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Comparison of Preferred Frequency Gain Settings Obtained with Category Rating and Modified Simplex Procedure

Francis K. Kuk*†
Chi-chuen Lau*

Abstract

We examined the relations between the preferred frequency gain settings obtained from the modified simplex procedure and those that were rated highest during category rating at three speech and noise levels (speech and noise levels at 60/65, 63/63, 65/60, all in dBA). During category rating, subjects rated short discourse passages on a 7-point scale using clarity and noise interference as criteria. Clarity was used as criterion in the modified simplex procedure. Results indicated that most subjects gave the same high rating to two or more frequency gain settings during category rating. Such settings varied across subjects and test conditions. The preferred frequency gain settings selected with the modified simplex procedure matched closely those rated highest in clarity and lowest in noise interference. This suggests that the modified simplex procedure may be used to determine preferred frequency gain setting on a hearing aid.

Key Words: Category rating, modified simplex procedure, subjective judgments, subjective response surface

The advent of digitally programmable hearing aids allows audiologists greater ease in determining the wearer's preferred frequency gain setting on the hearing aid. Such preferred setting can be estimated by comparing the wearer's subjective preference (through category rating or magnitude estimation) and/or objective performance (through speech recognition) on all possible combinations of electroacoustic settings on the hearing aid. The combination that is the most preferred or that yields the best performance is chosen. In this approach, all combinations of electroacoustic settings must be compared in order to ensure completeness.

Alternatively, an adaptive optimization procedure, the simplex procedure (Levitt et al, 1978) has been proposed to estimate optimal setting on a hearing aid. The advantage of adaptive testing is that not all available combinations of electroacoustic settings are compared in order to determine the most preferred setting on the hearing aid. A modification of the original procedure, the modified simplex procedure, was proposed by Neuman et al (1987) for the same purpose. The modified simplex procedure uses the method of paired comparison to select the preferred setting on the hearing aid. In this procedure, the subject's preference for one combination of electroacoustic setting is compared to another combination that differs only on one electroacoustic dimension at a time. The result of the comparison indicates the direction of the next comparison. For example, if a setting with 15-dB gain at 500 Hz is preferred over one with 10-dB gain, the next comparison will be between the settings with 15-dB gain and 20-dB gain. Implicitly, this suggests that settings with less gain will not need to be compared because they will not likely be selected. Comparison continues until a final setting that is deemed most preferrable is determined. Because not all combinations of settings are compared, the modified simplex procedure may be more efficient than other subjective and/or objective methods of selecting an optimal setting on a hearing aid. This advantage is especially desirable if there are a large number of settings on the hearing aid and if the preferred setting selected by the

*Department of Otolaryngology — Head and Neck Surgery, University of Illinois at Chicago, Chicago, Illinois; †currently Phonak USA, Inc., Naperville, Illinois

Reprint requests: Francis K. Kuk, Phonak, USA, Inc. 850 E. Diehl Road, P.O. Box 3017, Naperville, IL 60566

modified simplex procedure is similar to that derived from other methods of evaluating performance (e.g., category rating).

The successful selection of a preferred frequency gain setting with modified simplex procedure assumes that the wearer shows maximum preference for only one combination of electroacoustic settings on the hearing aid. Preference for multiple settings that are diametrically opposed (e.g., preferring both more and less low-frequency gain over an intermediate low-frequency gain) would violate the assumptions behind this subjective measure. These multiple preferences could lead to unreliability during evaluation with the modified simplex procedure because different settings may be selected at different runs. Preference for multiple settings that are similar may reflect generalized preference or insensitivity of the evaluative criteria to changes in electroacoustic settings. Fortunately, the assumption of unique preference may be partly supported by the results of studies demonstrating the reliability of the modified simplex procedure (e.g., Neuman et al, 1987; Kuk and Pape, 1992; Stelmachowicz et al, 1994), and by the findings that different combinations of starting electroacoustic settings lead to the same recommendation of preferred electroacoustic setting (Kuk and Lau, 1995).

An advantage of the modifed simplex procedure over subjective category rating is its relative sensitivity to electroacoustic changes on a hearing aid. For example, Surr and Fabry (1991) reported that the Speech Intelligibility Rating (SIR) (Cox and McDaniel, 1989) test failed to differentiate among three hearing aids that differed significantly in mid-frequency gain. Yet, this amount of frequency gain difference can be detected easily with the modified simplex procedure (Kuk and Pape, 1992).

One possibility for the difference in sensitivity between the modified simplex procedure and category rating may be related to the forced-choice nature of the modified simplex procedure. Kuk and Tyler (1990) showed that subjects' overall preference for a hearing aid depended on the judged quality of the speech passages and the amount of perceived noise in the listening environment. In a clarity rating task, subjects are allowed to assign the same clarity rating to different electroacoustic settings that provide the same clarity and they can ignore differences on other dimensions (e.g., noise interference). However, in a forced-choice task (as used in the modified simplex procedure), subjects will be forced to use additional criteria to help in the decision when no discernible clarity difference is noted. Kuk and Tyler's (1990) data would suggest that the criterion of noise interference will likely be used in a forced-choice comparison situation even if subjects are specifically instructed for clarity judgment and no instructions for noise judgment are given. Validation of this hypothesis may account for the difference in sensitivity between forced-choice procedure and category rating procedure.

We undertook this study in order to determine if the modified simplex procedure reported by Neuman et al (1987) would yield the same frequency gain setting as that recommended by subjective category rating. Specifically, we examined (1) the subjective response surface resulting from category ratings of clarity and noise interference; and (2) the relationship between the preferred frequency gain setting selected with the modified simplex procedure and that estimated from subjective category rating.

METHOD

Subjects

Seven hearing aid wearers with 1 to 15 years of hearing aid experience participated in the study. They ranged in age from 36 to 77 years, with a mean age of 62 years. All subjects had symmetrical (± 5 dB) sensorineural hearing loss. Their average audiometric thresholds (dB HL, re: ANSI, 1989) were 30 dB HL at 250 Hz and 500 Hz, 38 dB HL at 1000 Hz, 42 dB HL at 2000 Hz, 54 dB HL at 4000 Hz, and 65 dB HL at 8000 Hz.

Hearing Aids

The Widex Quattro Q8 behind-the-ear programmable hearing aid was used in the binaural mode in this study. The range of electroacoustic changes on this hearing aid is typical of those seen in most commercial hearing aids. In addition, there are four memories to allow storage of four combinations of electroacoustic settings for quick retrieval during the modified simplex procedure.

The hearing aid has several adjustable electroacoustic parameters that allow adjustment of maximum output, low-frequency gain, high-frequency gain, compression limiting, and overall gain. In this study, the hearing aid was set to a linear mode at maximum output (121 dB SPL). Three levels of high-frequency gain were provided in 4-dB discrete steps as measured at 2000 Hz. Settings of the low-frequency filters were adjusted to provide five levels of low-frequency gain in 6-dB steps as measured at 500 Hz. The 2-cc coupler full-on gain curves showing the range of high- and low-frequency gain change is depicted in Figure 1A. Additionally, the combinations of high- and low-frequency gain settings are represented in a matrix (Fig. 1B). The x-axis represents the low-frequency gain and the y-axis represents the high-frequency gain. Each cell represents a combination of high- and low-frequency gain setting. For example, cell (3L, 2H) represents the frequency response curve shown darkened in Figure 1A.

Each combination of the frequency gain setting was stored in each of the four memories on the remote control device. Because each remote control has only four memories, four remote control devices were used to store all 15 combinations.

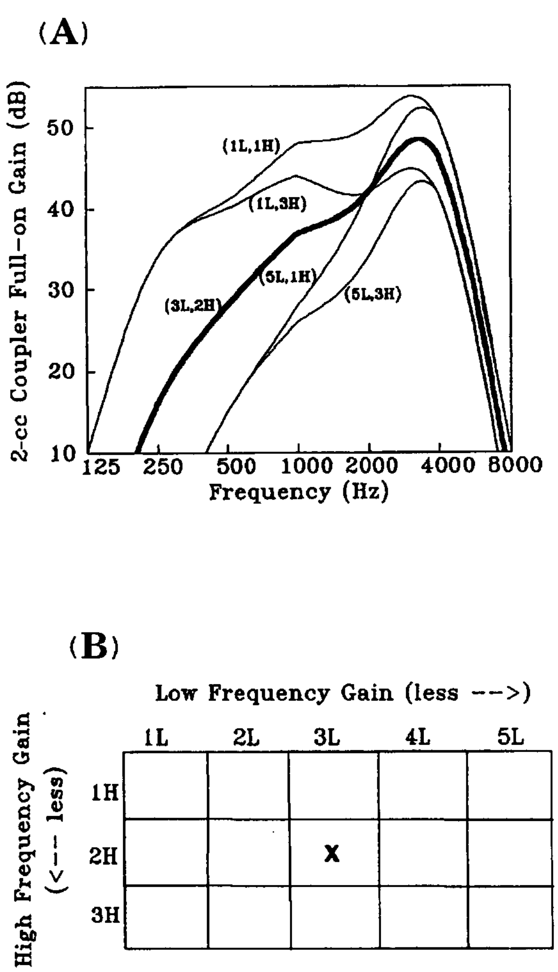

Figure 1 Two-cc coupler full-on gain curves (A) and matrix (B) showing the range of low- and high-frequency gain changes on the experimental hearing aid.

The remote control allows almost instantaneous access to different frequency gain responses during subjective rating and modified simplex comparisons.

All hearing aids were worn in the binaural mode. Lucite skeleton earmolds were used for coupling. Each earmold was individually vented according to the degree of hearing loss at 250 and 500 Hz. A Select-A-Vent plug with a 3-mm diameter was used if the hearing loss was less than 30 dB HL. A 2-mm vent diameter was used for losses between 30 and 40 dB HL and a 1-mm vent diameter was used for losses between 40 and 60 dB HL.

Stimuli and Test Conditions

Fifty-four discourse passages ranging from 9.8 sec to 13 sec in duration were used in the study. A detailed description of their preparation can be found in Kuk and Pape (1992). Briefly, these passages were read by a male talker in an anechoic chamber at a normal, monitored level of approximately 63 dB SPL. These passages were further evaluated by three listeners with normal hearing to be neutral in meaning, of good sound quality, and of similar intelligibility when they were presented in quiet. The noise stimulus was a 5-minute multitalker babble noise from the Widex Hearing Aid Co. The noise was presented continuously. The spectra of the speech and noise stimuli are presented in Figure 2.

Both subjective rating and modified simplex procedure were conducted at the same overall

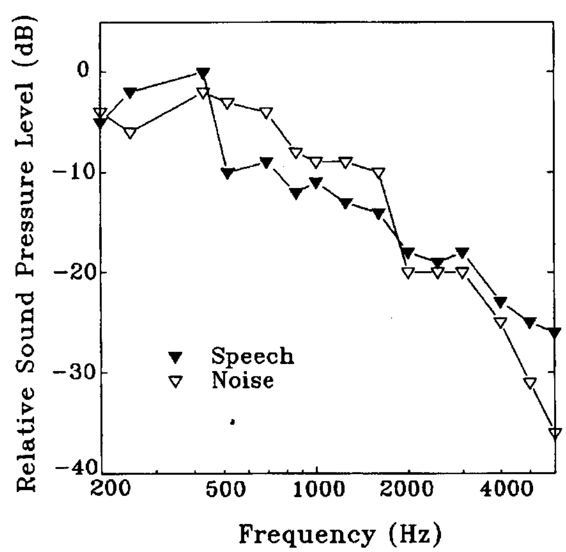

Figure 2 Spectra of the speech (▼) and noise (▽) stimulus used in the study (measured in ⅓-octave band).

stimulus presentation level and at three different signal-to-noise ratios. The speech levels were 60, 63, and 65 dBA while the noise levels were 65, 63, and 60 dBA, respectively. This yielded an overall level of 66 dBA and signal-to-noise ratios of –5, 0, and +5, respectively. Stimulus levels were measured with a Brüel and Kjaer (type 2235) sound level meter placed at the position of the listener's ear. All subjects were seated 1 meter directly in front of a loudspeaker. Speech and noise stimuli were appropriately attenuated and mixed before presentation from the loudspeaker.

Subjective Criteria and Instructions

Clarity rating and noise interference rating were used as criteria during category rating, and clarity was used as criterion during modified simplex comparisons. Clarity was chosen because of its growing popularity as a subjective criterion to estimate hearing aid preference. Hagerman and Gabrielsson (1985) reported that hearing aid wearers viewed clarity as the main determinant of hearing aid preference. Kuk and Tyler (1990) reported that speech quality/clarity correlated highly with subjects' overall liking for a hearing aid when discourse stimuli were presented in quiet and in noise. Balfour and Hawkins (1992) also reported high correlation between clarity and overall hearing aid reference.

Noise interference was used by Kuk et al (1990) to study the relative efficacy of low-frequency adaptive response hearing aids. It was reported that while other subjective criteria failed to demonstrate the efficacy of these circuits, more subjects indicated improvement with the action of the adaptive circuit under this criterion. Fabry and Schum (1994) also commented that this criterion may be sensitive to perceptual changes as a function of frequency gain changes on a hearing aid.

A 7-point, full description category rating task was used in subjective rating. Category rating was used because of its functional relevance to hearing aid wearers. A description was provided at each interval to guide meaningful choice. Only seven intervals were used because it was felt that listeners in daily situations would not be able to distinguish more than seven levels of functional difference in clarity or noise interference. Purdy and Pavlovic (1992), using hearing-impaired subjects with normal hearing up to 2000 Hz, reported similar group sensitivity among magnitude estimation, category rating, and paired comparison tasks. In order to increase the distinction between adjacent intervals, we included the criteria of acceptability and tolerance in the description of each subjective interval. An acceptable response is one that is tolerable and fairly satisfactory to the subject. An unacceptable response may either be tolerable or intolerable, but it is fairly unsatisfactory to the subject. An intolerable response is both unacceptable and unsatisfactory. Preliminary work suggests that this classification increased the distinction between adjacent intervals for response selection. A description of the response intervals used in each criterion is provided in Appendix A.

Procedure

Subjects completed the modified simplex procedure first before category rating in order to avoid biases with the explicit knowledge that noise interference can be used as a criterion during the forced-choice comparison. The overall gain setting on the hearing aid was adjusted to a most comfortable listening level for all three listening conditions. The same gain was used for both category rating and modified simplex procedure. No loudness compensation was made with frequency response changes.

Category Rating

At each test condition, subjects listened to each of the 15 combinations of high- and low-frequency gain settings and assigned two ratings for each setting. One rating was to reflect their impression of clarity and the other their perception of the amount of interfering noise. Presentation of frequency gain settings was randomized while the test conditions were presented in a counterbalanced order. The experimenters varied the frequency gain setting simply by pressing one of the 15 memories on the four remote controls. Subjects orally reported their ratings while aided with a cue card that described the meaning of each response interval.

A different passage was used for each high and low frequency setting. Passages were selected randomly. Subjects were allowed to repeat the same passage before responding. Approximately 1 hour was needed to complete category rating in all three conditions.

Modified Simplex Procedure

A detailed description of a modified simplex run is available from Neuman et al (1987) and Kuk and Pape (1992). The procedures described in Kuk and Pape (1992) were followed in this study. Briefly, the frequency gain setting that best approximated target NAL-R insertion gain (Byrne and Dillon, 1986) was used as the initial estimate to search for the preferred frequency gain setting. This target setting was determined through the use of a Frye 6500 real-ear measurement system with a probe tube that was placed at approximately 5 mm past the sound bore of the subject's earmold. A 65 dB SPL speech-shaped noise was used as the stimulus.

The modified simplex procedure was restricted to the selection of optimal setting in the high- and low-frequency regions. In each condition, the initial frequency gain setting was separately compared to another frequency gain setting that differed by 6 dB from this estimate in the low-frequency region and another by 4 dB in the high-frequency region. Subjects were instructed to select the frequency gain setting that yielded clearer speech. The same frequency gain settings were compared three times, with the setting that won two of the three comparisons identified as the winner. If subjects preferred the frequency gain setting with more low frequency gain, this setting would be compared to a setting with even more low-frequency gain and so on. The same was true for comparison in the high-frequency settings. Comparisons continued in the same direction (e.g., more low-frequency gain) until subjects changed their preference (e.g., from preferring more low-frequency gain to preferring less low-frequency gain). This indicated a reversal in the preference. Comparison continued with gain changes in the opposite direction. The run terminated after three reversals were encountered in both the high- and low-frequency regions. Subjects took approximately 10 minutes to complete one modified simplex run. Approximately 30 minutes were needed to complete comparisons in all three signal-to-noise conditions.

RESULTS

Subjective Response Surfaces from Category Rating

Patterns of Subjective Response Surface

The subjective ratings assigned to each of the 15 combinations of low- and high-frequency gain settings can be represented in a matrix format similar to that in Figure 1B. This response matrix is called a response surface. Figure 3 is a matrix showing hypothetical subjective ratings.

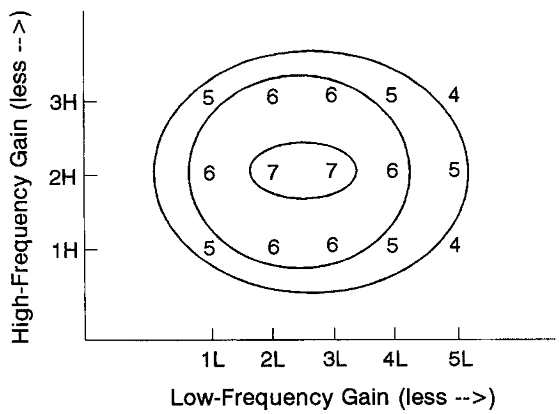

Figure 3 Hypothetical response surface. Numbers represent clarity ratings assigned to each combination of high- and low-frequency setting with 1 being undesirable and 7 being most desirable. The peak of the response surface occurs between cells (2L, 2H) and (3L, 2H).

This response surface shows that cells (2L, 2H) and (3L, 2H) receive the highest subjective rating and cells that deviate from this setting receive progressively lower ratings.

The task of matching simplex-selected frequency gain setting to that identified from subjective ratings is simplified if only one combination of high- and low-frequency gain setting (i.e., one cell on the matrix) receives the highest rating. However, this is not the case in most instances. All subjects showed the same high rating for more than one frequency gain setting on their response surfaces.

One can classify the patterns of subjective responses based on the number of frequency gain settings that received the highest rating and the spatial relationship among these settings on the response surface. There can be three patterns that describe the response surfaces seen in this study (Fig. 4).

The first pattern is the flat surface (see Fig. 4A). This is reserved for response surfaces whereby more than four-fifths of the adjacent frequency gain settings receive the same highest subjective rating. In this case, changes in frequency gain settings do not result in changes in subjective ratings.

The second pattern is the multimodal surface. The response surface shows two or more clusters of frequency gain settings that receive the highest subjective rating (see Fig. 4B). These clusters are separated by at least one cell on the response surface. This pattern suggests that subjects prefer more than one combination of frequency gain settings that may be diametrically opposed to each other. If this pattern of response

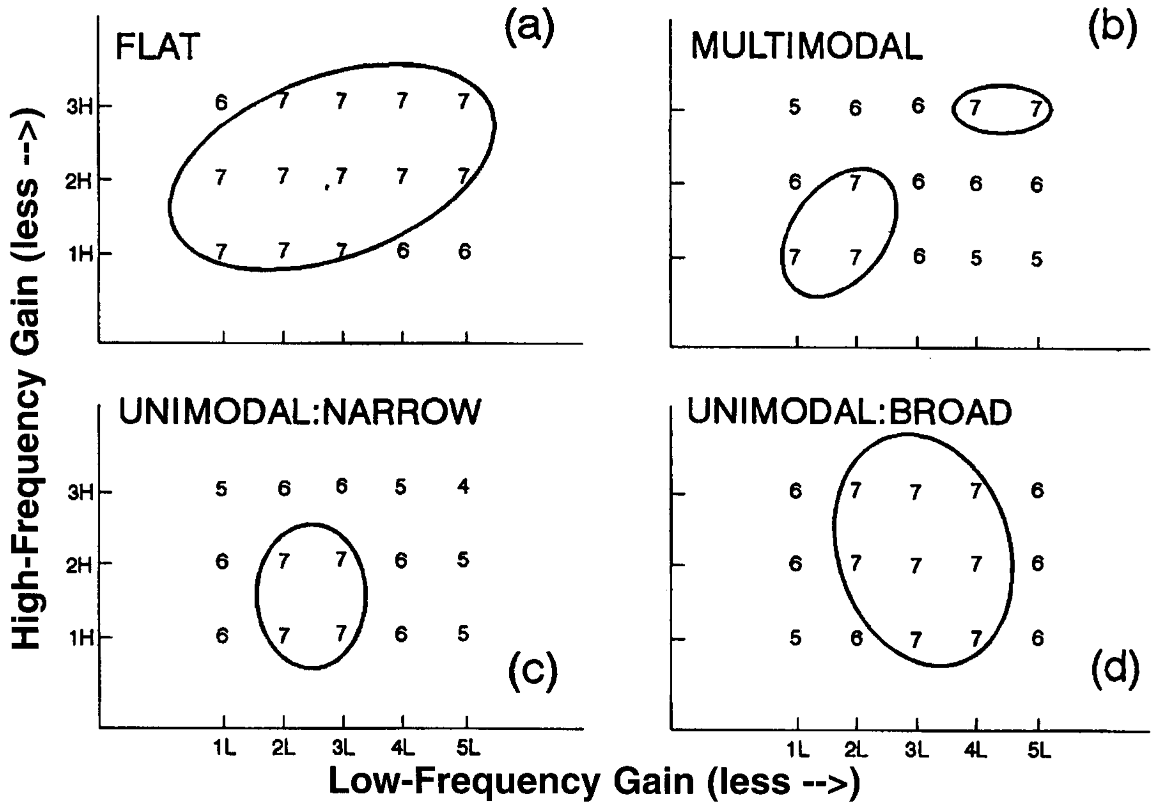

Figure 4 Hypothetical patterns of subjective response surface during a category rating task. Numbers represent the ratings that are assigned. Solid line encompasses frequency gain settings with the same highest ratings.

surface is also seen during the modified simplex procedure, it suggests the possibility of different preferred frequency gain setting with different initial estimates during the modified simplex comparison. In other words, subjects with this pattern of response surface may show more variability in their modified simplex run.

The third pattern is the unimodal pattern. In this case, the response surface is characterized by one or a cluster of frequency gain settings that yield the same highest rating. Depending on the number of cells making up the unimodal peak, one can further classify unimodal patterns into that of narrow or broad. Narrow peak is defined as that with one to four adjacent frequency gain settings that receive the highest rating. Broad peak is defined as that with 5 to 11 adjacent frequency gain settings that receive the highest rating (see Fig. 4, C and D). This type of response surface suggests that there are a small number of adjacent frequency gain responses that are most preferred by the listener. Subjects with this response surface may show less variability during the modified simplex run than those with multimodal peaks.

Frequency Distribution of Response Patterns

The number of subjects with response surfaces that fit each category is summarized in Figure 5. The incidence for each criterion and under each test condition is reported. An additional criterion, that of clarity and noise, is defined post-hoc as the response surface formed by the intersection of the surfaces from best clarity and least noise interference.

Figure 5 shows similar frequency distribution of response patterns across the three test conditions. When the speech and noise levels were 60 dBA and 65 dBA, respectively (60/65), five subjects showed a narrow unimodal response surface, one subject showed a multimodal surface, and one subject showed a flat surface as they judged the clarity of the stimuli. When noise interference was used as the criterion, three subjects showed a broad unimodal response surface and the remaining four subjects showed a narrow unimodal response surface. There were four subjects with a narrow, unimodal response surface under the clarity and noise criterion

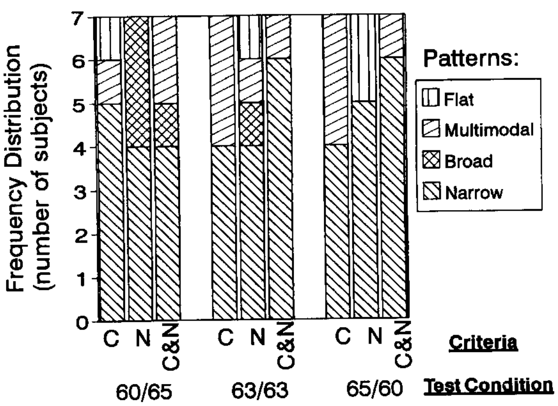

Figure 5 Frequency distribution of subjects whose response surface can be classified into different patterns for each response criterion: clarity alone (C), noise interference alone (N), and combined clarity and noise (C & N). When the criterion was C & N, only frequency gain settings that were rated highest in clarity and least in noise interference were included.

and one subject with a broad response surface. Two subjects were grouped under the multimodal surface because of no overlap in the response areas formed by both criteria. When overlap occurred, there were usually only one to two cells in the intersected area.

Although the actual numbers varied, similar distribution patterns can be observed in the 63/63 (63 dBA speech and 63 dBA noise) and 65/60 (65 dBA speech and 60 dBA noise) test conditions. In general, most subjects showed a unimodal response surface under the clarity and the noise interference criteria. The breadth of the response surfaces varied by subjects, response criteria, and test conditions. The criterion of clarity alone resulted in the most instances of multimodal response surface, whereas the post-hoc criterion of clarity and noise resulted in the most instances of narrow, unimodal peak on the response surface.

Preferred Frequency Gain Setting from Modified Simplex Procedure and Subjective Ratings

The preferred frequency gain setting selected with the modified simplex procedure (using clarity as criterion) was compared to that determined with the highest clarity rating and noise interference rating. The position of the simplex-selected preferred frequency gain setting on the subjective response surface formed by each criterion was examined. Four outcomes are possible. First, the preferred frequency gain setting selected with modified simplex may fall within the peak of the response surface resulting from clarity judgment. This is illustrated in Figure 6A. The preferred setting may fall within the peak formed by noise interference (Fig. 6B). It may fall into the area formed by the intersection of clarity and noise interference judgments (Fig. 6C). Last, it may not match the area formed by any criteria (Fig. 6D).

Two rules were used to count the frequency of matches in preferred frequency gain settings. First, the response area formed by a response criterion or by the intersection of two response criteria must have narrow, unimodal peak before it was counted. Broader response peaks were not counted. Second, if the simplex-selected frequency gain setting matched a region formed by the intersection of both response criteria, it was counted under the clarity and noise category and not separately under the clarity or noise interference categories. Consequently, the maximum number of matches across all criteria for each condition was limited to seven.

Figure 7 summarizes the frequency of matches between the preferred frequency gain settings selected with the modified simplex procedure and those from subjective ratings using clarity, noise interference, and clarity and noise criteria. In the 60/65 condition, there was one subject whose simplex-selected preferred frequency gain setting matched that identified by noise rating and one subject whose simplex-selected setting did not match any of the criteria. Five subjects matched their simplex-selected setting to the area bounded by both clarity and noise interference ratings. In the other two listening conditions, the simplex-selected setting fell within the area bounded by clarity and noise interference in five to six of seven subjects. The simplex-selected setting matched that selected by clarity rating in one to two subjects.

DISCUSSION

The present study examined the response surfaces resulting from clarity and noise interference ratings. In addition, the preferred frequency gain setting determined with subjective category rating and modified simplex was compared.

The majority of listeners gave the maximum rating for more than one frequency gain setting during category rating. A difficulty with multiple preferences is the selection of just one frequency gain setting to be the best among the frequency gain settings that are rated similarly. The use of single-criterion category rating, at

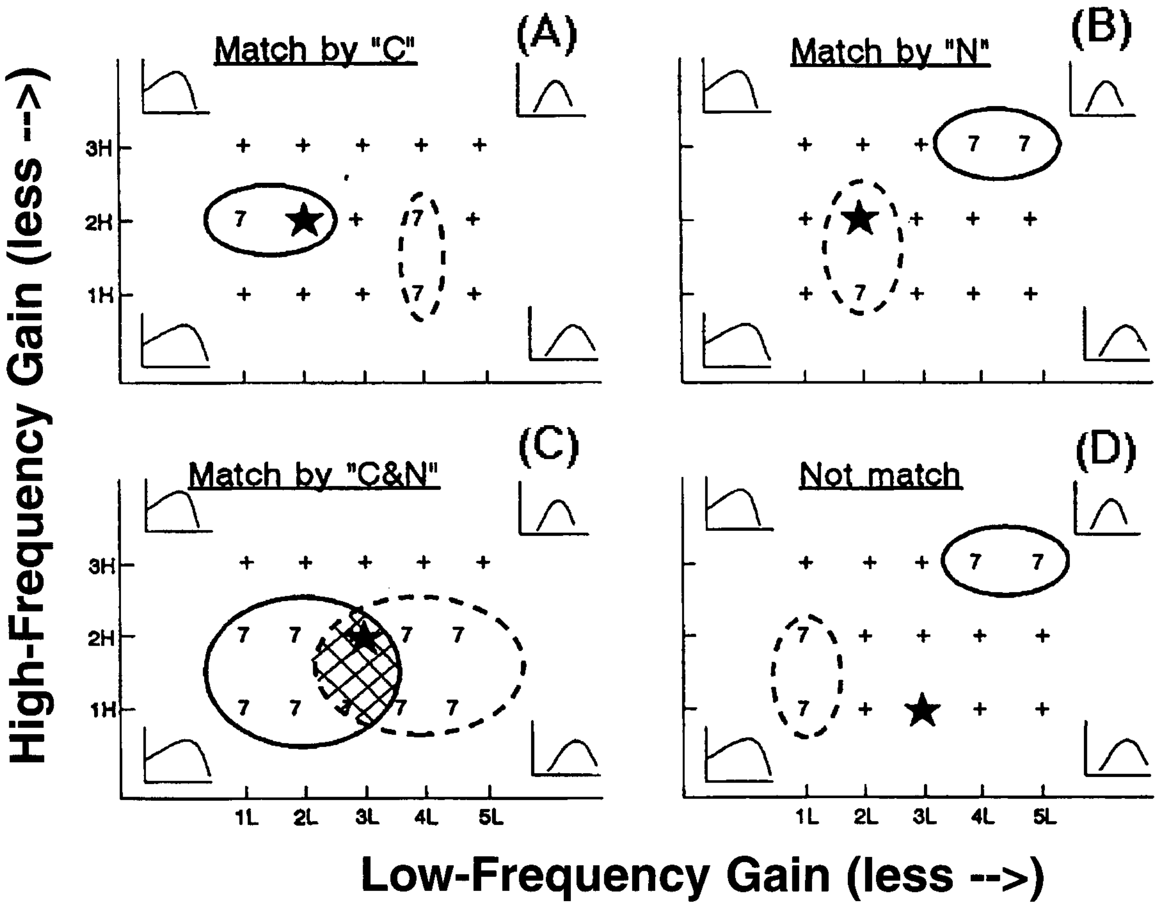

Figure 6 Different possible outcomes in which the preferred frequency gain settings selected by modified simplex (★) can match to the peaks of subjective response surfaces defined by (A) clarity (C), (B) noise (N), (C) clarity and noise interference (C & N), and (D) neither clarity or noise ~(C or N).

least for clarity and noise interference ratings, may allow evaluation on specific subjective attribute, but may be insensitive to the magnitude of changes in frequency responses available in this study.

The use of multiple criteria in category rating may improve the selectivity of category rating by restricting the number of frequency gain settings that yield the highest ratings under all criteria. This is seen in Figure 5, where as many as six subjects showed a narrow unimodal peak when the criterion was clarity and noise. The obvious difficulty with multiple criteria is the time involvement for response collection under different criteria and the display of such responses. Computer interface will certainly facilitate data collection and presentation in the future. On the other hand, use of multiple criteria will not reduce the number of preferred frequency gain settings if the preferred settings under each criterion do not overlap. This is seen in one subject in the 65/60 and 63/63 conditions and two subjects in the 65/60 condition.

An alternative to using multiple criteria to select one preferred setting on a hearing aid is the use of paired comparison (i.e., modified simplex procedure). The forced-choice nature of the procedure ensures that one and only one frequency gain setting is selected. Previous studies have shown that this technique is reliable (Kuk and Pape, 1992; Stelmachowicz et al, 1994) and likely yields frequency gain settings that are as good as, if not better than, that recommended by the NAL-R prescriptive formula (Kuk and Pape, 1993; Kuk, 1994). The high instance of matches between simplex-selected settings and those identified as common to both clarity and noise interference further confirms that it is a valid approach to compare the relative preference for frequency gain settings.

One of the assumptions behind the modified simplex (and, for that matter, category rating

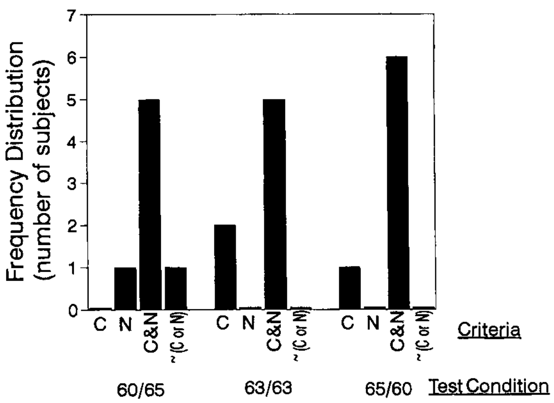

Figure 7 Frequency distribution showing the number of subjects whose preferred frequency gain setting selected by the modified simplex procedure matches the peaks of their subjective response surfaces defined by the criteria of clarity (C), noise (N), clarity and noise (C & N), and neither clarity nor noise ~(C or N).

when used to select one frequency gain setting of a hearing aid) is that the subjective response surface must show only one frequency gain setting with the best performance/preference. However, Figure 5 shows that a majority of subjects did not meet this requirement. A possibility is that the response surface generated from category rating of clarity alone (or of noise interference alone) is not the same as that generated from the modified simplex using clarity judgment as criterion. Rather, the response surface generated from the modified simplex procedure is probably generated as a result of several criteria. In this study, it may be from judgments of noise interference and clarity. This is seen in Figure 5 with the increased incidence of narrow unimodal peak using the dual criteria, and the high incidence of match between simplex-selected setting and the setting that represents overlap between clarity and noise ratings (Fig. 7).

These findings do not suggest that the modified simplex procedure is nonspecific in its recommendation (i.e., recommending a setting that is rated highly on both clarity and noise rather than clarity alone). On the contrary, the result of the modified simplex procedure can be very specific to the criteria used, provided that the criterion is sensitive to the available electroacoustic changes. A previous report (Kuk, 1990) using the modified simplex technique demonstrated that the preferred insertion gain for self-vocalization is markedly different from that for optimal listening. In this study, the match between simplex-selected setting and that selected under clarity and noise and not noise alone also supports its specificity. It is possible that the result may match to clarity better if the frequency settings produce greater differences in clarity or if no noise is used in subjective measurement.

The observation that simplex-selected setting matches that of clarity and noise interference rating is not a limitation but an advantage of the method. This is because the simplex-selected setting should normally result in the highest clarity rating, yet this method can also detect fine differences among frequency settings when such differences may not be detected by category ratings. The sensitivity of paired comparison judgment to small differences in electroacoustic characteristics and its relative freedom from ceiling effect have been reported by many investigators (e.g., Zerlin, 1962; Byrne and Parkinson, 1987; Studebaker, 1992). This study confirms that other criteria that are unspecified by the experimenter may be involved in the finer discrimination.

These results would suggest that, despite specific instruction to judge on the basis of clarity, subjects based their decisions during the modified simplex procedure on their overall preference for the particular frequency setting. This is suspected because Kuk and Tyler (1990) showed that the overall preference for a hearing aid in noise is dependent on its quality and the amount of perceived noise. This response behavior will probably have little effect on the clinical use of the modified simplex because, in most hearing aid selection, one is interested in the hearing aid setting that yields the best overall performance. On the other hand, its use to evaluate the preferred hearing aid setting under different response criteria may be more limited because subjects may use additional criteria to guide their decisions. A solution is to ensure that all of the comparison settings are discriminable and distinct under the particular response criterion prior to performing the modified simplex procedure. More work is needed to identify the discriminable intervals for various response criteria (e.g., intelligibility, clarity, etc.) and stimulus factors that may affect the choice of additional response criteria.

In summary, this study suggests that the modified simplex procedure would be a more desirable tool than category rating to select the best electroacoustic setting on a hearing aid. Its time efficiency and ability to converge at one setting despite similar preference for multiple settings are some of its major advantages. To minimize variability among subjects, one may instruct subjects to use a criterion of overall preference or clearest speech with least interfering noise in the clinical application of this technique.

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APPENDIX A

Descriptors for Each Subjective Interval

Clarity

1. extremely unclear, unacceptable, intolerable
2. very unclear, unacceptable, tolerable
3. mildly unclear, unacceptable, tolerable
4. slightly unclear, acceptable, tolerable
5. mildly clear, acceptable, tolerable
6. very clear, acceptable, tolerable
7. extremely clear, acceptable, tolerable

Noise Interference

1. extremely noisy, unacceptable, intolerable even for a brief moment
2. very noisy, unacceptable, intolerable
3. noisy, unacceptable, barely tolerable
4. moderately noisy, unacceptable but tolerable
5. some noise — easy to notice, acceptable, tolerable
6. some noise — difficult to notice, acceptable, tolerable
7. no noise, acceptable, tolerable