# A Tactual 'Hearing' Aid for the Deaf

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## 1. Introduction

Much work aimed at using the sense of touch, to at least partly overcome the effects of a profound hearing loss, is going on in several research facilities throughout the world. Almost all authors have shown that it is possible to convey acoustic information, including speech, via the skin. Spens (1980) in a comparative study of different tactile systems, has shown that the information conveying capacity of a tactile 'hearing' aid is significant even if the processing scheme is rather simple and the number of channels (vibrators) is restricted to one. One possible conclusion from that result is that it may not be worthwhile to wait for the development of the optimal tactile 'hearing' aid but rather to design a tactile aid which at least fulfills the two very important characteristics of: 1) being capable of conveying some important acoustic information and 2) being conveniently wearable and cosmetically acceptable. Wearability has so far been a feature which has not received highest priority. In order to make daily use of the aid possible, however, and to be able to collect long term evaluative data this is a necessary feature.

## 2. Description of the aid

The aid looks just like a conventional body-worn hearing aid (Fig. 1). It has a built-in microphone and uses batteries which last for about a week. The aid's circuitry, however, is very different from that of a conventional hearing aid. The aid is designed to extract the intensity (loudness) variations of sound and convert them into vibratory patterns. The aim of the processing system is to present an unambiguous representation of the syllabic patterns in speech. These patterns are felt via a small vibrator which is connected to the aid by a thin cord. The vibrator has been especially designed to match the vibratory capacities of the skin while using very little power. Most users of the aid prefer to wear the vibrator on their wrists although some use it hand-held while one subject has it mounted into an ear mould. This does not mean that he hears the signal but rather feels it through the skin in contact with the ear mould. Another option currently being investigated is to mount the vibrator onto a ring which is worn on the finger. One obvious advantage with the tactile aid is that there is no feedback problem. This is a critical factor when

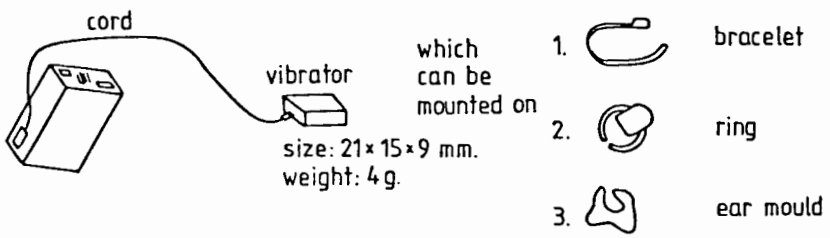


*Fig. 1.* The 'hearing' aid for deaf persons and different ways to stimulate the skin.

we take into consideration that many deaf persons have rejected hand-held bone conductor aids on the grounds that the feedback from such aids is potentially embarrassing to the hearing impaired person and disturbing to hearing persons.

### 3. Some preliminary results

At this time, approximately 15 deaf persons have had some experience with the aid for periods ranging from 3 to 20 months. Most of these are now wearing the aid on a daily basis. All but one of them has an acquired hearing loss. The prelingually deaf subject has a background of oral training and does not use sign language. Six of the subjects received special training for 2 hours weekly over a period of 12 weeks. This training was administered at a training center for deaf adults and was provided by 2 experienced teachers.

It is difficult to give a quantitative measure of the aid's effectiveness but the continued use of the aid by users indicates that they receive some net benefit from its use. Net benefit is defined as the sum of the positive and negative aspects of the aid. The positive aspects appear to be the perception of useful acoustic information while the negative aspect includes the inconvenience of wearing a technical aid. It appears that the aid's potential lies in three main areas:

1. a. The awareness of sounds in the environment.
   b. The detection of warning signals in the environment.
2. As a supplement to lipreading.
3. To provide information enabling the deaf person to monitor his/her own voice.

Both objective and subjective tests have been administered in an attempt to gain information on the advantages and disadvantages of the aid. The subjective evaluation consisted of a questionnaire which sought to obtain the deaf person's own perception of his/her handicap with and without the vibrotactile aid for the areas; environmental sounds, lipreading and voice monitoring. The scores obtained for the questionnaire are given in Table I. The scoring method used a 5-point scale ranging from 0-4 points, where 0 point corresponds to a situation of no perceived handicap. Thus the higher



*Table I.* Subjective rating of the handicap in the aided and unaided condition (N = 6). Results are given in % of the maximum value.

| | Unaided | Aided |
|---|---|---|
| Environmental sounds | 60,5 | 36,6 |
| Lipreading | 57,4 | 53,5 |
| Monitoring of own voice | 66,7 | 70,0 |

the score obtained the higher the subjects' own rating of his/her handicap. It can be seen that in the perception of environmental sounds and, to a lesser extent in lipreading, the subjects feel that the aid provides benefits. For the monitoring of the subjects' own voice, however, it appears that there are no differences between the aided and unaided conditions.

A further indication of the aid's value can be found in the written comments of those deaf persons currently using the aid. These include:

'The vibrator helps me to perceive more with less effort'.

'People say to me "You seem to be more confident" '.

'The rhythmic information helps me, especially when I am talking to persons who are difficult to lipread'.

'I enjoy being able to feel environmental sounds.....it helps me feel more in contact with the environment'.

'When you see a movie, theatre or TV the aid helps by telling me about those background sounds gunfire, cars, music etc. which are not captioned'.

'As far as environmental vibrations, it feels like a part of myself. (i.e., the subway door closing, or traffic noise, or the sound of the vacuum cleaner plus assisting me in my lipreading.)'

'The rhythm conveys the voice quality. A ring master uses one sort of rhythm while a teacher uses another, and an auctioneer sounds different to a news reader'.

'All of these things I take for granted until I take the aid off at night'.

Efforts to objectively evaluate the effectiveness of the aid was done for environmental sounds and for lipreading.

To measure the aid's ability to transmit environmental sounds, 2 sets of 5 common environmental sounds were presented. The sounds were first presented in a set order to familiarize the subjects with the test material. The sounds were then readministered in a random order and the subjects were asked to indicate which of the 5 had been presented. The mean scores obtained for both tests were around 80% correct which is a level well above that which could be attributed to chance (20%).

The subjects' lipreading ability with and without the vibrotactile aid was measured using two methods. Fig. 2a presents the results obtained in a lipreading test by normally hearing persons artificially deafened by the

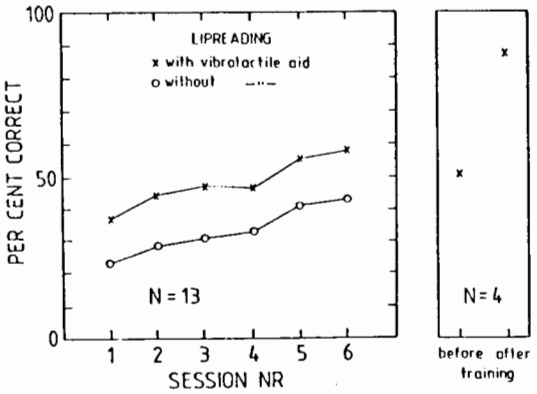


*Fig. 2.* a. Lipreading of sentences by artificially deafened normal hearing subjects with and without the vibrotactile aid. b. Lipreading of sentences by deaf subjects with the vibrotactile aid before and after training.

presentation of masking noise through headphones for the duration of the testing. These results highlight the value of the vibratory signal as a supplement to lipreading even with minimally trained subjects. Fig. 2b presents results obtained on a lipreading test by those deaf subjects who received special training. Both of these tests, however, used sentence materials and it was thought that a better measure of the aid's effectiveness would be obtained if material was used which more closely resembled every-day communication. The 'Tracking Technique' (De Filippo and Scott, 1978) was felt to most closely meet these demands. The method involves the reading of portions of a text to the deaf person and then asking them to repeat exactly what was said. Any deviations from the text are unacceptable and the phrase or sentence is repeated until it is repeated perfectly. This is a very difficult task which provides an extremely beneficial form of training. The material is presented for a set period of time, in this case 5 minutes aided and 5 minutes unaided, and the number of words correctly identified is calculated. This is then used to derive the number of words per minute perceived. Results obtained using this method with the training group are presented in Fig. 3. The results again show an improvement in the aided condition. It should be noted, however, that these are average results for the group and do not show individual differences between subjects. Some of the subjects appear to derive far more benefit from the aid than others. In all cases, however, the scores obtained with the aid were at least as high as those obtained in the unaided condition. All of these results indicate that the aid provides a positive support for lipreading.

These results indicate that the vibratory aid described in this paper provides useful information which help overcome, at least partially, some of the problems resulting from a profound hearing loss. Further research is needed which attempts to maximize the information available through a wearable vibrotactile aid.



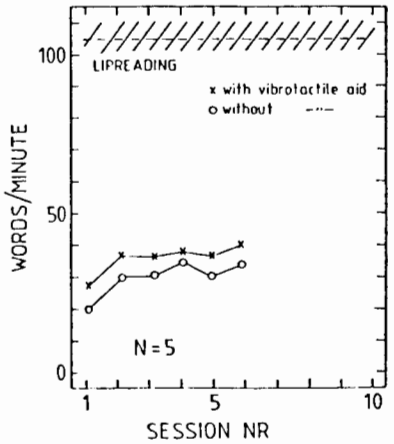


*Fig. 3.* Lipreading using the tracking technique by deaf subjects with and without the vibrotactile aid.

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