A tactual "hearing" aid for the deaf

Spens, K-E. and Plant, G.

journal: STL-QPSR
volume: 24
number: 1
year: 1983
pages: 052-056

http://www.speech.kth.se/qpsr
C. A TACTUAL "HEARING" AID FOR THE DEAF* 
K-E. Spens and G. Plant** 

Abstract  
This paper describes the development of a new wearable "hearing aid" for the profoundly deaf and initial results obtained with a group of deaf subjects. The aid transforms the sounds of speech and the environment into tactile patterns which are received by the skin.

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 circuit, however, is very different from that of a conventional hearing aid. The circuit is designed to extract the intensity (loudness) variations of sound and convert them into vibratory patterns. These patterns are felt via a small vibrator which is connected to the aid by a thin cord. The vibrator has been specially 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.

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 persons are now wearing the aid on a daily basis. All but one of these persons has an acquired hearing loss. The prelingually deaf subject has a background of oral training and does not use sign. Six of the subjects received special training for 2 hours weekly for a period of 12 weeks. This training was administered at a training center for deafened 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 those fitted 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

* Presented at the IX World Conf. of the Deaf, Palermo, July 1-6, 1983.  
the negative aspect includes the inconvenience of wearing any 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. 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 five point scale ranging from 4 points for a situation of no handicap to 0 points for maximal handicap. Thus the higher the score obtained the less the subject's own rating of his/her handicap. It can be seen that in the perception of environmental sounds and in lipreading the subjects feel that the aid provides positive benefits. For the monitoring of the subjects' own voice, however, it appears that there are no differences between the aided and unaided conditions.

<table>
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<th>Table I. Scores obtained on a subjective rating scale in the aided and unaided condition (N = 4).</th>
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<tbody>
<tr>
<td>Environmental Sounds</td>
<td>30</td>
</tr>
<tr>
<td>Lipreading</td>
<td>50</td>
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<tr>
<td>Monitoring of own voice</td>
<td>13</td>
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Tests of lipreading with and without the vibrotactile aid have also been undertaken. Fig. 2a presents the results obtained in a lipreading test by normally hearing persons artificially deafened by the 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 materials were used which more close-
ly replicated every-day communication. The "Tracking Technique" (De Filipp 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 word 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.

A measure of the aid's ability to transmit environmental sounds was also attempted. This consisted of 2 sets of 5 common environmental sounds. The sounds were first presented in a set order to familiarize the subjects with the test material. The sounds were then represented in a random order and the subjects 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.

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".

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.

Acknowledgements

We would like to express our sincere appreciation to Birgit Ossian-Grubbström, Director of the Pedagogical section of the Audiological Department of Södersjukhuset, and Teacher of the Deaf Birgitta Rollven for providing the training procedures which have enabled us to gain a more complete knowledge of the use of the vibrotactile aid by deaf persons.

The vibrotactile aid will in a very short future be manufactured and marketed by Special Instrument AB, box 27066, 102 51 Stockholm, Sweden.

Reference