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Effect of Hearing Aid Experience on Preferred Insertion Gain Selection

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Abstract

The effect of hearing aid experience (measured as years of hearing aid use and user insertion gain at octave frequencies from 250 Hz to 4000 Hz) on the selection of preferred insertion gain under six listening conditions and one vocalization condition was examined. Thirteen experienced hearing aid users selected their preferred insertion gain in each test condition using a modified simplex procedure. The results showed that for the listening conditions, preferred insertion gain was highly correlated with the subjects' hearing loss from 500 Hz to 2000 Hz. Hearing aid experience did not correlate at all with preferred insertion gain. On the other hand, user insertion gain at 250 Hz and 500 Hz correlated highly with preferred insertion gain selected during vocalization. Years of hearing aid use did not correlate with preferred insertion gain selection. These results suggest that user insertion gain can affect preferred insertion gain selection only when the test conditions are identical to those that the hearing aid wearers experience in everyday lives. In typical laboratory conditions, preferred insertion gain is likely determined by the stimulus characteristics and subjective preference.

Key Words: Hearing aid experience, modified simplex, paired comparison, preferred frequency gain response

Most conventional and many programmable hearing aids are fit using prescriptive formulae. In this approach, a fixed frequency gain response is prescribed for the same degree of hearing loss regardless of individual differences in ear canal characteristics or preferences. While the use of prescriptive formulae may be efficient for the initial estimation of electroacoustic settings on a hearing aid, it may not be optimal for all hearing aid wearers, as evidenced by a significant number of wearers expressing preference for alternate frequency gain responses from the NAL-R (Byrne and Dillon, 1986) prescription (Byrne and Cotton, 1988; Kuk and Pape, 1992; Kuk, 1994a). The multitude of available prescriptive formulae would also argue that no one single formula has proven effective for all hearing aid wearers.

Paired comparison of hearing aid frequency gain responses has been proposed as a means to select optimal electroacoustic settings on a linear hearing aid as far back as 1962 (Zerlin, 1962). Kuk also proposed the use of this technique to verify the adequacy of a selected frequency gain response (e.g., Kuk, 1994b). In paired comparison, the hearing aid wearer is instructed to listen through two sets of electroacoustic settings and select one that is more preferable under a specified criterion. This technique is simple to use and is reportedly reliable (Kuk and Pape, 1992; Stelmachowicz et al, 1994) and efficient (Neuman et al, 1987; Kuk 1994a), and may yield electroacoustic settings that are more preferable than those selected using the NAL-R prescriptive formula (Kuk, 1994a).

Gatehouse and Killion (1993) speculated that the brain can be acclimatized to the electroacoustic characteristics on a hearing aid. Acclimatization varies among individuals depending on the appropriateness of the hearing aid to the wearer. Hearing aids that are appropriate may require shorter acclimatization time. What is significant is that the brain can be acclimatized to a hearing aid that is clearly inappropriate (as judged by the wearer and the audiologist) after a period of hearing aid use. One of the clinical implications of acclimatization is the potential effect of hearing aid experience (defined as the duration of hearing aid use and the amount of insertion gain used)

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on the selection of preferred insertion gain using paired comparison technique. It would suggest that experienced hearing aid wearers may select a preferred frequency gain response that resembles most closely the ones used in their previous hearing aids. If that is the case, one may logically question the utility of this technique because the selected frequency gain response does not improve over the listener's own hearing aid. The use of paired comparison is justified only if hearing aid experience does not dictate listener preference. Factors such as stimulus characteristics and subjective preference should be the determining factors in paired comparison.

This study was designed to determine if hearing aid experience (years of hearing aid use and amount of insertion gain use) affects the choice of preferred frequency gain response. Specifically, the relationship between insertion gain selected under different listening and vocalization conditions was compared to the insertion gain to which the users were accustomed (i.e., user gain). High correlation among these measures would suggest that user experience could dictate preferred insertion gain selection.

METHOD

Subjects

Thirteen hearing aid wearers of linear amplification (10 males and 3 females) with 1 to 18 years of hearing aid usage participated. They ranged from 21 to 77 years of age, with a mean age of 57 years. The mean audiometric thresholds were 28 dB HL at 250 Hz, 30 dB HL at 500 Hz, 41 dB HL at 1000 Hz, 48 dB HL at 2000 Hz, 56 dB HL at 4000 Hz, and 65 dB HL at 8000 Hz. The hearing losses were sensorineural in nature and were symmetrical (± 5 dB) for the range of octave frequencies tested.

Ten of the 13 subjects were binaural hearing aid users. Eight subjects wore in-the-canal hearing aids, three wore in-the-ear hearing aids, and the remaining two subjects wore behind-the-ear hearing aids. With the exception of two subjects who had a moderately severe hearing loss, the typical vent size used was 2 mm in the majority of subjects. Although none of the subjects wore the Widex Quattro hearing aid in their daily lives, all listened through this hearing aid for over 10 hours as a consequence of their participation in other studies conducted at this facility.

Hearing Aid

The Widex Quattro Q8 programmable hearing aid was used in the binaural mode during the study. The availability of a remote control allowed the storage and rapid retrieval of four distinct frequency gain response settings. The remote control and multiple memories capabilities made this device appropriate for performing paired comparisons in the clinical setting.

The hearing aid can be adjusted in several electroacoustic parameters. These included maximum power output, high-frequency gain, low-frequency gain, overall gain, and compression limiting. For the purpose of this experiment, paired comparisons were restricted to only gain changes in the high-frequency and low-frequency regions. All hearing aids were set to the linear mode and at maximum output (i.e., 120 dB SPL). At the start of all test conditions, overall gain on the hearing aid was adjusted to the subject's most comfortable listening level while they listened to discourse passages presented at 63 dB SPL. The frequency response of the hearing aid was adjusted to approximate real-ear target NAL-R gain.

Preferred insertion gain was selected using a paired comparison technique. The algorithm that was used, the modified simplex procedure, required that the available electroacoustic settings be divided into discrete frequency regions for comparison. For this purpose, the available low-frequency gain (measured at 500 Hz) was divided into five 6-dB intervals. The high-frequency gain (measured at 2000 Hz) was divided into three 4-dB intervals. This resulted in 15 combinations of high- and low-frequency gain intervals for comparison. The family of frequency gain response curves showing the range of gain change is reported in Figure 1A. This change can also be illustrated in a matrix form (Fig. 1B). Each cell in the matrix represents a frequency response curve. For example, cell (3L, 2H) represents the darkened curve in Figure 1A.

Stimulus and Test Conditions

Fifty-four passages, each averaging approximately 10 seconds in duration, were used for subjective evaluation during paired comparison judgments. These passages were prepared for previous studies (Kuk and Pape, 1992), and a detailed description of their preparation can be found in the cited reference. Briefly, these passages were read by a trained male vocalist at normal vocal effort in an anechoic chamber (voice

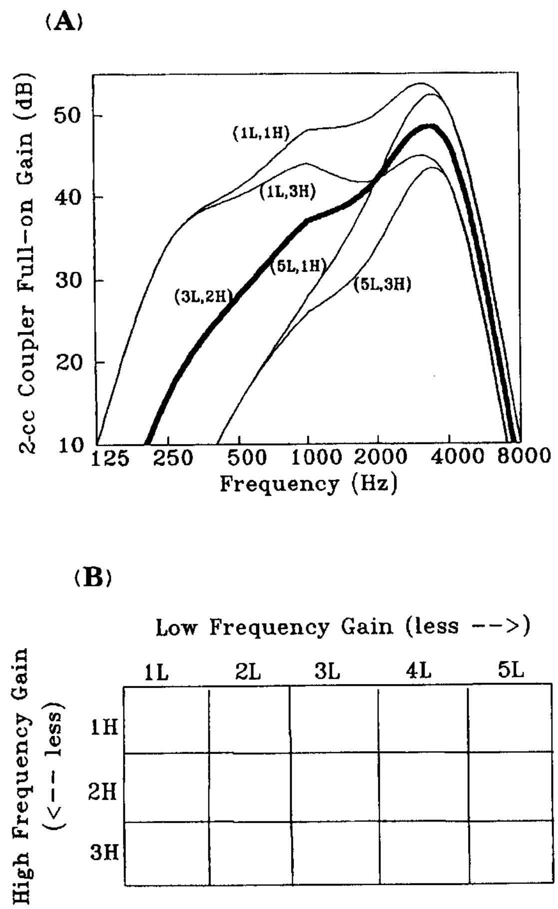

Figure 1 *A,* 2-cc coupler full-on gain curves showing the range of electroacoustic changes on the experimental hearing aid; *B,* matrix representation of the available frequency-gain response changes.

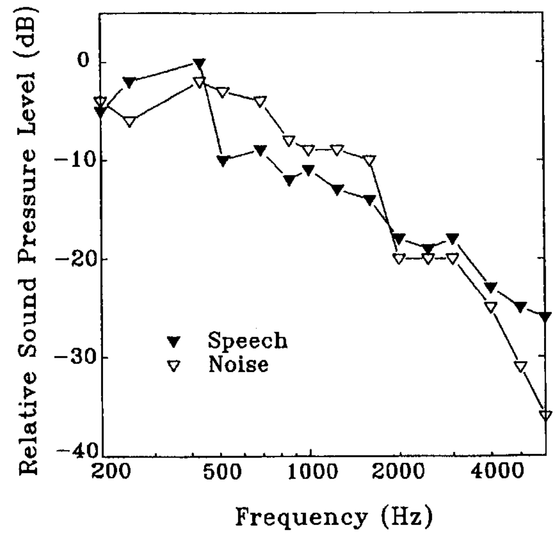

Figure 2 Spectra of speech (▼) and noise (▽) stimuli used in the study.

level at approximately 63 dB SPL). These passages were recorded digitally and presented under computer control. Only passages that were judged by four normal hearing listeners to be of equal difficulty, devoid of emotional overlay, and of similar sound quality were used. A multitalker babble noise (Widex Hearing Aid Company) was used as the competing stimulus. The spectra of the speech and noise stimuli are presented in Figure 2.

Preferred insertion gain was determined for six listening conditions and one vocalization condition. The six listening conditions varied by the levels of the speech and noise stimuli. In speech level (in dBA) to noise level (in dBA) ratio, these levels included 55/50, 65/60, 75/70, 50/55, 60/65, 70/75. These six conditions were chosen to represent a wide range of intensity change (56 dB to 76 dB overall intensity change) and signal-to-noise ratio (S/N) changes (+5 to –5). Although it is difficult to replicate the individual wearer's listening environments in the laboratory, testing over a wider range of intensities and S/Ns could ensure representativeness of the evaluation and perhaps help identify the laboratory condition(s) that may best approximate daily listening in a majority of subjects. In all test conditions, speech and noise were appropriately attenuated, mixed, and presented from one loudspeaker placed at 1 meter directly in front of the subject.

A vocalization task was included as one of the test conditions in order to examine the effect of user insertion gain on the selection of insertion gain that minimized occlusion (or perceived hollowness). In this task, subjects repeated the phrase "Baby Jeannie is teeny tiny." This phrase was selected because of the abundance of the vowel /i/, which may best demonstrate any occlusion effect (Killion et al, 1988).

Modified Simplex Procedure

Preferred insertion gain for listening and for vocalization was selected using paired comparison technique. The algorithm proposed in the modified simplex procedure (Neuman et al, 1987) was followed in the preferred gain selection. The modified simplex procedure has been used previously by this investigator for the selection of preferred frequency gain in listening and vocalization tasks (e.g., Kuk, 1990). A detailed description of this procedure can be found in the cited reference.

In the modified simplex procedure, the experimenter starts out with a frequency gain response setting that is estimated to be the most preferred by the listener. This starter setting is called the initial estimate and is represented by a cell (e.g., 3L, 2H) in the matrix of frequency gain settings shown in Figure 1B. This setting is then compared to surrounding cells that differ in the amount of low-frequency gain (e.g., 4L, 2H) and high-frequency gain (e.g., 3L, 3H). The subject listens to a pair of frequency gain responses (e.g., cell 3L, 2H and cell 3L, 3H) three times, and is instructed to choose the response that is clearer (in the listening task; "less hollow" was used in the vocalization task). The response that is preferred two out of three times is selected as the winner of the comparison. The results of the comparison in both electroacoustic dimensions define the position of the new optimal estimate and the direction for further paired comparisons. For example, if cell (3L, 2H) wins over cell (4L, 2H) and cell (3L, 3H), the new optimal estimate will still be cell (3L, 2H). However, the direction of the next comparison will be with cells of more gain (i.e., cells 3L, 1H and 2L, 2H). A change in the direction of preference is indicated as a reversal, and comparisons terminate after three reversals are encountered in all electroacoustic dimensions. The outcome after the third reversal is identified as the final estimate (or choice) of optimal frequency gain setting for the specific test condition.

Procedure

The amount of insertion gain provided by the subject's own hearing aid was measured at the beginning of the study. This measure was made at a volume setting that was reported by the subjects to be typical of daily usage. The Frye 6500 real-ear measurement system was used to measure real-ear insertion gain. A 65 dB SPL speech-shaped noise was used as the stimulus. This was presented at an angle of 45° from the side of the test ear. The probe tube was placed either through the Select-A-Vent (SAV) vent or underneath the hearing aid/earmold. Great care was taken to ensure that the probe tip was at least 5 mm beyond the opening of the sound bore.

The experimental hearing aids were worn in a binaural mode with skeleton lucite earmolds. A parallel SAV system was available in all earmolds. The earmolds were vented according to subject's hearing loss at 250 Hz and 500 Hz. Considerations were also given to the vent size used in subjects' own hearing aids. A 3-mm vent was used for an average loss of less than 40 dB HL at these two frequencies. The vent size was decreased 1 mm for every 10-dB increase in hearing loss (i.e., 2-mm vent for 50 dB HL, 1 mm for 60 dB HL) until the hearing loss exceeded 60 dB HL. In those cases, a pressure relief vent was used instead. Vent diameter was decreased in cases where the target initial estimate (i.e., NAL-R gain) up to 2000 Hz could not be achieved due to feedback.

Under each of the seven test conditions (six listening and one vocalization), the hearing aids were first adjusted so that the measured insertion gain approximated target NAL-R insertion gain. The Frye 6500 real-ear measurement system was used in the verification. In all subjects, the measured NAL-R insertion gain was ±1 dB from the NAL-R target up to 2000 Hz, and about –5 dB from the NAL-R target at 4000 Hz. This frequency gain setting was used as the initial estimate (or starting point) in the modified simplex in all test conditions. For each test condition, subjects adjusted the volume on the hearing aids to a most comfortable listening level before proceeding with the modified simplex procedure. No loudness compensation for frequency response change was made during the modified simplex procedure because such compensation is time consuming if implemented manually and may not improve the clinical validity of the modified simplex fitting over a case where loudness compensation was not made (Kuk, 1994c). The selected insertion gain response was measured once a modified simplex run was completed. The listening conditions were counterbalanced.

The experimental hearing aids were also set to real-ear target NAL-R insertion gain during the vocalization task. With the hearing aids in the ears, subjects were asked to repeat the phrase "Baby Jeannie is teeny tiny" three times at normal vocal effort. Subjects were asked to adjust the volume on the hearing aids so that the loudness of their voice was at a comfortable level (ignoring its hollowness). The level of the vocal production was monitored on the VU of a sound level meter. Gain on the sound level meter was adjusted so that the VU peaked at 0 during most of the production. Subjects were instructed to repeat the phrase at the same vocal effort in all subsequent comparisons so that the VU peaked at 0 during all vocal production.

Subjects repeated the phrase twice with each frequency-gain response. Settings on the high- and low-frequency gain dimensions were evaluated to determine the optimal setting. Each pair of frequency gain responses was compared three times to determine the winner of the comparison (two out of three wins).

RESULTS

Insertion Gain at User Setting and from Different Experimental Conditions

Figure 3A shows the mean insertion gain curves determined with the subject's own hearing aid, the mean preferred insertion gain (PIG) averaged across all listening and vocalization conditions, and the target NAL-R insertion gain. Mean preferred insertion gain was not markedly different from user insertion gain and target insertion gain from 250 Hz to 1000 Hz. The preferred insertion gain at 2000 Hz was significantly less than the user insertion gain but the preferred gain at 4000 Hz was significantly more than the user gain.

Figure 3B shows the mean preferred insertion gain curves obtained in the six listening conditions and the vocalization condition. Three observations are apparent. First, the amount of preferred insertion gain decreased with increases in stimulus intensity; however, the decrease was nonlinear. More decrease was noted when the overall stimulus level was increased from 56 dB to 66 dB than when it was increased from 66 dB to 76 dB. Second, the amount of preferred insertion gain selected at a negative S/N condition was typically less (about 2 dB) than that obtained at a positive S/N condition for the same overall stimulus level. This was especially seen below 1000 Hz at and above the 66 dBA stimulus condition. Last, the preferred insertion gain above 1000 Hz selected during vocalization was intermediate in value between the gain selected at overall inputs of 56 dB and 66 dB. Below 500 Hz, the preferred gain selected during vocalization was less than that selected during listening.

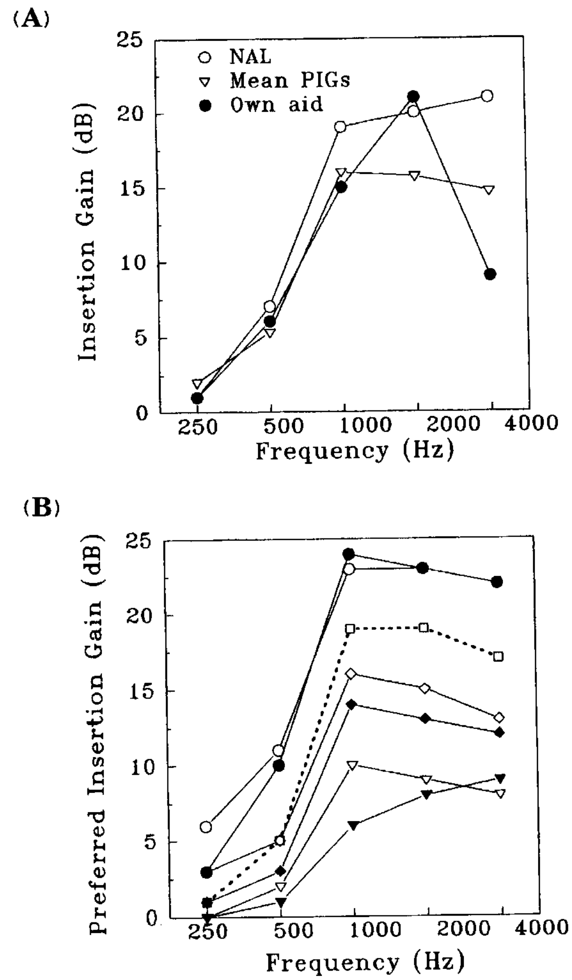

Figure 3 *A* Mean insertion gain curves determined with the subjects' own hearing aids (●—●), the averaged preferred insertion gain selected in six listening and one vocalization tasks (▽—▽), and the target NAL-R insertion gain (○—○); *B*, mean insertion gain curves determined in each test condition: 55/50 (○), 65/60 (◇), 75/70 (▽), 50/55 (●), 60/65 (◆), 70/75 (▼), and vocalization (□).

Relationship between Preferred Insertion Gain and Prescribed NAL-R Gain

The predictability of preferred insertion gain from prescribed gain was examined using Pearson product–moment correlation. The resulting coefficients are summarized in Table 1. Correlation coefficients that are significant at the $p < .01$ level are indicated with an asterisk.

Statistically significant correlations are seen between preferred gain and prescribed gain at 1000 Hz and 2000 Hz in the majority of test conditions. Correlation coefficients ranged from $R = 0.67$ to $R = 0.87$, suggesting that 45 percent to 76 percent of the variance (i.e., R^2) seen in the preferred gain selection can be accounted for by the prescribed gain. At 500 Hz and 4000 Hz, moderate correlations were seen only when the S/N ratio was negative (except at 70/75 for 500 Hz). No significant correlation was seen between prescribed and preferred gain at 250 Hz under any test conditions. These observations suggest that the preferred gain can be partly predicted from prescribed NAL-R gain under some stimulus conditions. Preferred gain in the low frequencies, especially for favorable S/N conditions, cannot be predicted easily. This may be partly attributed to a true lack of predictability of low-frequency gain and partly to the lack of between-subject variability in low-frequency gain.

Table 1 Pearson Correlation Coefficients between Preferred Insertion Gain and Prescribed (NAL-R) Insertion Gain

	Frequency (Hz)				
Test Condition	*250*	*500*	*1000*	*2000*	*4000*
55/50	−.08	.72*	.67*	.58	.59
65/60	−.22	.51	.78*	.81*	.63
75/70	.30	.63	.80*	.74*	.60
50/55	.58	.68*	.71*	.87*	.80
60/65	.47	.71*	.81*	.82*	.77*
70/75	.25	.52	.68*	.77*	.75*
Vocalization	.46	.50	.71*	.84*	.60

Significant correlation coefficients ($p < .01$) are indicated with an asterisk.

Relationships between Preferred Insertion Gain and User Gain, Hearing Loss, and Years of Hearing Aid Use

The relationships between preferred insertion gain, user gain, degree of hearing loss, and years of hearing aid use were examined using a multiple regression technique. The part correlation, which is the correlation between an independent variable X (e.g., hearing loss) and the dependent variable Y (i.e., preferred insertion gain) when the effect of the other independent variables is removed, is determined also. Table 2 summarizes for each independent variable its beta-weight (i.e., the standardized weight it contributes to the regression equation; the larger the number, the greater the contribution), the part correlation, and the tolerance (T) for each variable. The amount of variance explained by the three independent variables (i.e., R^2) and the F-ratio for the regression equation are also summarized in Table 2. T-values and F-ratios that are significant at the $p < .05$ level are indicated with asterisks.

Hearing loss showed the most significant correlation with preferred insertion gain in the listening conditions. This observation is expected, given the high correlation between preferred and prescribed insertion gain, as seen in the earlier section. However, most of the correlations were seen in the 50/55 and 60/65 conditions. There was no systematic correlation between hearing loss and preferred gain when the S/N was +5. Years of hearing aid use and insertion gain used by the subject (IG-own) alone did not correlate with preferred insertion gain when the effect of hearing loss was removed (i.e., part correlation). They did, however, contribute to the prediction of preferred insertion gain, as seen in the overall significant R^2 on the regression equations in the 65/60 and 75/70 conditions. This suggests that prior hearing aid experience does not affect preferred insertion gain selection during listening tasks.

On the other hand, user insertion gain below 500 Hz was significantly correlated with preferred gain obtained during vocalization. This is seen in the high correlation between preferred gain and IG-own in Table 2. Indeed, IG-own alone explained over 60 percent of the variance seen in preferred insertion gain selection below 500 Hz. When the effects of all three independent variables were included, they explained as much as 83 percent of the variance seen in preferred insertion gain selection during vocalization. This confirms that preferred insertion gain selected for vocalization is affected by prior hearing aid experience.

DISCUSSION

This study examined the effect of user experience with hearing aids (years of usage and user insertion gain response) on the selection of preferred insertion gain in six listening conditions and one vocalization condition. With some exceptions, the results showed that preferred insertion gain selected in a listening condition is not correlated with user insertion gain or years of hearing aid use but with the degree of hearing loss at 500 Hz to 2000 Hz. Berger and Hagberg (1982) and Leijon et al (1990) also reported negligible correlation between preferred insertion gain and years of hearing aid use. On the other hand, significant correlation was seen between user insertion gain and preferred insertion gain below 500 Hz during vocalization.

The differential effect of experience on preferred frequency gain selection during listening and vocalization suggests that hearing aid experience could affect the selection of preferred insertion gain. Perhaps the closeness of the test stimuli to sounds that occur in the subjects' daily listening environments affected the degree of such correlation. It is reasonable to expect that subjects are accustomed to their own voice through their own hearing aids. During the vocalization task, assuming that subjects vocalized in the same manner and at the same vocal intensity as they would in their daily lives, the stimulus they hear (and judge) during the vocalization task will be identical to what they hear in their daily lives. Since audibility of one's own voice is not an issue, subjects selected a frequency gain response that is most familiar. This

Table 2 Summary of Multiple Regression on Contribution of Each Independent Variable on Prediction of Preferred Insertion Gain

		Years			Hearing Loss			IG-own			Regression	
Condition	Frequency (Hz)	B	PC	T	B	PC	T	B	PC	T	R^2	F
55/50	250	−.08	−.07	−.22	.18	.18	.56	.16	.13	.41	.06	.22
	500	−.14	−.10	−.46	.69	.67	2.85*	.07	.05	.24	.49	2.93
	1000	−.10	−.08	−.30	.69	.54	2.01	−.11	−.08	−.31	.35	1.62
	2000	.20	.18	.79	.39	.35	1.55	.43	.42	1.87	.52	3.32
	4000	.40	.31	1.11	.12	.10	.36	.47	.44	1.57	.29	1.24
65/60	250	−.20	−.16	−.52	−.19	−.18	−.56	.22	.18	.55	.05	.18
	500	.08	.06	.23	.51	.49	1.86	.15	.11	.43	.35	1.64
	1000	−.06	−.05	−.26	.33	.25	1.30	.59	.42	2.15	.64	5.43*
	2000	.36	.33	2.14	.64	.58	3.78*	.10	.10	.65	.78	10.71*
	4000	.75	.58	2.69	.06	.05	.26	.46	.43	1.98	.57	4.03*
75/70	250	.39	.32	1.23	.07	.07	.27	.26	.21	.80	.35	1.68
	500	.54	.42	2.17	.72	.70	3.65	−.47	−.36	−1.87	.66	5.88*
	1000	.09	.07	.36	.55	.43	2.11	.24	.11	.86	.62	5.00*
	2000	.40	.37	1.71	.40	.36	1.69	.24	.24	1.11	.57	4.10*
	4000	.63	.49	1.78	−.10	−.08	−.30	.33	.31	1.12	.30	1.32
50/55	250	.08	.07	.22	.29	.27	.89	−.33	−.27	−.88	.12	.44
	500	.07	.05	.20	.61	.60	2.28*	−.30	−.22	−.86	.37	1.81
	1000	−.21	−.16	−.70	.89	.69	2.99*	−.21	−.15	−.67	.51	3.22
	2000	−.12	−.11	−.49	.68	.62	2.66*	.23	.22	.97	.50	3.09
	4000	−.46	−.36	−1.61	.82	.67	3.00*	.28	.26	1.17	.54	3.60
60/65	250	.48	.40	1.51	−.10	−.10	−.38	.18	.15	.57	.36	1.73
	500	.57	.44	1.94	.57	.55	2.44*	−.29	−.22	−.97	.53	3.42
	1000	−.14	−.10	−.58	.66	.51	2.77*	.33	.24	1.30	.68	6.65*
	2000	.15	.14	.74	.67	.61	3.33*	.21	.21	1.12	.66	6.08*
	4000	.13	.10	.40	.49	.40	1.50	.30	.28	1.04	.34	1.56
70/75	250	.43	.35	1.32	−.01	−.01	−.05	.22	.18	.67	.34	1.54
	500	.54	.42	1.63	.31	.30	1.18	−.05	−.03	−.14	.39	1.99
	1000	.38	.29	1.52	.43	.33	1.74	.13	.09	.48	.66	5.83*
	2000	.34	.31	1.40	.42	.38	1.70	.26	.25	1.13	.54	3.53
	4000	−.18	−.14	−.49	.57	.46	1.61	.01	.01	.05	.23	.94
Vocalization	250	.31	.26	1.70	.09	.08	.58	.65	.52	3.46*	.79	11.29*
	500	.34	.26	1.94	.20	.19	1.43	.58	.44	3.18*	.82	14.49*
	1000	.50	.38	2.10	.35	.27	1.49	.10	.07	.42	.69	6.75*
	2000	.48	.43	2.18	.42	.39	1.95	.14	.14	.70	.63	5.28*
	4000	.78	.61	3.03*	−.13	−.10	−.54	.70	.65	3.23*	.63	5.20*

IG-own = user insertion gain, B = beta-weight, PC = part correlation, T = tolerance level, F = F-ratio.

Variables that are significant ($p < .05$) in contributing to preferred insertion gain, as well as significant regression equations, are indicated with an asterisk.

stimulus similarity may have resulted in the high correlation between user gain and preferred gain during vocalization. Because the perception of hollowness is primarily determined by the amount of low-frequency gain on a hearing aid (Killion et al, 1988; Kuk, 1990), significant correlations between user and preferred insertion gain were seen only below 500 Hz.

The stimuli and test condition used in the listening task cannot be identical to the full range of acoustic stimuli that subjects experience in their daily lives. In the listening task, subjects would have to base their selection on the audibility of the stimuli and their preference. The selected frequency gain response will be similar to the user frequency gain response if the user frequency gain response already provides optimal audibility and preference for the specific test stimulus. Otherwise, an alternate frequency gain response may be selected.

Although preferred insertion gain can be predicted by the degree of hearing loss in as many as 76 percent of the subjects, over 20 percent of subjects remain for whom preferred insertion gain cannot be predicted easily. This incidence is similar to Byrne and Cotton's (1988) report that over 20 percent of hearing aid wearers preferred a frequency gain response that is significantly different from that prescribed by NAL-R. In addition, preferred gain at several frequencies (250 Hz, 500 Hz, and 4000 Hz) and preferred gain selected under favorable listening conditions cannot be easily predicted from hearing loss or hearing aid experience. The use of paired comparison to estimate preferred insertion gain could ensure optimal fit across a wider frequency gain range as well as over a larger population of hearing aid wearers and listening conditions.

Experience is not the only factor that affects the selection of preferred insertion gain, let alone the factor that may deter the use of paired comparison in preferred insertion gain selection. Indeed, experience may enhance the utility of paired comparison technique in preferred gain response selection. Given the relative nature of the paired comparison task where two hearing aids are compared side by side, it is difficult to envision that if a user had worn an inappropriate hearing aid that she/he would choose the same inappropriate frequency gain setting during paired comparison. It is even less likely that she/he will select an even less appropriate hearing aid than what she/he already has. A hearing aid wearer will choose a frequency gain response that is "better" than what she/he has from "prior experience." The same frequency gain response (re: user's own hearing aid) will be selected only if the old settings are appropriate to the wearer. In other words, experience can ensure that the selected setting is at least as good as, if not better than, the user's own hearing aid. To this end, paired comparison should only be used when the wearer has some experience with amplification. Additionally, given the significant role that stimulus and test conditions play in the selection of preferred insertion gain, future attention should be devoted to better understanding of the stimulus and test conditions that could maximize the utility of the paired comparison technique.

REFERENCES

Berger K, Hagberg E. (1982). Gain usage based on hearing aid experience and subject age. *Ear Hear* 3:235–237.

Byrne D, Dillon H. (1986). The National Acoustic Laboratories' (NAL) new procedure for selecting the gain and frequency response of a hearing aid. *Ear Hear* 7:257–265.

Byrne D, Cotton S. (1988). Evaluation of the National Acoustic Laboratories' new hearing aid selection procedure. *J Speech Hear Res* 31:178–186.

Gatehouse S, Killion M. (1993). HABRAT: Hearing Aid Brain Rewiring Accomodation Time. *Hear Instr* 44(10): 29–32.

Killion M, Wilber L, Gudmundsen G. (1988). Zwislocki was right. *Hear Instr* 39(1):14–20.

Kuk F. (1990). Preferred insertion gain of hearing aids in listening and reading aloud situations. *J Speech Hear Res* 33:520–529.

Kuk F. (1994a). A screening procedure for modified simplex in frequency gain response selection. *Ear Hear* 15(1): 62–70.

Kuk F. (1994b). Use of paired comparisons in hearing aid fittings. In: Valente M, ed., *Strategies for Selecting and Verifying Hearing Aid Fittings*. New York: Thieme Medical Publishers, 108–135.

Kuk F. (1994c). Reply to Byrne. *Ear Hear* 15(6):478–479.

Kuk F, Pape N. (1992). The reliability of a modified simplex procedure in hearing aid frequency response selection. *J Speech Hear Res* 35:419–429.

Leijon A, Lindkvist A, Ringdahl A, Israelsson B. (1990). Preferred hearing aid gain in everyday use after prescriptive fitting. *Ear Hear* 11:299–303.

Neuman A, Levitt H, Mills R, Schwander T. (1987). An evaluation of three adaptive hearing aid selection strategies. *J Acoust Soc Am* 82:1967–1976.

Stelmachowicz P, Lewis D, Carney E. (1994). Preferred hearing aid frequency responses in simulated listening environments. *J Speech Hear Res* 37:712–719.

Zerlin S. (1962). A new approach to hearing aid selection. *J Speech Hear Res* 5:370–376.