

Efficacy of directional-microphone hearing aids

SUMMARY

Agence d'évaluation des technologies et
des modes d'intervention en santé

Québec 

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Technical note prepared for AETMIS
by François Bergeron

Original French version: May 2003
English translation: July 2003

This report was translated from an official French publication of the Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS) by Jocelyne Lauzière, MA, trad. Both the original document, titled *Efficacité des prothèses auditives à microphones directionnels*, and its English version are available in PDF format on the Agency's Web site.

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How to cite this report:

Agence d'évaluation des technologies et des modes d'intervention en santé (AETMIS).
Efficacy of directional-microphone hearing aids. Technical note prepared by François Bergeron.
(AETMIS 03-03). Montréal: AETMIS, 2003, x-23 p.

Legal deposit

Bibliothèque nationale du Québec, 2003
National Library of Canada, 2003
ISBN 2-550-41049-1

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FOREWORD

EFFICACY OF DIRECTIONAL-MICROPHONE HEARING AIDS

As part of the review of the *Programme d'aides auditives*, the *Ministère de la Santé et des Services sociaux* formed an advisory group mandated to recommend appropriate amendments to ministry officials. The work of the subcommittee on new technologies led the group to ask the *Agence d'évaluation des technologies et des modes d'intervention en santé* (AETMIS) to rule on the clinical efficacy of directional-microphone hearing aids.

Difficulty understanding speech in the presence of noise is a common cause of users' dissatisfaction with hearing aids. Several technological approaches have been explored to offer hearing-impaired people better listening ability in noisy environments. Work on microphone directionality has pursued this goal.

According to AETMIS's evaluation, the few studies presenting an intermediate level of evidence allow us to classify as "experimental" technologies both single-microphone solutions and approaches based on a microphone array. These solutions appear promising but further controlled trials will be required to confirm their efficacy.

Dual-microphone approaches can be considered "accepted" technologies but only in optimal listening conditions, when the speaker and the noise are diametrically opposite each other in environments with low reverberation. The application of this technology in other conditions reduces (sometimes significantly) their effectiveness. Finally, eligibility requirements for devices with the directionality option must take into account the candidate's physical and cognitive abilities to use the directional properties effectively.

In submitting this report, AETMIS wishes to provide decision makers in the Québec health-care system with the necessary information to offer appropriate services to people with a hearing loss.

Renaldo N. Battista

President and chief executive officer

ACKNOWLEDGMENTS

This technical note was prepared at the request of the *Agence d'évaluation des technologies et des modes d'intervention en santé* (AETMIS) by **François Bergeron**, PhD, audiologist, assistant professor, Département de réadaptation, Faculté de médecine, Université Laval, and associate researcher, *Centre interdisciplinaire de recherche en réadaptation et intégration sociale* (CIRRS). We would like to express our sincere appreciation for his work.

The author also received the unflagging support of a working group who read and commented on the different drafts of this report. We would like to thank each of the members of this group, namely:

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AETMIS also thanks the external reviewers whose many comments helped improve the quality and content of this report.

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SUMMARY

Origin of the request for evaluation

Since 1979 the *Ministère de la Santé et des Services sociaux* (MSSS) has offered a program giving free access to hearing devices to Québec residents with a hearing loss. Administered by the *Régie de l'assurance maladie du Québec*, this program has since undergone several changes in both its coverage and its eligibility requirements. Initially limited to hearing aids for people up to the age of thirty-five, the program now includes a wide range of hearing devices available to people of all ages.

To take into account technological advances and to better meet people's needs, the MSSS formed an advisory group mandated to review this program and to recommend appropriate amendments to ministry officials. The work of the subcommittee on new technologies led the advisory group to ask AETMIS to rule on the clinical efficacy of multi-microphone hearing aids.

Description of hearing aids

Deafness is essentially manifested by a reduced ability to perceive acoustic signals in the environment. Even when audibility has been restored by means of a hearing aid, people with hearing impairment need better listening conditions than people with normal hearing to perform well on speech-intelligibility tasks. Difficulty understanding speech in the presence of noise is a common cause of users' dissatisfaction with hearing aids, irregular use and disuse. Several technological solutions have been explored to offer hearing-impaired people better listening ability in a noisy environment. Work on microphone directionality has pursued this goal.

The application of the principles of directionality to hearing aids offers the possibility of improving the signal-to-noise ratio (SNR) even when speech and noise are similar. This solution is especially relevant when speech and noise come from sources that are spatially separate. In theory, omnidirectional microphones pick up sounds equally from all directions, as opposed to directional microphones

that respond more to sounds emitted from a specific direction. Applied to deafness, directionality targets sounds coming from the front, that is, where a speaker would normally be.

The first directional microphones were incorporated into hearing aids at the beginning of the 1970s. By 1980 they represented nearly 20% of all manufacturers' sales. The popularity of in-the-ear hearing aids, along with distributors' scepticism, later led to a gradual decline in the demand for this approach. Newer technological prospects, particularly miniaturization, as well as advances in electronic and digital signal processing, have recently renewed researchers' interest in hearing-aid directionality.

Analysis of scientific data

The literature-search strategy for querying the databases located seventeen articles dealing with directional hearing aids in the last decade. Nineteen supplementary documents were obtained from the expert group or taken from the bibliographic references cited in the articles. This literature includes twenty-four studies reporting on clinical trials. None of the reports relies on a study design with the highest level of evidence, that is, a randomized crossover trial with high statistical power, but all of them present data comparing hearing aids with different directionality (e.g., omnidirectional vs directional) worn by the same subjects, following a crossover design, with or without randomization. The sample sizes are generally small.

Regardless of the technological approach used, all of the studies (i.e., those with an intermediate level of evidence as well as those with a low level of evidence) show that hearing aids with directional properties provide speech-intelligibility benefit in noisy environments. This advantage is optimal in listening conditions where the noise is behind and the speaker in front of the hearing-impaired person in an environment with low reverberation. In listening situations more representative of daily reality, where noise is diffuse and the room reverberant, this advantage decreases to

the point of becoming comparable to that provided by conventional hearing aids with omnidirectional microphones.

Conclusion

With respect to directional properties, the few studies available presenting an intermediate level of evidence allow us to classify as “experimental” technologies both single-microphone solutions and approaches based on a microphone array. These solutions seem promising, but additional controlled trials will be required to confirm their efficacy.

Dual-microphone approaches can be considered “accepted” technologies but only in optimal listening conditions, when the speaker and the noise are diametrically opposite each other in rooms with low reverberation. The application of this technology in other conditions reduces (sometimes significantly) their effectiveness. Finally, eligibility requirements for devices with the directionality option must take into account the candidate’s physical and cognitive abilities to use the directional properties effectively.

GLOSSARY

Anechoic:

Having no reverberation.

Assistive listening device (ALD):

Any device that is part of a user's environment and designed to compensate for a hearing impairment, to prevent or alleviate a handicap situation.

Binaural:

Involving both ears. Binaural means that a hearing aid is fitted to each ear, as opposed to a monaural system in which only one ear is fitted with a hearing aid.

Hearing aid:

Any device worn by a user that is designed to correct a hearing impairment, to compensate for a hearing disability, to prevent or alleviate a handicap situation.

Hearing device:

Any device designed to correct a hearing impairment, to compensate for a hearing disability, to prevent or alleviate a handicap situation.

Linear:

Relating to a hearing aid that provides a fixed level of amplification regardless of the intensity of the incident acoustic signal. By definition, these devices do not have compression circuits allowing for more or less advanced methods of processing the dynamic range of the sound environment.

Signal-to-noise ratio (SNR):

Ratio of the sound intensity of a signal and that of competing noise, expressed in decibels (dB).

Speech reception threshold (SRT):

The sound intensity required for recognition of 50% of two-syllable words, expressed in decibels (dB).