The Journal of Laryngology and Otology
June 1991, Vol. **105**, pp. 405–408

Randomized, cross over study to assess patient preference for an acoustically modified hearing aid system

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Abstract

It seems reasonable to postulate that if a patient has a hearing impairment at particular frequencies, selective amplification at those frequencies would be an advantage. Attempts have been made in the laboratory to show that when this is done scores on various audiometric tasks will improve. Whether such laboratory benefit will be preferred by patients in their daily life is another matter. Despite a lack of knowledge on this subject, modifications are frequently made to a hearing aid system in the expectation that this will improve auditory performance and hence be preferred by the patient. The most common modifications made to an ear level aid in the British National Health Service are adjusting the tone control and venting the ear mould with the aim of emphasizing the higher frequencies.

A randomized crossover study was carried out in 83 first time hearing aid users with a mild to moderate hearing impairment to assess whether a hearing aid at the 'H' tone setting and with a 2 mm vented mould would be preferred by those with a more marked high frequency impairment. BE series aids were used so that any findings could be directly translated to NHS practice.

No consistent preference for the modified system was identified when patients were subgrouped according to the overall slope (0.5 to 4 kHz) of their audiogram. However, when the slope between 0.25 and 1 kHz, which corresponds to the real ear effect of these modifications, was analyzed patients with a slope at these frequencies preferred the high-tone emphasis system ($p<0.005$). A second but lesser predictor of preference was age, those under 66 years preferring a modified and those over 69 years preferring an unmodified system ($p<0.05$).

These findings need to be confirmed using different methods of altering the frequency response. What acoustical effect these achieve in a specific patient need to be confirmed using 'in the ear' measures before any preference they might have can be related to the configuration of their audiogram.

Introduction

When a patient has a hearing impairment that is more marked at some frequencies than others, it might be expected that greater amplification of those frequencies would be preferred. As the higher frequencies are those more commonly affected in patients with a predominantly sensorineural impairment, the most frequent modifications attempt to produce high-tone emphasis. Indeed, the majority of hearing aids have a rising rather than a flat frequency response curve and it is the exaggeration of this rise that is often attempted. This can be achieved in several ways but when a British NHS aid is being provided the most frequent modifications, singly or in combination, are adjusting the tone control of the aid to the 'H' setting and venting the earmould with a vent greater than 1 mm in diameter (Lybarger, 1985). Unfortunately 'in the ear' measures of the effect of these modifications are highly variable, most likely because of the differing anatomy of the canal. In addition, the effect is mainly below 1 kHz (MacKenzie and Browning, 1989). Whether such modifications give benefit and are preferred by patients is unknown.

The main way of assessing benefit is to compare a patient's performance on various audiometric tests with different hearing aid systems. The main problem with this is the difficulty in being able to demonstrate a significant difference between two broadly appropriate aids (Walden *et al.*, 1983). Patient preference for, rather than benefit from, a particular system can be elucidated in the clinic following a short listening period. This was perhaps the most frequent way in which commercial aids were provided before 'in the ear' assessments of the frequency response became more available. In such circumstances the reproducibility of choice is likely to be low, considering other factors such as size and design are likely to have a major influence. The more appropriate way would be to allow patients to compare the performance of the aids being considered in different listening conditions in daily life. Although this method has been used to assess patient preference for monaural versus binaural amplification (Erdman and Sedge, 1981) and side of hearing aid provision (Swan *et al.*, 1986), there have been no reports which have used this method to investigate patient preference from modifications to a hearing aid system.

The relationship between acoustic benefit and patient preference is not straightforward. It could be argued that though a particular hearing aid system might perform better, a period of adjustment to what might

Accepted for publication: 23 February 1991.

https://doi.org/10.1017/S0022215100116159 Published online by Cambridge University Press

initially appear an unusual sound would have to occur before the patient came to prefer it. There is now some evidence (Gatehouse, 1990) that adapting to an aid does occur with time. It is also known that even if a particular aid is likely to give a superior performance other factors, particularly cosmesis, are as likely to influence which aid a patient chooses. The historical example of this is that high powered body aids were rejected by the severely impaired and preference given to lower powered, ear level aids when these were introduced. A more relevant example to the current context is the preference for a vented mould because of comfort (MacKenzie *et al.*, 1989).

In the United Kingdom the majority of aids are provided through the National Health Service (NHS) and are thus BE series aids. Unlike commercial aids, where a wide variety of frequency responses are available, the BE aids within a series are virtually identical. The only modifications that can be made to the frequency response is by choosing between an 'N' and an 'H' tone setting. Even this does not greatly alter the frequency response, but there is also the possibility of acoustically modifying the earmould, the horn and the tubing. Venting of the earmould is the most common of these to be used.

How best to adjust the response of a BE system has never really been studied and prescription strategies based on commercial systems are obviously not translatable to NHS practice because of the more limited options available. Experienced technicians and audiological scientists have for many years recommended that high-tone emphasis be given to patients with a sloping as opposed to a flat pure tone audiogram. Although at present the implementation of such a tailoring provision policy is not time consuming it could become so once 'in the ear' methods of tailoring the frequency response become more widely available. Hence it seemed reasonable to subject a common NHS provision policy to scientific study. A crossover study of a modified hearing aid system to give high-tone emphasis with an unmodified one was carried out in an unselected group of naive, mild to moderate hearing impaired individuals, to see whether after a period of use in daily life their preference between these two aids was related to the configuration of their audiogram.

Patients and Methods

Eighty-three patients (44 male, 39 female; mean age 69 years, range 42–83) with a mild to moderate hearing impairment (pure tone average over 0.5, 1, 2 and 4 kHz between 25 and 70 dB HL) in their better ear were studied. Each had been referred to an NHS clinic for assessment of their hearing and was considered likely to benefit from the provision of a monaural hearing aid. Clinical assessment and pure tone audiometry were carried out using the recommended procedures of the British Society of Audiology, (1981), in a sound-proofed booth using masking where necessary (Coles and Priede, 1970). The side chosen for the aid was the poorer hearing ear, if any (Swan *et al.*, 1986), provided the speech frequency average in that ear was less than 70 dB HL. Otherwise an ear was chosen by consultation with the patient. An impression was taken from that ear from which two identical hard acrylic shell moulds were manufactured. One of these was then chosen at random to have a 2 mm parallel vent drilled in it, the other remaining non-vented.

TABLE I
PATIENT PREFERENCE OVERALL

Preference Rating	System preferred None	'H' system	'N' system
None	12	–	–
Little	–	12	23
Moderate	–	10	9
Large	–	8	9
Total	12	30	41

Although the patients were not to be fitted binaurally, two BE 14 (n = 76) or two BE 32 (n = 7) NHS aids were available for each patient. One of each pair of aids was adjusted to the 'H' setting with the other remaining unmodified at the 'N' setting. The gain characteristics of each aid were measured on a Bruel and Kjaer Acoustic Test Station to ensure that they were consistent with the manufacturers' specifications at both the 'N' and 'H' settings. The aid at the 'N' setting was then coupled, using standard acoustic tubing, to the non-vented earmould and henceforth will be called the unmodified or 'N' system. The aid at the 'H' setting was coupled, using standard acoustic tubing containing a Knowles smoothing filter, to the 2 mm parallel vented earmould which subsequently is called the high-tone emphasis or 'H' system.

It was explained to the patients that they would be trying out two different aids, distinguishable by coloured dots on the casing, to find out which system they preferred. Each aid was randomly issued, twice for two weeks, over an eight week period the sequence being NHNH or HNHN. At the end of the eight week period the patients were asked which system they preferred, if any, for hearing and if there was a difference, to rate it as a little, a moderate or a large amount.

Results

Overall 86 per cent (71 of 83) of the patients stated a preference for one of the hearing aid systems. Of these 30 (42 per cent) preferred the high-tone emphasis and 41 (58 per cent) the unmodified system, 42 per cent rating the difference between them as a little, 23 per cent a moderate and 21 per cent a large amount (Table I). There was no order effect between first choice for hearing and the sequence of aid issue.

As it might be expected that patients with a generally sloping audiogram would prefer the high-tone emphasis system, the relationship between the audiometric characteristics of the 83 ears fitted and the patients' preferences was investigated. The overall slope of each patient's audiogram was calculated over the four frequency range (0.5 to 4 kHz) using the formula:

$$\text{slope} = \frac{{}^{T}4\,\text{kHz}^{+T}2\,\text{kHz}^{-T}1\,\text{kHz} - {}^{T}0.5\,\text{kHz}}{2}$$

These were then plotted against the pure tone average for those that preferred the high tone and those the unmodified system. No difference in the distribution was apparent which also held for those who expressed a moderate or large preference for a specific aid.

https://doi.org/10.1017/S0022215100116159 Published online by Cambridge University Press

TABLE II

MEAN SLOPE ACROSS VARIOUS COMBINATIONS OF FREQUENCIES OF THOSE PATIENTS PREFERRING A HIGH-TONE EMPHASIS SYSTEM AND THOSE PREFERRING AN UNMODIFIED SYSTEM

Frequency (kHz)	Mean slope of those preferring a high-tone emphasis system	Mean slope of those preferring an unmodified system	p value
1–0.25	+5.8	−1.7	<0.05
1–0.5	+8.5	−1.2	<0.001
1–0.25/0.5	+7.2	−1.5	<0.005
2–0.25	+8.7	+7.7	N.S.
2–0.5	+11.3	+8.2	N.S.
2–0.25/0.5	+10.0	+7.9	N.S.
4–0.25	+26.3	+21.5	N.S.
4–0.5	+29.0	+22	N.S.
4–0.25/0.5	+27.7	+21.7	N.S.

However, when the slope was analyzed as the difference between the thresholds at combinations of two different frequencies, significant correlations with aid preference emerged (Table II). Using parametric and non-parametric analyses, the mean slope between 0.25 or 0.5 and 1 kHz was significantly greater in those stating a preference for high-tone than for those choosing the unmodified system. If frequencies at ≥2 kHz are included in the slope calculation, then patient preference becomes unrelated to the slope.

When the patients are subdivided into those younger and older than the median age of 69 years, of those that made a choice, 50% (22 of 44) of younger patients preferred the high-tone emphasis system whereas 64% (25 of 39) of the older patients preferred the unmodified system ($P<0.01$). If the patients are further subdivided into four age bands (Table III) it was only those between 66 and 69 years of age that had no preference ($p<0.01$).

If a logistic regression analysis is performed with preference as the dependent variable and age and slope of the pure tone audiogram at 0.25 and 1 kHz as the independent variables, there is still a significant effect of age ($p<0.05$) after the effects of slope have been entered into the stepwise regression. This indicates that preference is primarily influenced by the slope between 0.25 and 1 kHz with age having a secondary effect.

The sex of the patient had no effect on the distribution of preferences in any of the analysis.

Discussion

As the commonest form of hearing loss to be aided is a mild to moderate, high frequency sensorineural hearing impairment the most frequently used modifications to a hearing aid system aim at amplifying these frequencies.

Until now, who might find this 'high-tone emphasis' advantageous has, in the majority of cases, been determined by assessing the slope across all frequencies, and in those with a steep slope a hearing aid with some form of high-tone emphasis is prescribed, whilst the remainder receive an unmodified one. This study has demonstrated that patient preference for a combination of an 'H' setting and a 2 mm mould vent is not related to the overall slope of the pure-tone audiogram but is related to the slope between 0.25 and 1 kHz. Those choosing such a high-tone emphasis system have a greater slope than those choosing an unmodified system. Why exactly this should occur is unclear but it is between these frequencies that the combination of a 2 mm vent and the high-tone setting in the hearing aid have their maximal effect (MacKenzie and Browning, 1989). The most likely reason for this is that it allows patients with a steeply sloping audiogram to increase the amount of gain they use at higher frequencies. An interesting secondary influence on the patient preference is age, the younger age group preferring high-tone emphasis. Again, the exact reasons for this are unclear, however, it could be due to an improvement in speech discrimination in background noise caused by a reduction in low frequency babble. As such, the younger group, who are presumably more socially active, may find this of particular benefit.

TABLE III

PATIENT PREFERENCE SUBDIVIDED ACCORDING TO AGE (n = 83)

System preferred	Age years <66	66–69	70–74	>74
None	2	4	1	5
Unmodified 'N'	8	8	15	10
High-tone emphasis 'H'	13	9	3	5
Total	23	21	19	20

In conclusion, it is suggested that the slope of the pure tone audiogram between 0.25 and 1 kHz could act as a predictor of patient preference for the combination of H setting and 2 mm vented earmould in a hearing aid system. Both this and the apparent preference of the younger age group for these modifications requires further evaluation.

Acknowledgements

Elizabeth Lawson performed the audiometry and fitted the aids. Alastair Sword helped analyse the data. Dr Stuart Gatheouse gave valuable advice and criticism.

References

British Society of Audiology (1981) Recommended procedures for pure-tone audiometry using a manually operated instrument. *British Journal of Audiology,* **15:** 213–216.

Coles, R. R. A., Priede, V. M. (1970) On the mis-diagnoses resulting from incorrect use of masking. *Journal of Laryngology and Otology,* **84:** 41–63.

Erdman, S. A., Sedge, R. K. (1981) Subjective comparisons of binaural versus monaural amplification. *Ear and Hearing,* **12:** 225–229.

Gatheouse, S. (1990) Can you learn to love your hearing aid? *Clinical Otolaryngology.* in press.

Lybarger, S. F. (1985) Earmoulds. In: Katz J. (ed) Handbook of Clinical Audiology, 3rd Edition, Williams & Wilkins, Baltimore, 885–910.

https://doi.org/10.1017/S0022215100116159 Published online by Cambridge University Press

MacKenzie, K., Browning, G. G. (1989) The real ear effect of adjusting the tone control and venting a hearing-aid system. *British Journal of Audiology,* **23:** 93–98.
MacKenzie, K., Browning, G. G., McClymont, L. G. (1989) Relationship between earmould venting, comfort and feedback. *British Journal of Audiology,* **23:** 335–338.
Swan, I. R. C., Browning, G. G., Gatehouse, S. (1986) A cross-over study of side of hearing aid provision. *Clinical Otolaryngology,* **11:** 205–208.
Walden, B. E., Schwartz, D. M., Williams, D. L., Holum-Hardegen, L. L., Crowley, J. M. (1983) Test of the assumptions underlying comparative hearing aid evaluations. *Journal of Speech and Hearing Disorders,* **48:** 264–273.

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Key words: Hearing aid

https://doi.org/10.1017/S0022215100116159 Published online by Cambridge University Press