How consumers perceive the differences in the two types of hearing devices

A subjective evaluation of K-AMP™ vs. linear hearing aids

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The K-AMP™ hearing instrument is described by manufacturers as a high-fidelity hearing aid which amplifies quiet sounds, while allowing loud sounds to pass through unamplified. This study measures the subjective evaluation of 40 experienced hearing instrument wearers after they wore K-AMP instruments for two weeks. The subjects were asked to evaluate how well K-AMP instruments and their current instruments performed in several listening situations. When asked their preference between instruments, 55% preferred the K-AMP hearing instruments, 27.5% preferred their current instruments and 17.5% indicated no preference. Implications of the results are reported.

A common complaint of hearing instrument wearers is difficulty understanding conversation in noisy situations. Linear hearing aids amplify speech and noise equally well and do not take into account the phenomenon of loudness growth that is common to many with sensorineural hearing loss. The use of binaural fitting, directional microphones, moving physically nearer to the speaker and multiple, fixed frequency responses in conventional hearing aids have been shown to be effective nonadaptive processing approaches to noise reduction.[11]

In recent years, many efforts have been made to manufacture adaptive processing circuitry that efficiently addresses the signal-to-noise problem. These include compression limiting, variable compression threshold, pre-filtering, post-filtering, frequency independent compression, directional microphones and etymotic frequency response.[1,10] The reader is referred to an excellent review of adaptive processing in noise reduction hearing aids by Sammeth and Ochs.[11]

Automatic signal processing (ASP) circuits have been described as a means to sort speech from noise.[1,3,5,7,8,12,13] A common problem occurs when compression results in the reduction of gain at all frequencies, so that the intelligibility of soft speech sounds is reduced. Hall and Jacobs[2] point out, "The limitation of ASP circuitry is that it does not address the different gains and output requirements of a hearing impaired patient at various pitches as the dynamics of a listening situation change" (page 16).

A common hearing loss configuration results in normal or near-normal hearing in the low frequencies, but a significant decrease in hearing for the higher frequencies. ASP circuits that reduce the gain of low frequency signals may not be maximally beneficial for this type of configuration.

The K-AMP™ hearing aid is designed for hearing instrument wearers with mild-moderate and/or sharply sloping high frequency losses who require greater gain for quiet sounds than they do for loud sounds. It also is intended for those desiring good sound quality.

The K-AMP amplifier provides high frequency gain for lower input levels, since the hearing loss for soft sounds is typically greater at high frequencies. Killion, Staab and Preves[7] describe the K-AMP with the acronym TILL (Treble Increases at Low Levels). The treble response is automatically reduced for higher input levels.

Manufacturers claim that the K-AMP circuitry is good for patients with tolerance problems, for patients whose listening environments vary constantly or for patients who are often in listening environments where loud noise is present. Overall gain is automatically reduced for high-level inputs, preventing audible distortion under all listening conditions. According to Killion[6], "The K-AMP was designed to work without distortion up to 110-115 dB SPL inputs. Many hearing aid circuits are designed to operate only to 90 dB SPL even at minimum volume control setting. However, many sounds peak at higher levels than 90 dB SPL, making distortion a problem" (page 38).

The frequency range of the K-AMP instrument is from 100 to 14,000 Hz depending on the specifications of the manufacturer. This ability to choose wide bandwidth, in combination with reduced distortion, is intended to enhance speech intelligibility in many listening situations. Various trimpots are available on K-AMP instruments to provide for different fittings. A low frequency cut trimpot can be adjusted to reduce the low frequency gain of the output circuit. A threshold knee trimpot serves to prevent feedback in heavily vented fittings. The threshold knee trimpot, however, may limit gain in quiet settings and subsequently not take advantage of the dynamic range compression capabilities of the instrument. A tone switch is also available on some models to provide a user-controllable low frequency cut in the microphone input circuit. There is a 15 dB gain available in an active circuit in a quiet room that may sound like "circuit noise" to patients with normal hearing in low frequencies. When more ambient noise is introduced to the listening situation, this "circuit" noise is no longer noticeable. Adjustment of venting or of a threshold knee trimmer can help to reduce this "circuit noise." The K-AMP aid also contains a low-battery warning that provides a quiet, low motorboating sound which becomes louder and faster as the battery voltage drops below proper operating value.

Methodology

This study used a one page, four-point-index (poor, fair, good and excellent) questionnaire asking respondents to compare the overall performance and clarity of the K-AMP (questions 9 and 10) in eight listening environments (questions 1 - 8) to the performance of their current hearing aids. (See Appendix). Forty experienced (at least two years of experience) hearing instrument wearers were selected from patients at the Louisville Hearing Aid

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Center, Inc. in Louisville, KY, to use K-AMP instruments for a two-week trial period. All subjects in the study had sensorineural hearing loss. Speech discrimination was in the good or excellent categories (>/=76% in one or both ears) for 92.5 % (n = 37) of the subjects (Table 1).

The subjects' current hearing instrurments were working properly at the time of the study. None of the subjects indicated dissatisfaction with their current instruments prior to the K-AMP hearing aid usage period. Care was taken to not guide the subjects in stating their preference for the hearing aids. The manufacturers' procedures were followed in fitting the K-AMP instruments. The subjects were fitted with K-AMP instruments in the same format as they wore their current instruments. For example, those wearing a canal aid in the right ear were fitted with a canal K-AMP instrument in the right ear. Twenty-six were fitted binaurally and 14 monaurally. Twenty-one were fitted with Rexton K-AMP in-the-canal (ITC) type hearing aids and 19 with Qualitone QII K-AMP in-the-ear (ITE) instruments. The subjects were asked to evaluate how well the K-AMP instruments and their current instruments performed when listening to speech: 1) from a television, 2) at religious services, 3) in a restaurant, 4) in a theater or lecture hall, 5) in a car, 6) in a noisy room, 7) when listening to music and 8) when listening in a quiet environment.

The subjects were asked to rate the overall clarity of speech with each type of hearing aid and to rate the overall performance of each type of hearing aid. The subjects were requested to rate the performance of the hearing aids as poor, fair, good or excellent. They were also asked to indicate which they preferred, the K-AMP hearing aid or their current aid. Some questionnaires were not fully completed; hence, analyses for some questions include less than the total subject number.

Results and Discussion

The first three bars in Fig. 1 indicate that 55% (n = 22) of the respondents preferred the K-AMP hearing aids, 27.5% (n = 11) preferred their current instruments and 17.5% (n = 7) stated no preference between the K-AMP aid and their current instruments. A comparison of the canal and ITE instruments indicated that 57.8% (n = 11) of the canal wearers preferred the K-AMP instruments, 31.6% (n = 6) preferred their current instruments and 10.2% (n = 2) indicated no preference. Fifty-two percent (n = 11) of the ITE hearing aid wearers preferred K-AMP instruments, 23.8% (n = 5) preferred their current instruments and 23.8% (n = 5) indicated no preference. These similarities in responses for canal and ITE wearers indicate that type of instrument may not influence the preference for the K-AMP hearing aid.

Binaural wearers preferred K-AMP instruments more often than those fitted monaurally. All subjects in the study would have benefitted from an initial binaural fitting because of the degree of their hearing loss. However, several did not desire to use two hearing aids. Many studies have shown the advantages of binaural fittings in improving speech intelligibility in noise[4,9]. It is suspected that the lack of a strong response in favor of K-AMP instruments for the monaural wearers is due to their not receiving optimal benefit from amplification. Sixty-one percent (n = 16) of those fitted binaurally (n = 26) preferred the K-AMP aids, 23.1% (n = 6) preferred their current hearing aids and 15% (n = 4) indicated no preference. Of those fitted monaurally (n = 14), 42.8% (n = 6) preferred the K-AMP instruments, 35.7% (n = 5) preferred their current instrument and 21.5% (n = 3) indicated no preference.

The K-AMP instrument was rated excellent or good by at least 63% of respondents in each listening situation except speech in a noisy room (43.6%; n = 17) (See Fig. 2). Although this rating was lower for K-AMP hearing aids, only 12.8% (n = 5) rated their current instruments as excellent or good in this

Patient audiometric data, hearing aid type and preference

	250	500	1000	2000	4000	8000	WRS	TYPE	PREF.
S1 R	40	35	40	40	50	85	92	ITE	NONE
L	40	35	40	50	50	80	92	ITE	
S2 R	20	20	40	45	60	70	88	ITE	NONE
S3 R	15	5	10	50	60	30	92	ITE	CURRENT
L	25	10	15	50	60	35	92	ITE	
S4 R	15	30	45	60	70	60	96	CANAL	K-AMP
S5 R	10	20	35	70	70	70	88	ITE	K-AMP
L	25	25	45	60	75	70	80	ITE	
S6 R	20	45	65	70	75	65	64	ITE	K-AMP
L	75	75	80	75	60	65	64	ITE	
S7 R	20	45	55	70	65	75	68	CANAL	K-AMP
L	15	45	50	60	65	85	84	CANAL	
S8 R	20	30	40	55	80	NR	72	ITE	NONE
L	30	45	65	65	80	70	76	ITE	
S9 R	30	20	35	35	65	85	88	ITE	K-AMP
L	25	20	45	50	70	70	76	ITE	
S10R	25	35	35	50	55	75	96	CANAL	K-AMP
L	25	40	45	55	50	75	92	CANAL	
S11R	25	30	40	55	75	70	72	ITE	K-AMP
L	25	35	50	50	70	80	84	ITE	
S12R	30	30	65	95	70	80	52	ITE	CURRENT
L	30	35	70	70	65	70	84	ITE	
S13R	40	35	50	65	65	75	76	ITE	K-AMP
L	50	50	50	55	50	65	80	ITE	
S14L	30	45	30	65	70	80	68	ITE	K-AMP
S15R	15	20	55	70	65	80	64	ITE	K-AMP
L	10	15	55	75	70	NR	76	ITE	
S16R	30	40	50	55	65	80	88	ITE	NONE
S17R	25	30	40	40	55	55	96	CANAL	K-AMP
S18R	35	35	35	55	75	75	80	CANAL	NONE
S19R	35	40	40	65	70	NR	80	ITE	K-AMP
L	25	45	45	70	100	NR	72	ITE	
S20L	45	45	45	45	55	80	96	CANAL	CURRENT
S21L	30	45	65	80	85	80	84	CANAL	K-AMP
S22R	40	40	55	55	70	NR	60	ITE	CURRENT
L	30	30	50	55	75	75	52	ITE	
S23R	50	50	45	35	30	45	92	CANAL	K-AMP
L	45	45	55	55	75	75	80	CANAL	
S24R	40	45	60	50	60	80	84	CANAL	NONE
L	35	35	40	55	55	75	88	CANAL	
S25R	10	15	10	30	55	NR	88	CANAL	K-AMP
L	15	15	25	55	75	70	96	CANAL	
S26R	40	40	30	35	55	45	100	ITE	K-AMP
S27L	25	25	55	65	65	70	76	ITE	CURRENT
S28L	25	45	45	50	70	85	88	CANAL	CURRENT
S29L	40	45	40	30	50	65	100	CANAL	CURRENT
S20R	40	40	45	45	65	60	96	CANAL	K-AMP
L	35	35	40	50	75	65	100	CANAL	
S31R	25	30	50	50	55	55	84	CANAL	CURRENT
L	20	30	45	50	45	85	80	CANAL	
S32R	5	5	15	55	105	NR	84	ITE	NONE
L	5	10	15	80	95	NR	64	ITE	
S33R	25	20	45	50	65	75	96	CANAL	K-AMP
L	15	20	45	60	60	70	80	CANAL	
S34R	20	40	40	35	55	80	88	CANAL	CURRENT
L	35	55	45	35	60	70	92	CANAL	
S35R	15	20	40	30	60	60	92	CANAL	K-AMP
S36R	60	55	65	60	65	70	84	ITE	CURRENT
L	45	65	60	60	65	70	72	ITE	
S37R	25	35	40	40	55	65	84	ITE	K-AMP
L	25	30	40	40	50	50	96	ITE	
S38L	35	45	55	45	50	85	96	ITE	CURRENT
S39R	40	60	60	75	75	65	80	CANAL	K-AMP
L	25	50	55	65	65	60	80	CANAL	
S40R	30	35	25	65	80	75	84	ITE	K-AMP
L	20	20	20	65	65	NR	70	ITE	
MEAN	36.21	34.45	45.00	55.23	65.30	69.74	82.70		
SD	15.37	13.68	14.24	13.44	12.45	11.83	11.32		

Table 1. The mean audiometric data,word recognition scores and standard deviations for subjects of study.

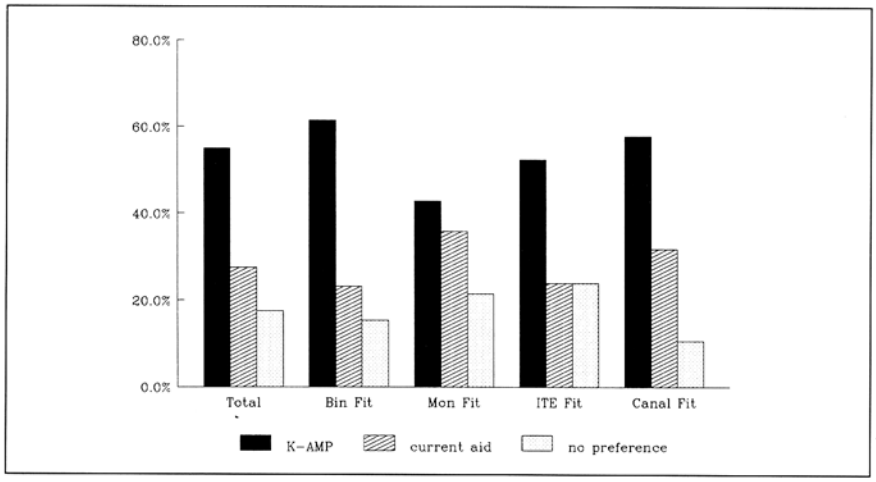

Fig. 1. Preferences of subjects for type of amplification: BIN-binaural, MON-monaural, ITE-in-the-ear.

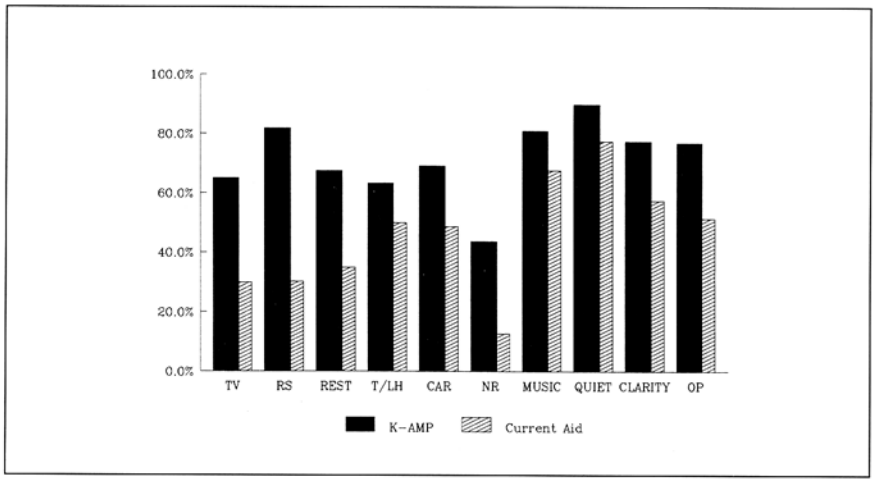

Fig. 2. Percentage of respondents rating K-AMP instruments and/or current hearing aids as excellent or good in various settings: TV-television, RS-religious services, REST-at a restaurant, T/HL-theater or lecture hall, CAR-speech in a car, NR-speech in a noisy room, MUSIC-listening to music, QUIET-single speaker in quiet, CLARITY-overall clarity of speech, OP-overall performance.

same listening environment. This suggests that the K-AMP aid provided better performance than their own hearing instruments in this situation, but still has limitations.

The strongest rating for the K-AMP hearing aid was listening to speech in quiet (90%; n = 36) rating of excellent or good). This was expected, but the rating for the current amplification was only 77.5% (n = 31), substantially lower than the rating for the K-AMP hearing aid.

According to the respondents, the K-AMP instrument seems to perform significantly better than their current hearing aids in restaurants and when listening to television. The excellent or good rating given for K-AMP aids in a restaurant was 67.5% (n = 27) and for the current hearing aids 35% (n = 14). Television listening was rated as good or excellent for the K-AMP instruments by 65 (n = 26) of the respondents and for their current instruments as 3% (n = 12).

Regarding the performance of the hearing aids in religious services, 27 of the 33 who responded (81.8%) rated the K-AMP instruments as excellent or good. Only 30.3% (n = 10) rated their current instruments as excellent or good in this listening situation.

Nineteen of the 30 subjects (63.3%) rated the performance of the K-AMP instruments as excellent or good in a theater or lecture hall. Half of the subjects rated their current instruments as excellent or good in these situations.

Twenty-seven of the 39 subjects (69.2%) who responded to the question about listening to speech in a car rated the K-AMP instruments as excellent or good, and 48.7% (n = 19) rated their current hearing aids as excellent or good in this situation.

Although only 43.6% (n = 17) of the 39 subjects who responded rated the K-AMP hearing aids as good or excellent when listening to speech in a noisy room, the response was significantly better than for the current hearing aids. Only five (12.8%) rated their current instruments as excellent or good for this category.

Thirty of the 37 subjects (81.1%) rated the K-AMP hearing aids as excellent or good, and 67.6% (n = 25) rated their current instruments as good or excellent when listening to music.

In evaluating the clarity of the instruments, 77.5% (n = 31) rated K-AMP aids as excellent or good, while 57.5% (n = 23) rated the clarity of their current amplification as excellent or good.

Only 35 of the 40 subjects rated the overall performance of the two types of hearing aids. Seventy-seven percent (n = 31) rated the K-AMP instruments as excellent or good and 51.4% (n = 18) rated their current hearing instruments as excellent or good.

Conclusions

The subjective acceptance of amplification by those with hearing loss is of great concern to hearing health care professionals. The possibility of functioning comfortably with adequate amplification in many social settings is a vigorously pursued goal of the hearing-impaired population. The development of amplification systems that effectively address the signal-to-noise problem is continually sought by researchers. The recent manufacture of K-AMP circuitry is an effort to provide clarity of speech in noisy situations. The reduction of distortion and increase in comfortable listening at high input levels may be the major benefit of the K-AMP circuitry rather than actual improvement in the signal-to-noise ratio. ❐

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