Comparison of Two Digitally Programmable Hearing Aids

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Abstract
The purpose of this project was to compare the Widex Quattro® and the Ensoniq Sound Selector° hearing instruments as to benefits (real and perceived) and overall convenience. It is the premise of the Ensoniq designers that a high fidelity (wide band) hearing aid is adequate for all listening conditions due to its exact reproduction of sound. Conversely, it is the premise of the Quatto designers that a hearing aid user needs access to multiple frequency responses (memories) for optimal benefit in different communicative situations. Subjective measures showed little differentiation between the two instruments, except for the Ease of Communication subtest of the Profile of Hearing Aid Performance (PHAP). New users rated the Quatto as performing better, while experienced users rated the Ensoniq significantly better. Objective measures indicated some differences in the performance of the two instruments, although these results may be related to the fitting strategies employed.

Key Words: Programmable hearing aids, hearing aid fitting, speech perception

Current digitally programmable hearing instruments (DPHI) differ from the conventional analog hearing instrument in that the functional characteristics of the analog components (i.e., the amplifier as well as various analog filtering systems) are programmed by some external programmer through the use of a controlling microchip within the hearing instrument itself. It is proposed by these manufacturers that the advantages of such a system include: (1) increased levels of accuracy in setting the desired frequency responses; (2) ability to fine tune the response to an individual wearer’s needs; and (3) enablement of the dispenser to make “significant” electroacoustic modifications in their offices, instead of having to return the instrument to the manufacturer (Sandlin and Anderson, 1989). In addition to programmability and re-programmability, a few manufacturers of DPHIs have introduced additional features into their instruments that can not currently be reproduced by the conventional analog hearing instrument; hence, they incorporate new and innovative technologies that are only made possible by digitally programmable control.

One such feature is that of multiple memories and the control allowing the user to choose between memories with different frequency responses (Mahon, 1989). The manufacturers of these instruments propose that through digital control they can effectively give the wearer several instruments in one, each allowing for the optimal fit given the particular listening environment of the moment (Sandlin and Anderson, 1989). The manufacturers of such instruments make two critical assumptions. First, and most basic, it is assumed that the wearer of such an instrument will derive the most benefit from shaping the frequency response differently in different environments; that is, the wearer will want to hear differently in different environments. Secondly, it is assumed that the users of these instruments will be sophisticated enough to change the programs of the hearing aid appropriately in order to match the differing environments.

The Ensoniq Sound Selector does not incorporate the option of user controlled memories, rather the manufacturer proposes to give the user the one “best” response, which will be appropriate in all environments. The Ensoniq
utilizes very large scale integration (VLSI) design capabilities in an attempt to achieve a “transparent fit” (Rapisardi, 1989). The manufacturer describes “transparent” sound reproduction as one in which the amplified signal is roughly equivalent to the original sound. There are three technologies incorporated in the Sound Selector that set it apart from the majority of hearing instruments currently on the market (Rapisardi, 1989). First, the Sound Selector purports to provide usable gain through 8000 Hz, which is substantially greater than the 4000 to 6000 Hz limit imposed on the majority of hearing instruments on today’s market. Secondly, the frequency range is divided into 13 interdependent bands. This is accomplished by using 13 very narrow-band filters, which essentially operate in the same manner as does an equalizer in stereo equipment. According to Ensoniq, the precision of each audio band was determined by its relative contribution to the Articulation Index (AI). The Sound Selector also incorporates 2:1 input compression (TA = 3 msec, TR = 50 msec) with a low knee-point (55 dB SPL according to the manufacturer). Finally, the fitting strategy incorporated by Ensoniq is unique, as it is accomplished through the use of a probe-tube microphone system that provides an on-line measure of how an average, occluded real ear would respond to changes made in the program of the hearing aid plus or minus the calibration values obtained for the individual subject. A factor that sets this system apart from other probe-tube measures of insertion gain is its electrical generation of a diffuse sound field as the calibration stimulus. It is proposed that such a sound field will exclude the variables of head shadow effect and reference probe microphone placements, and yet be more representative of an environmental input.

Given the differing philosophies proposed, it is evident that validation of either claim would enhance the progress of DPHI technology. Specifically, these philosophies include the concept of one “high fidelity” frequency response, which will be the most appropriate in all environments as opposed to user control of a number of different frequency responses, which are the most appropriate for specific environments.

The purpose of this experiment was to compare the Widex Quattro Q8 and the Ensoniq Sound Selector hearing instruments as to (1) perceived benefit and overall convenience and (2) speech intelligibility afforded by the particular instruments in a variety of environments.
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These instruments were chosen because the Quattro is representative of those instruments intended to provide the user the maximal control for different listening environments; the Ensoniq is representative of the philosophy of “one best frequency response for all environments.”

Among the many variables that may affect an individual’s preference for one or the other of these instruments, the following are of particular note: ease of use, size of the hearing instrument (though size differences are quite small), range of frequency response, presence of the input compression circuitry in the Ensoniq, strength of tele-coil, amount of circuit noise, amount of overall distortion, number of user memories, various compression parameters, differences in fitting strategy, and shape of frequency response. These differences were also examined and related to overall satisfaction.

METHOD

Subjects

The subjects were eight adults with similarly sloping, mild to moderately severe sensorineural hearing losses (Table 1). Four of these subjects were new users of amplification, and four were experienced users of amplification (at least 1 year with an average of 2.5 years). This design also allowed the user experience bias of the particular manufacturer to be tested. The biases of the particular companies are: Ensoniq contends that new users adapt to the Sound Selector more easily, as they are not used to the sound of conventional hearing instruments (Rapisardi, 1989); Widex contends that experienced users will derive more use from their instrument because these users do not have to first become accustomed to a hearing aid before they experiment with the user memories (Sandlin and Anderson, 1989).

Procedures

Each subject was fitted using the Revised National Acoustic Laboratory (NAL-R) prescriptive procedure (Byrne and Dillon, 1986). In addition, the Quattro was also programmed for three different environments (i.e., party noise, music, quiet) using the fitting strategy proposed by Widex. Four of the subjects (Group A) were initially fitted with the Ensoniq Sound Selector and the four remaining subjects (Group B) with the Widex Quattro Q8. After a period of 30 days with the respective instruments, Group A was refitted with the Sound Selector and Group B with the Quattro. A standard, full-shell earmold, with a 1-mm vent, standard tubing and an average 9.5-mm insertion depth was used for all subjects. Thresholds of Discomfort (TDs) for speech were measured under earphones for each of the subjects. Matched NAL-R prescription insertion gain served as an intra-subject control factor.

The following test battery was administered to each subject at the fitting and orientation session for each hearing aid, and following 30 days of use with each instrument.

Insertion Gain measures were used to track any change in the user volume control or instrument circuitry. The measures were obtained using the Rastronics probe microphone system (Version 10.3) and a swept pure tone at 50 dB SPL. This relatively low level was used to avoid the activation of the compression circuitry of the Ensoniq Sound Selector.

The Nonsense Syllable Test (NST) (Levitt and Resnick, 1978), presented at 70 dB SPL in quiet and at +5 dB signal-to-noise ratio (multi-talker babble), was used as a measure of speech intelligibility. The NST consists of eight lists of 62 items each. These items were selected to include all consonant sounds in combination with the vowels /i/, /a/, and /u/ representing the extremes of the vowel triangle. The NST has been found to have reliability and precision similar to that obtained with nonspeech stimuli such as pure tones (Elkins, 1984).

The Connected Speech Test Version 3 (CSTv3) (Cox et al, 1989), presented in the sound field at 70 dB SPL, was given as a second measure of speech intelligibility. A signal-to-babble ratio (SBR) was determined for each client individually (between 5 and 7 dB) to yield 50 to 80 percent correct overall as described by Cox et al (1988). The test consists of 48 passages about familiar topics; each passage consists of ten sentences. A six-talker babble is used as a competing message.

Profile of Hearing Aid Performance (PHAP) (Cox and Gilmore, 1990) was administered as a subjective measure of general satisfaction. The PHAP is a 66-item self-report inventory that yields a seven- or four-scale profile quantifying perceived hearing aid benefit. The seven-scale profile measures the following areas: familiar talkers (FT); ease of communication (EC); reverberation (RV); reduced cues (RC); background noise (BN); aversiveness to sound (AV); and distortion of sound (DS). The
four-scale profile combines these areas into four types of listening situations, as follows: (1) Environment A (normal conversational level of speech with visual cues), FT and EC; (2) Environment B (reduced speech cues due to reduced intensity, reverberation, and/or limited or absent visual cues), RV and RC; (3) Environment C (high environmental noise levels, increased speech levels, and visual cues available), AV and DS; and (4) Background Noise. The internal consistency, test-retest reliability, and critical differences are reported to be similar to those obtained using other self-assessment tools (Cox and Gilmore, 1990).

Qualitative Judgment of Overall Sound Quality and Intelligibility was a measure devised by the investigator. Qualitative assessments of tape recorded speech sounds were made in six one-minute trials. These trials consisted of continuous discourse, male and female voice, presented in the sound field at 70 dB SPL in the following backgrounds: quiet, multi-talker babble (+ 0 dB s/n), music (+ 0 dB s/n). The subject was asked to rate the speaker's voice in each trial using three bipolar pairs, which have been shown to affect sound quality: sharpness/mildness, clear/blurred, and loud/soft. These factors were shown to represent 91 percent of the total variance in perception of sound quality (Gabrielsson and Sjögren, 1979). A ten-step scale was used between the extremes of the factors.

Hearing Aid Questionnaires (Forms 1, 2, and 3) were also developed by the investigator (modified from Seyfried, 1990). These measures were developed to assess perceived overall benefit. These questionnaires were developed to determine the relative strengths and weaknesses of the two differing manufacturer philosophies (multiple vs. single response) perceived by the individual subjects. They included questions pertaining to, but not limited to, ease of use, intelligibility of speakers in quiet and in noise, "naturalness" of sound quality, number of programs used and in what environments (in the case of the Quattro), as well as overall satisfaction. These factors represent some of the advantages and disadvantages proposed by the many advocates of the two hearing aids studied here (Rapisardi, 1989; Sandlin and Anderson, 1989). Form 1 was designed to be given prior to the subject having experience with a particular hearing aid. In this way it served as an expectations questionnaire. Forms 2 and 3 differed from Form 1 only in that the tense of the questions asked was changed, and more specific questions about each of the hearing aids individually were asked. (Refer to Appendix for Form 3 version of Hearing Aid Questionnaire.)

RESULTS

Average insertion gain difference from the NAL-R prescription gain for the Sound Selector as well as the four different programs of the Quattro can be seen in Figures 1, 2, and 3. Recall these measures were made using the Rastronics (Version 10.3) probe mic system and in general indicate reduced agreement to prescriptive values in the highest frequencies.

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2 This recorded tape was compiled from previously recorded materials. Specifically, the male and female discourse were Auditec of St. Louis' tape of connected discourse (C122); and the noise backgrounds were provided by the environmental noise tapes sold in conjunction with the Widex Quattro.
The results of the NST presented in quiet (Fig. 4) indicated essentially no difference between subjects using the Ensoniq (78.5%), the Quattro "party noise" (77.4%), and the Quattro "NAL" setting (75.9%). When the NST was presented in a background of noise, however, subjects using the Quattro "party noise" setting performed slightly better (65.3%) than those subjects using the Quattro "NAL" setting (59.6%) or the Ensoniq (59.6%). When the subject pool was split into two groups representing those subjects with consistently higher discrimination scores (N = 6) and those with consistently lower discrimination scores (N = 2), this difference in scores for the two conditions becomes slightly larger (Fig. 5). Although still not statistically significant, the group with higher discrimination scores (see Fig. 5) showed more improvement, and there was essentially no difference for the low discrimination group.

The Quattro ("noise" setting), Quattro (NAL setting), and the Ensoniq were further compared as to enhancement of speech intelligibility in noise using the CSTv3 (Cox et al., 1989). While wearing the Quattro ("noise" setting) subjects performed slightly better than when using the Quattro (NAL setting), or the Ensoniq (Fig. 6). New users performed slightly (though not significantly) better than the experienced users, especially when using the Quattro ("noise" setting) and the Ensoniq as shown in Figure 7. A two-way ANOVA and Duncan’s multiple range test revealed that this difference becomes significant when looking at only those six subjects classified as having higher discrimination scores (p = .0253) for the Quattro ("noise" setting), when compared to the Ensoniq (Fig. 8). These tests also indicated that subjects performance when using the Quattro (NAL setting) did not differ significantly from either the Quattro ("noise" setting), or the Ensoniq.
No self-reported differences between hearing aids were noted on the 4-scale profile of the PHAP (Cox and Gilmore, 1990) for all four environments. Slight differences were noted between hearing aids on the 7-scale profile, when subjects were separated as to their previous hearing aid experience (Fig. 9). These differences were seen only in the ease of communication category. Within the EC profile, new users rated the Quattro as performing better (p = .159) while experienced users rated the Ensoniq significantly higher (p = .029) than the Quattro.

Qualitative judgment of sound quality in different environments showed the Quattro to be slightly clearer (p = .132) and significantly more intelligible (p = .030) for speech in quiet when compared to the Ensoniq (Fig. 10). In the various noise backgrounds this difference was not evident; however, the Ensoniq was rated as slightly more "harsh" (p = .105) for the male talker when compared to the Quattro. It may be noted that these slight differences for the male speaker occurred for all subjects. In contrast, although no statistical differences were noted for the female speaker, two subjects consistently rated the female speaker's voice as much more harsh when using the Quattro than the remaining six subjects. If the data from the other six subjects are analyzed separately, it may be noted that the female speaker is also rated as slightly more "harsh" sounding through the Ensoniq (p = .128).

The Hearing Aid Expectations Questionnaire (Form 1) revealed that new wearers of amplification rated themselves as performing better with both the Quattro and Ensoniq equally (a raw score for both of +2) than predicted by the expectations questionnaire, whereas experienced users rated themselves as performing better with the Quattro (raw score
An item analysis of the Hearing Aid Questionnaires (Forms 2 and 3) revealed the following: Four of eight (50%) subjects rated the Quattro as easier to operate with the remaining four rating the Ensoniq as easier; seven of eight (88%) reported that the sound quality of the Quattro was more natural than the Ensoniq; six of eight (75%) reported that the Quattro was more beneficial in understanding speech than the Ensoniq; and six of eight (75%) felt the Quattro provided the most overall benefit, one subject rated the Ensoniq as providing the most overall benefit, and the final subject ranked the hearing aids as equal. All subjects indicated that both hearing aids made at least some sounds uncomfortably loud. Seven of eight (88%) subjects reported that this loudness discomfort was experienced equally for both hearing aids, while the remaining subject reported that they experienced more loudness discomfort when wearing the Quattro.

Specific to the Quattro, four of eight (50%) subjects indicated that they liked the remote control, while the remaining half indicated a strong dislike. Four of the subjects indicated that they used one program exclusively, while two subjects reported using two programs, one subject reported using three, and one subject four programs. It may be noted that seven of the eight subjects reported using one user program at least 75 percent of the time they wore the hearing aid. Additionally, seven of the eight subjects reported that they felt the remote control was helpful; however, only four subjects reported that it was easy to use. For six of the seven subjects who reported using one program most of the time, the program was either the NAL program or within two dB of the NAL program at all frequencies.

**DISCUSSION**

On the average, it can be seen from Figure 1 that the Quattro (NAL program) yielded a slightly better match to the NAL prescription at 3000 and 4000 Hz than the Sound Selector; the opposite is true at 6000 Hz. Recall that the Ensoniq was fitted using its own NAL fitting strategy and calibration, while the Widex was adjusted to the NAL target values in situ. Average interprogram differences obtained with the Quattro over the frequency range (ranging from 0 to 8 dB) are shown in Figure 2; however, differences for the individual subjects were greater, ranging from 0 to 14 dB for particular frequencies, with the greatest differences being seen between the "noise" program and the other three (especially the "music" program as might be expected).

When looking at individual’s insertion gain/frequency response results, the differing fitting strategies utilized by the two instruments must be considered. The strategy used by the Widex Quattro suggests that the instrument be programmed using the general shape of the audiogram. It is evident that the same program for the same hearing loss can yield insertion gain measures that are quite different, due in part to differences in external ear resonance characteristics. This can have an effect on differences between the frequency response between programs for individual subjects as well as affecting the overall frequency shape. The range of difference from NAL prescribed insertion gain for the "quiet" setting is indicative of the effects that may be seen when fitting only by the shape of the audiogram (see Fig. 3). Note that these differences are caused by varying volume-control-wheel settings, as well as ear canal resonance and earmold differences.

The Ensoniq programmer sets the hearing aid parameters while using a probe tube microphone system. Initially, probe microphone measures are taken to compare the resonance characteristics of the individual subject’s occluded ear canal and earmold/hearing aid system with that of the Knowles Electronics Manikin for Acoustic Research (KEMAR). It is important to note, however, that this calibration is accomplished through the use of a computer generated diffuse sound field and the matched prescription fitting is based on this calibration. To ensure a proper fit, it is essential for proper calibration to occur. A number of factors were observed to affect calibration including ear canal resonance and tubing size. In addition, if calibration was attempted in the presence of a vented earmold, a relatively large earmold to tympanic membrane (TM) space, or without proper probe-tube insertion depth (the manufacturer suggests at least 2 to 3 mm past the end of the earmold) the system will often complete the calibration process with little or no apparent problems. An erroneous fit might subsequently be measured on a conventional probe-tube system, however. The error in this fit was most often seen to be additional insertion gain at 200 to 400 Hz on the order of 10 to 30 dB, and 5 to 20 dB less insertion gain in the area be-
between 2000 and 4000 Hz. This problem was minimized in the present study by using proper care and taping the earmold vent off during calibration. It appears, however, that in order to maximize the fit with the Ensoniq, proper care must be taken in using a fully occluding, tight fitting earmold with an insertion depth of at least 10 to 12 mm.

It can be seen from the results of the CSTv3 that some subjects appeared to perform better in noisy situations while fitted with the Quattro than when fitted with the Ensoniq. It appears from these data that a significant advantage is gained in noisy situations (when the noise stimulus is multi-talker babble) with the Quattro (“noise” setting) than with the Ensoniq or the Quattro (NAL setting). Despite the relatively small differences in insert gain measured for individual subjects between the “noise” and NAL settings (see Fig. 2), there seems to be some evidence as to the validity of the pre-selected “noise” setting employed by the Quattro.

The greatest advantage appears to be realized by those subjects whose speech discrimination skills are initially good. Though this advantage is not apparent when looking at the results of the NST, this same trend is suggested.

The single statistically significant difference reported on the PHAP was on the Ease of Communication sub-profile among the experienced users. Upon individual analysis of this profile, it was determined that the significance was primarily caused by the negative ratings of one of the four experienced subjects. When this subject’s scores were removed, the difference between ratings on the two hearing aids was reduced to chance. It is interesting to note that this subject’s fit with the Ensoniq was the closest of all subjects to the NAL prescription (within +1 and −4 dB throughout the frequency range as measured by the Rastronics probe-tube microphone system); however, this subject reported that he only wore the hearing aid during the first 2 weeks of his 1-month trial period as he found “high pitched sounds very bothersome.”

It appears evident from this report as well as the data from the qualitative judgment scale, that some subjects find this added high-frequency information annoying or even distressing, yet some subjects appear to receive benefit in speech from matched NAL insertion gain in the higher frequencies (through 6000 Hz). It seems apparent that hearing aids that provide gain in the higher frequencies may require a more involved fitting procedure. This procedure may involve: (1) more client feedback as to the sound quality of their hearing aid/aid in a variety of different environments and (2) some shaping of the frequency response over time. That is, some clients may have to be fitted initially with a more traditional frequency response and, over a period of several follow-up sessions, be given more and more high-frequency gain. This additional time commitment must be considered by those who are fitting such an instrument.

The most immediately apparent discrepancy found upon analysis of the Hearing Aid Questionnaire pertains to subjects’ ratings of the Quattro remote control. Subjects who disliked the remote gave the following reasons: difficult to use; easily forgotten; and “a bother to carry.” It may be noted that two of the subjects who did like the remote control also found it difficult to use, but reported that they felt that they would get used to it. As indicated previously, seven of the eight subjects felt a remote control may be helpful. Reasons given for this rating included: discrete adjustment, meaningful volume control changes (the Quattro utilizes a digital volume control with equal 1.5 dB steps, which are assigned numbers one through 30), ease and ability of making user memory changes, and the ability to easily turn the hearing aid on and off quickly. These findings suggest that a remote control may only be appropriate for certain people who have hearing losses and its use may demand extended orientation time. All subjects were instructed on the use of the remote control and were provided practice time within the session; however, three of the subjects required a second appointment for re-instruction. It is evident that an easy to follow instruction manual would be beneficial to new remote control users. Such a manual may, however, bias subjects against experimenting with using different programs in situations other than the ones for which they are designated.

The most noteworthy results indicated on the Hearing Aid Questionnaire may be the greater reported satisfaction with the Quattro. Subjects reported it sounded the most natural, provided the most benefit in understanding speech, and provided the most benefit overall. Several reasons have been proposed as to why the Quattro may have provided the most overall benefit, including its apparent advantage in understanding speech in noise and its reported greater clarity and intelligibility in quiet (see Fig 10). However, reasons for less satisfaction with the Ensoniq have not been fully explored.
It was noted that the Ensoniq has relatively high equivalent input noise (electroacoustic evaluation performed to ANSI specifications revealed a range of 34.3 dB to 35.7 dB with an average of 35.1 dB); subsequently, three subjects with borderline normal hearing at 250 and 500 Hz reported “an annoying buzzing or humming.” Because the Quattro has a remote control, it is possible that clients believe it to be a more sophisticated instrument, hence, rating it more highly. Three subjects also reported that they found the tele-coil sensitivity to be markedly stronger on the Quattro than on the Ensoniq. Two of these subjects were previous users of amplification. These subjects reported that the tele-coil “seemed much stronger than anything they had tried before.” Due to the reported sensitivity of the Ensoniq fitting system and the “standard” earmold and tubing used, subjects may not have received the most optimal fit on the Ensoniq. Because of the indicated high-frequency insertion gain of the Ensoniq, when optimally fit, some subjects may need more time to be “shaped” to an optimal frequency response.

In general, it appeared from the Hearing Aid Questionnaire (expectations), that subjects may have performed better with these hearing aids than they expected. All four previous users of amplification reported that they performed much better with both of the DPHI’s than with their conventional analog instrument. While three of those four subjects reported a strong preference for one of the DPHI’s, they reported that both instruments were substantially better than their previous instrument.

Due to the reported benefits provided by these instruments, subjects were all asked if they would consider the purchase of either of the DPHI’s. Only two of the eight subjects reported that they would consider a hearing aid that was not of the in-the-ear style.

In conclusion, it appears that DPHI’s will provide benefit to some people with hearing losses. The decision regarding which of these instruments is superior for a particular client appears to be best made on an individual basis; that is, it was not possible to support either the multiple memory or the wide-band high fidelity premise as being superior. It is obvious, however, that additional time, care, and precision will have to be taken during the fit of such instruments.

REFERENCES


APPENDIX

Hearing Aid Questionnaire (Quattro)
(modified from Seyfried, 1990)

Each item below describes a belief or expectation related to hearing aids(s). If the statement accurately describes your beliefs or expectations then mark either STRONGLY AGREE, MODERATELY AGREE, or SLIGHTLY AGREE. If the statement doesn't accurately describe your beliefs or expectations then mark either STRONGLY DISAGREE, MODERATELY DISAGREE, or SLIGHTLY DISAGREE. You may feel you would like more information before making a decision on these statements. However, please respond with your beliefs or expectations at this time.

1. I have difficulty operating the controls on my hearing aid(s).
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

2. My hearing aid(s) fit comfortably.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

3. My hearing aid(s) make speech sounds more distinct.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

4. My family believes my hearing aid(s) help me communicate better.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

5. I have difficulty inserting and removing my hearing aid(s).
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

6. I adjusted slowly to my hearing aid(s).
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

7. In some noisy situations, my hearing aid(s) are helpful.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

8. I need my hearing aid(s) in most listening situations in which I find myself.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

9. When I am using my hearing aid(s) I need to watch speakers' faces, and ask them for repetitions occasionally.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

10. When I am speaking to others in a quiet room my hearing aid(s) are helpful.
    STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
    AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

11. When I am using my hearing aid(s) some sounds are uncomfortably loud.
    STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
    AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE
12. I feel self-conscious when I am wearing my hearing aid(s).
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

13. Speech and noise sound “natural” through my hearing aid.
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

14. Overall I am satisfied with the sound quality of my hearing aid(s).
   STRONGLY MODERATELY SLIGHTLY SLIGHTLY MODERATELY STRONGLY
   AGREE AGREE AGREE DISAGREE DISAGREE DISAGREE

15. What do you believe to be the (one) main reason for your answer to the last question. (check one)
   _ benefit in noisy settings
   _ availability of control options
   _ thoroughness of professional instruction
   _ ease of user controls
   _ overall sound quality
   _ comfort of hearing aid
   _ size of hearing aid/mold
   _ response of significant others
   _ other(s), please specify

16. Check all other contributing reasons for this answer.
   _ benefit in noisy settings
   _ overall sound quality
   _ thoroughness of professional instruction
   _ ease of user controls
   _ comfort of hearing aid
   _ size of hearing aid/mold
   _ response of significant others
   _ other(s), please specify

17. How many hours a day do you wear your aid(s)?

18. The number of programs I regularly use on my Quattro remote control is? (check one)
   _ 1
   _ 2
   _ 3
   _ 4

19. The program I find most beneficial in the following settings is?
   Quiet _ Music ___________
   Restaurant _____ Other noises (list)
   Car ______________

20. The program I most often use in the following settings is?
   Quiet _ Music ___________
   Restaurant _____ Other noises (list)
   Car ______________
21. Overall I find the Quattro remote (check one)
   - difficult to use but helpful having multiple programs.
   - difficult to use and not helpful having multiple programs.
   - some difficulty using it but helpful having multiple programs.
   - some difficulty using it and not helpful having multiple programs.
   - easy to use and helpful to have multiple programs.
   - easy to use but not helpful having multiple programs.

22. Is there any additional information you would like to provide?

23. When comparing the two hearing aids I have worn over the past two months:

   I found the Ensoniq/Quattro the easiest to operate. (circle one)

   I found the Ensoniq/Quattro sounded the most natural. (circle one)

   I found the Ensoniq/Quattro most beneficial in understanding speech. (circle one)

   I found the Ensoniq/Quattro most beneficial overall. (circle one)