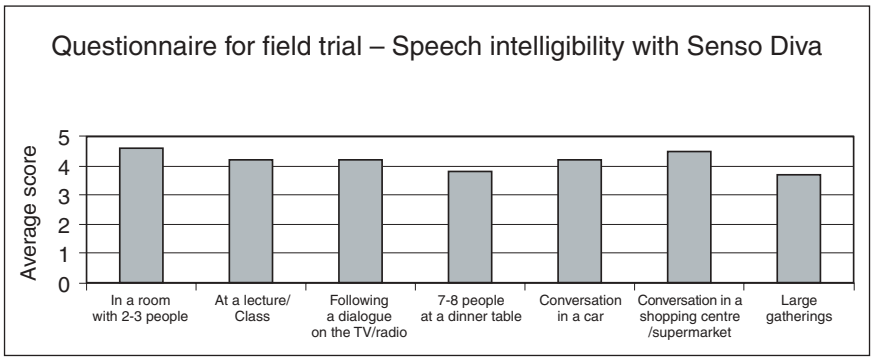


Figure 11. *The test subjects' average score for response to the question regarding speech intelligibility. 5 points is the highest score obtainable for an individual question.*

Music program evaluation

Finally, the test subjects evaluated the quality of music reproduced with the hearing aid set to the music program. The music program is characterised by being optimised for reproduction of music. In this program, several of the adaptive features designed to improve speech intelligibility and increase comfort, including the directional system, active feedback cancellation and noise reduction, are deactivated or set to a special music setting. The music program option is not available in CIC hearing aids. The test subjects were – as a group – very positive in their general evaluation of the music program. The standard deviation between all test subjects was small, indicating that their assessment was relatively similar. The same tendency applied to the questions which concerned a more detailed evaluation of the loudness, fullness and clarity of the music reproduced. See figures 12, 13, 14 and 15.

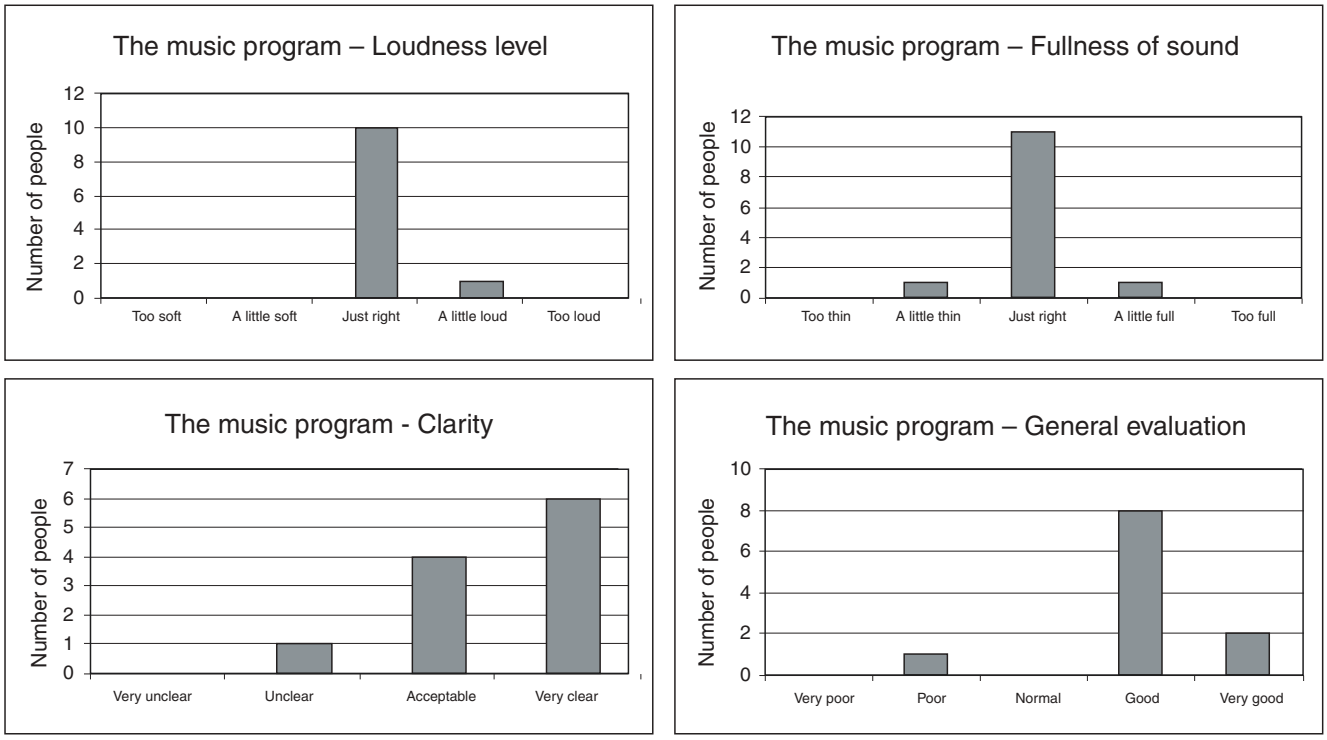
Discussion

The field test compared the users' satisfaction with their own hearing aids and with *Senso Diva* by means of APHAB and NSH questionnaires. The responses to all four APHAB main categories indicated a significant improvement with *Senso Diva* compared to the subjects' own hearing aids. The largest average improvement was recorded relative to the questions dealing with background noise, closely followed by the categories concerning reverberation and aversiveness of sound. A significant improvement was also noted for the "Ease of communication" category, although it was surprising that the improvement in this category was not more notable, as many of the test subjects had spontaneously commented on the increased ease of communication experienced with *Senso Diva*. A reason for this may be that many of the sub questions in the APHAB questionnaire deal with communication in quiet environments where the test subjects' own hearing aids probably perform as well as the *Senso Diva* instruments, and that many *Senso Diva* features are designed to improve speech intelligibility in noise.

The responses to all the individual questions on the NSH questionnaire for clinical testing showed a considerable improvement with *Senso Diva* compared to own hearing aids, and for 18 out of 21 questions this improvement was significant. In accordance with the results from the APHAB questionnaire, a very significant increase in ease of communication in noisy environments was recorded. The questionnaire also documented a significant improvement in the perception of the subjects' own voice as well as a significant reduction in feedback whistling. Hearing aid users' perception of their own voice is a well-known problem, especially for first-time users, who are not used to the partial blocking of the ear canal by the hearing aid. The improved perception of own voice may be due to the use of many narrow-band compression channels with only a small time delay in *Senso Diva*. The significant reduction in feedback whistling is probably due to the active feedback cancellation in *Senso Diva*.

In the category of listening comfort, the results showed that the test subjects rated degree of comfort with *Senso Diva* as high, and situations which people with normal hearing would also consider difficult were regarded as acceptable. This was also apparent from the test subjects' general assessment of speech intelligibility which they perceived as good – also in difficult listening situations. This suggests that *Senso Diva*'s noise reduction features worked satisfactorily in noisy environments.

The music program was available to the test subjects with ITC and BTE



Figures 12, 13, 14 and 15. *Spreading of the test subjects' evaluation of four aspects of the music program.*

hearing aids. The evaluation of the music program was generally positive. Some of the test subjects were extremely positive and found that the music program was very important for the musical experience. Among the test subjects were several practising musicians, and their evaluation was more varied. The results suggest that some practising orchestral musicians derive limited benefit from the music program, depending on the size of the orchestra and the sound level of the music.

Conclusions

The field trial results showed that the test subjects' evaluation of *Senso Diva* was very positive. 69% of the test subjects used *Senso Diva* with the basic fitting which they considered as optimum, thus making fine tuning unnecessary. The positive evaluation applies to speech intelligibility in difficult listening situations as well as listening comfort. The test subjects also perceive the reproduction of their own voice to be satisfactory, and they experience fewer feedback whistling problems. The vast majority of them prefer *Senso Diva* over their own hearing aids.

Overall conclusions

From the two trials described it can be concluded on an overall basis that the *Senso Diva* directional system with adaptive directional mode and a short microphone distance is an effective method for improving speech intelligibility in noise for both experienced and inexperienced hearing aid users. It could also be noted that *Senso Diva* can be used with no venting or moderate venting, also by inexperienced users. This makes it possible to obtain the full benefit from the noise reducing features in *Senso Diva*, including the adaptive directional system and 15-band noise reduction with speech intensification.

For listening situations occurring on a daily basis, a group of test subjects evaluated that they obtained improved speech intelligibility in difficult listening situations and higher listening comfort with *Senso Diva*. The test subjects also experienced fewer problems with feedback whistling. The test subjects represented different configurations and degrees of hearing loss, and it must therefore be presumed that similar positive results can be achieved for the majority of hearing impaired people within the *Senso Diva* fitting range.

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