

**THE UNIVERSITY OF MELBOURNE
DEPARTMENT OF OTOLARYNGOLOGY**

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Victoria*

The University of Melbourne Department of Otolaryngology runs a general ENT Clinic as well as a Cochlear Implant Clinic. It forms the core of a Multicentre research group for deafness research, is heavily involved in teaching and education, and includes a School of Audiology. This article presents an overview of the activities of the Department.



FIG. 1. The Peter Howson and Smorgon wings of The Royal Victorian Eye and Ear Hospital, East Melbourne. A. Department of Otolaryngology, The University of Melbourne. B. Medical Suite of the Cochlear Implant Clinic. C. Audiology and Speech Science Suite of the Cochlear Implant Clinic.

The Department of Otolaryngology is situated at the Royal Victorian Eye and Ear Hospital, East Melbourne (Figure 1). It is responsible for running a general Ear, Nose and Throat Clinic and as well as a Cochlear Implant Clinic. It has a School of Audiology, which is housed separately in Ensor (Figure 2) in the East Melbourne precinct. The Department of Otolaryngology was awarded

a Special Centre of Excellence for research in Human Communication. It is a core partner in a Co-operative Research Centre for Cochlear Implant, Speech and Hearing Research and has been awarded National Health and Medical Research Council of Australia program and project grants, as well as U.S. National Institutes of Health contracts and grants. The Department is

Editorial Note – Graeme M. Clark M.S., Hon.M.D. Hannover, Hon.M.D. Sydney, F.R.A.C.S., F.R.C.S., Ph.D., was appointed as Foundation Professor of Otolaryngology at the University of Melbourne in 1969 and took up the position in January 1970. His academic career has concentrated on the mechanisms by which sound is encoded and transduced into nerve discharges and how the brain codes electrical stimuli. Allied with this has been ongoing research in order to assess the effects of short term and long term electrical stimulation. His Ph.D. was awarded for work on Middle Ear and Neural Mechanisms in Hearing and the Management of Deafness. Election to the Chair of Otolaryngology enabled this research to both continue and be applied to the development of a computer programmable implantable device which has now become one of Australia's finest Biotechnological achievements.

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FIG. 2. Ensor, The Royal Victorian Eye and Ear Hospital, housing the School of Audiology and Speech Science, which runs the post-graduate Diploma in Audiology and a Masters Degree in Audiology and Speech Science.

geographically and functionally closely associated with the Australian Bionic Ear Speech and Hearing and Research Institute, a separate research institution (Figures 3 and 4), also in the East Melbourne precinct.

History of the Chairs of Otolaryngology, and Audiology and Speech Science

Chair of Otolaryngology

Dr George Swinburne was the prime mover in establishing a Chair of Otolaryngology at the University of Melbourne. In the 1960s he initiated fund raising efforts through a public appeal and sought support from the Heads of ENT clinics in the major hospitals in Melbourne; namely, Dr Peter Freeman (Alfred Hospital), Dr Colin Richards (Prince Henry's Hospital), Dr Cecil Cantor (The Royal Victorian Eye and Ear Hospital), Dr Frank Nagle (St Vincent's Hospital), Dr Ray Hennessy/Dr Clive Pyman (The Royal Children's Hospital). The family of William Gibson, and in particular Miss Maude Gibson, gave a substantial amount to help establish the Chair on an ongoing basis, and it was therefore to be named the William Gibson Chair of Otolaryngology. The Honourable Peter Howson helped considerably with this bequest. Sir Sidney Sunderland, Dean of the Faculty of Medicine, also did much to facilitate its development at the University. The Chair was established in 1969.

Chair of Audiology and Speech Science

In 1971, an approach was made to establish a training course in Audiology within the Department of Otolaryngology. This was reviewed by a special committee set up by the State Government and The University of Melbourne, and as a result it was agreed to



FIG. 3. Mollison House, headquarters of the Australian Bionic Ear and Hearing Research Institute, a separate research Institute.



FIG. 4. Burlington Terrace, annex of the Australian Bionic Ear and Hearing Research Institute.

establish a postgraduate diploma in Audiology and a School of Audiology within the Department of Otolaryngology. In 1973, Field Rickards was appointed as lecturer in charge of the course. Subsequently, in 1993, Field Rickards was appointed to the position of Professor in Education of the Hearing Impaired within the Deafness Studies Unit, Institute of Education, at the University of Melbourne. The Deafness Studies Unit has close links with the School of Audiology. In 1994, as a result of bequests from Mrs. Beth Smallwood, the University agreed to establish a Foundation Chair in Audiology and Speech Science within the Department of Otolaryngology, to be named the Beth MacLaren Smallwood Chair. This will be the first full Chair in this discipline in Australia.

Teaching and Education

The Department of Otolaryngology has been actively involved in the teaching of medical students since 1970 through formal lectures, and by holding clinical training sessions in Otolaryngology and Audiology. A number of medical students have also undertaken Bachelor of Medical Science degrees within the Department of Otolaryngology during their medical course.

Postgraduate training commenced through the Postgraduate Diploma in Laryngology and Otology. Subsequently, the Department of Otolaryngology has

provided teaching in Otolaryngology and Audiology to registrars in training, and has run special courses in Audiology and in research procedures. The Department has trained postgraduate students for Master of Surgery, and Master of Audiology and Otoneurology degrees. Ten overseas Surgeons from Great Britain, US, Germany and Japan have trained in research within the Department of Otolaryngology. Their research has been submitted for Master of Surgery and Doctorate of Medicine qualifications.

The School of Audiology was established in 1973. It is the only School of Audiology based in a medical faculty and within a Department of Otolaryngology in Australia, with over 20 students per year graduating as audiologists. In addition to the post-graduate Diploma in Audiology, the School also offers advanced studies in Audiology at the Masters level.

Research

The Department of Otolaryngology forms the core of a multi-centre research group bringing together both public and private sector funding for deafness research, and the development of devices to assist people with a hearing loss. Figure 5 outlines the research centres which are part of the Department of Otolaryngology, as well as the Centres and Institutes with which the Department of Otolaryngology collaborates.

The Human Communication Research Centre (HCRC) is a "Centre of Excellence" and aims at understanding the underlying mechanisms of speech perception, speech production and language so that advanced communication aids for hearing impaired people can be developed. The HCRC was awarded to the Department of Otolaryngology under the Federal Government's Special Research Centres program by the Australian Research Council and the Department of Employment, Education and Training in 1988. The Centre's funding was renewed on its second triennial review, securing funding for a further three years to 1996. The Department has also been awarded a number

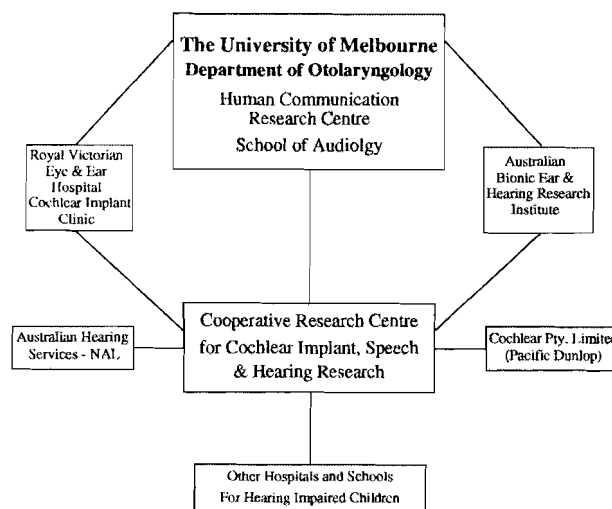


FIG. 5. The relationship of the Department of Otolaryngology, including the Human Communication Research Centre, with the Cooperative Research Centre and other organizations.

of National Health and Medical Research Council project grants, as well as US National Institute of Health grants in order to undertake research into deafness and the application of devices to aid hearing.

The Cooperative Research Centre for Cochlear Implant, Speech, and Hearing Research (CRC), funded from 1992, and bringing together the core partners of The University of Melbourne, the Australian Bionic Ear and Hearing Research Institute, Australian Hearing Services and Cochlear Pty. Limited, now acts as a focus for research, and the development of the more basic research undertaken by the HCRC and other research programmes of the Department of Otolaryngology. The CRC was awarded by the Federal Department of Prime Minister and Cabinet. The Australian Bionic Ear and Hearing Research Institute is the managing agent of the Centre. The CRC has a clear focus on the commercialisation of devices to aid hearing impaired people, and has close links to the Australian biotechnology industry through Cochlear Pty. Limited, one of the core parties.

The Australian Bionic Ear and Hearing Research Institute, as well as being the managing party for the CRC, provides infrastructure and other support to the research group, as well as undertaking research through private sector funding, for example, through the Lions Clubs International Deafness Research Fellow.

Cochlear implant

In the many cases where normal medical intervention has been unable to help the hearing impaired person, hearing loss has traditionally been treated by simply amplifying the sound through the use of a hearing aid. This does not, however, necessarily assist profoundly deafened people, nor does it provide useful information for totally deafened individuals.

The multi-channel cochlear implant was developed in the Department of Otolaryngology, and can restore some hearing to profoundly and totally deaf people by directly stimulating the residual nerve fibres of the VIIIth nerve. The cochlear implant consists of a number of parts (Figure 6). The microphone picks up the sounds, and signals are sent to the speech processor worn by the patient. This unit processes speech, and converts it into a code. This code is sent by radio frequency across the skin to the surgically implanted receiver-stimulator (embedded in the mastoid bone) which decodes the signal and sends electrical stimulus pulses to the electrode array, which lies within the cochlea. Place pitch is varied by selecting the electrodes to be stimulated. The loudness is varied by changing the intensity of stimulation.

Over 60% of people with the multi-channel cochlear implant can understand some speech without the aid of lipreading. The device, developed by the Department of Otolaryngology, is manufactured by Cochlear Pty. Limited, and holds nearly 90% of the world market, with over 9,000 patients using the device worldwide. Over 3,000 of these patients are children.

The research group is continuing its work in order to improve the cochlear implant and increase the benefit that people gain from the device. Research to further develop the cochlear implant continues in the following areas:

- *Advanced speech processing algorithms.* Continued

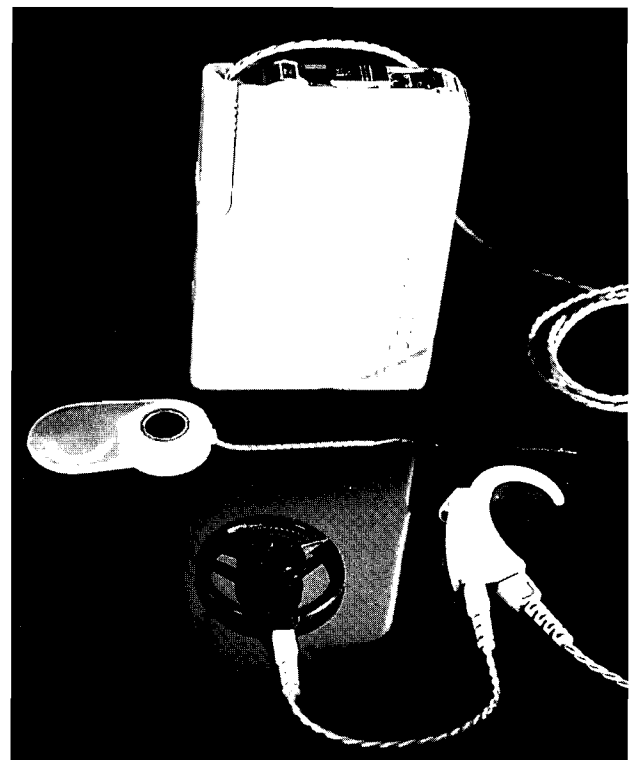


FIG. 6. The speech processor (top centre), headset and implantable receiver-stimulator (middle left).

improvements over the past 10 to 15 years have led to significant improvements in the perception of speech by cochlear implant users, as seen in Figure 7. Research continues in this area to further increase the average speech perception understanding of cochlear implant users.

- *Biology and physiology* studies are being undertaken to ensure that any changes to design, or the parameters used, are safe. For example, safety studies are presently underway in order to ensure that high rate stimulation of the cochlear implant does not lead to nerve or tissue damage, since a number of promising speech

Research Subjects: Open Set Monosyllables % Words Correct Hearing Alone

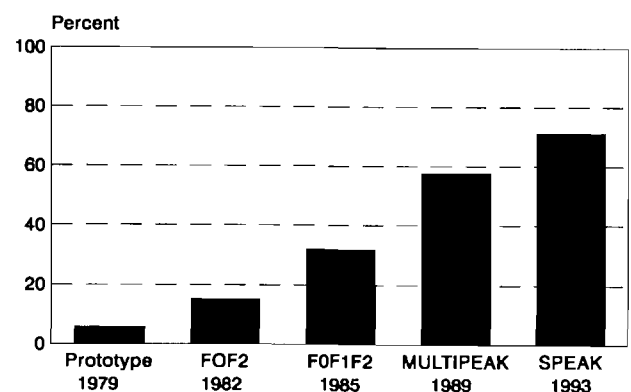


FIG. 7. The open-set monosyllable scores in adults using electrical stimulation alone for each improvement in cochlear implant speech processing.

processing algorithms that rely on high rate stimulation have been designed.

- *Bioengineering* and the development of improved electrode and package design is an important element in the continued improvement of the cochlear implant. For example, a curved electrode array, designed to be seated closer to the modiulus, instead of lying on the outer wall of the scala tympani in the cochlea, is presently being developed through the CRC.
- *Psychophysics*, the study of the perception of sound, is a key area of work since much of the speech processing research is based on the understanding, developed through psychophysics, of how cochlear implant users perceive the electrical stimulation.
- *Clinical studies* in the application of the cochlear implant, particularly with children, are undertaken to maximise the benefit which cochlear implant users derive from the device. In the case of children, educational and social issues need to be managed carefully in order to ensure that the child gains the greatest benefit from the device. One of the key parameters for success is age of implantation, as outlined in Figure 8, where it can be seen that children implanted with the device at an early age, and who are implanted more quickly after the onset of profound deafness, are able to achieve better speech understanding performance. This finding has a number of significant clinical implications, since it suggests that implantation at a very young age, shortly after onset of profound deafness, increases the probability of good performance with the cochlear implant.
- *Binaural Bionic Ears*, where research is presently indicating better speech understanding in noise can be achieved.

Combionic Aid

The Combionic Aid intelligently presents sound to one ear via the cochlear implant, and sound to the other ear via a

special speech processing hearing aid. As a result of the continuing increase in average cochlear implant speech understanding, more patients are being implanted with the device while still having significant residual hearing in the non-implanted ear. Consequently, the Combionic Aid is a necessary extension of the work undertaken by the research group.

Advanced psychophysics and speech processing is required to effectively co-ordinate the sounds presented. In addition, significant engineering and software development has been required.

The Electrotactile Hearing Aid or "Tickle Talker"

The Tickle Talker electrically stimulates the digital nerve bundles on each side of the base of the fingers, eliciting a vibration-like sensation. Eight different points are stimulated, with different pitch sounds stimulating an appropriate finger, and the intensity of the sensation providing an indication of loudness. With appropriate training, the Tickle Talker can be used to supplement the person's aided hearing by providing speech cues that would otherwise be missed.

Extensive psychophysical, speech processing and engineering studies are being undertaken to further develop this device. Results to date indicate that the Tickle Talker provides significantly more information than any other tactile hearing aid presently available (Figure 9).

Speech processing hearing aids

Speech processing hearing aids intelligently amplify sound so that the sound is not only intense enough for the severely deaf person to hear, but also provides more information than a normal hearing aid. A speech processing hearing aid can be programmed so that precise amplification can be realised. In addition, advanced speech processing algorithms can be used to enhance important speech features and minimise the effects of background noise.

Present work, undertaken through the Co-operative Research Centre, and in association with Australian hearing Services, is concentrating on the engineering development of prototype devices and determining optimal psychophysical parameters and speech processing algorithms.

Central Auditory Prosthesis

The Central Auditory Prosthesis is in the developmental stage and will directly stimulate the brainstem to evoke hearing sensations. This device will be used where the patient has non-functioning VIIIth nerves, for example through bilateral acoustic neuroma.

Presently, studies are being undertaken in order to determine the safety of long term electrical stimulation of the ventral cochlear nucleus. In addition, bioengineering studies to develop appropriate electrode arrays are necessary.

Automatic brainwave audiometer

The automatic brainwave audiometer measures the steady state brainwave responses to acoustic stimulation, enabling the accurate and objective measurement of hearing thresholds. The Automatic

Speech Perception Performance and Length of Deafness For Children

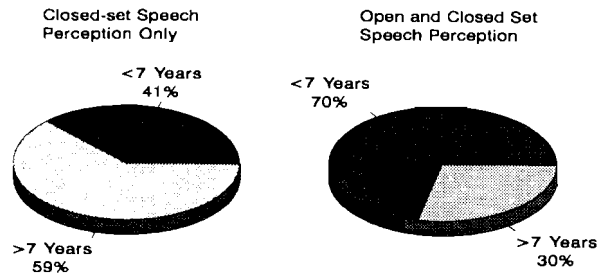


FIG. 8. The open-set monosyllable word scores using electrical stimulation alone for children of different ages. It can be seen that children who have been deaf for less than seven years constitute the greater proportion of the children who are able to understand open-set speech material, such as sentences, without lipreading (right pie graph) while using the cochlear implant. In contrast, children who have been deaf for more than seven years constitute the greater proportion of the children who can only understand closed-set speech, that is, are able to distinguish the correct word from a pre-defined set.

Feature Contrast Scores for Six Tactile Devices

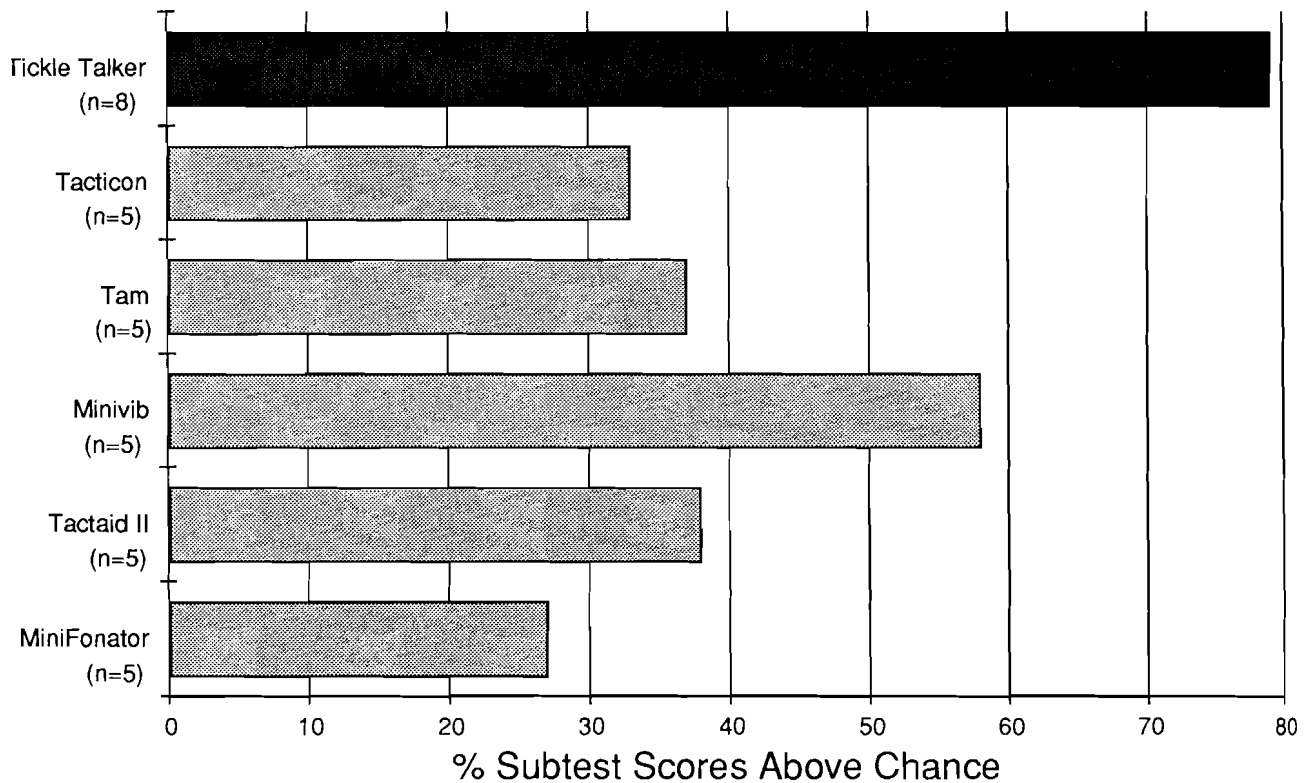


FIG. 9. Comparative speech perception results for the Tickle Talker and other devices described in the literature and commercially available.

Brainwave Audiometer is particularly useful in determining hearing thresholds in difficult to test patients, such as newborn infants and in cases of non-organic hearing loss.

This device has been developed in the Department of Otolaryngology to a point where it is presently being commercialised by an Australian biotechnology

company. Research continues in the Department of Otolaryngology to further develop the device and apply the technology for determining electrically evoked thresholds in order to enable the accurate and objective setting of cochlear implant stimulation parameters, particularly for use with very young cochlear implant patients.



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