

The 2009



Libby Harricks Memorial Oration number 11

Libby Harricks

Memorial Oration

Honouring the Deafness Forum's first president & profoundly deaf achiever

Elisabeth Ann Harricks AM 1945 – 1998



deafness forum of australia

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Introduction to the 11th Libby Harricks Memorial Oration

Dr Jenny Rosen, Chairman, Libby Harricks Memorial Oration Committee



As a young wife and mother Libby Harricks became profoundly hearing impaired. She soon developed skills to manage her own hearing difficulties and subsequently became a committed advocate for hearing impaired people. Libby was a founding member and long term President of SHHH Australia Inc (Self Help for Hard of Hearing People), and in 1993 was elected inaugural President of Deafness Forum of Australia, the national peak body in deafness and related issues. In this voluntary role, she travelled widely throughout Australia raising awareness of the need for inclusion of hearing impaired people, and lobbying for this on their behalf. Amongst her many activities, Libby represented the needs of hearing impaired people on the Sydney 2000 Olympics Access Committee, resulting in communications access for hearing impaired people being installed in Olympic venues. We are still benefitting from her work in this role at this Olympic site today. In recognition of her many advocacy achievements, in 1990 Libby was made a Member of the Order of Australia.

Libby died in 1998. The Libby Harricks Memorial Oration Series was established by Deafness Forum to honour her work. The aim of the Oration Series is to continue her commitment to achieving appropriate recognition, awareness, and access, for hearing impaired people. To further this aim in a more permanent form, the Oration Series is also published by Deafness Forum in a Monograph series.

The first Oration entitled 'Hearing Access Now!' was presented by Emeritus Professor Di Yerbury in Sydney in 1999. The second, in 2000, was given by Professor Bill Gibson who spoke on tinnitus and Menieres Disease at the Sydney-based International Federation of Hard of Hearing Conference. In Canberra in 2001, Senator Margaret Reid discussed 'The Politics of Deafness'. In 2002 at the XXVI International Congress of Audiology in Melbourne, Professor Paul Mitchell presented findings of a major demographic study, the Blue Mountains Hearing Study, which addresses the prevalence and impact of hearing loss in a representative older Australian



community. In 2003, Donna Sorkin summarised progress in disability law and hearing loss from an international perspective as the keynote address to a full day hearing access seminar at Macquarie University in Sydney.

In 2004 Dr Peter Carter spoke on issues relating to Aboriginal ear health at the 3rd National Deafness Sector Summit in Brisbane. For 2005, we moved to the Blue Mountains, and Alex Jones gave the first of the Orations to be presented in Auslan. Entitled 'Deafness and Disability Transformed: An Empowering Personal Context' his Oration indeed had a very powerful impact. For 2006, Professor Harvey Dillon presented his paper 'Hearing Loss: The Silent Epidemic' at the 4th National Deafness Sector Summit in Perth. In 2007 in Albury, Rick Osborn enthralled the 9th Rural Health Conference with insights relating to 'Hearing and Communication – A Primary Concern in Aged Care.' At the 2008 5th National Deafness Summit in Canberra, Professor Robert Cowan spoke on 'Access, Equity and Hearing Loss in Australia in 2008'.

The series speaks for itself in carrying forward Libby's commitment to raising awareness of issues relating to hearing impairment, and in furthering the aims of Deafness Forum. We have been extremely fortunate with a series of outstanding Orators presenting on a wide range of relevant topics. We are equally gratified that it has also been possible to provide the opportunity for audiences across Australia to hear these Orators, as well as to enable continuing availability via the Monograph series. I must acknowledge the support of the Libby Harricks Memorial Oration Committee, and the invaluable continuing support of the Deafness Forum national secretariat. I am pleased to also acknowledge our Oration sponsors for 2009, Australian Hearing and Cochlear Ltd, without whose generous support neither the presentation of this Oration nor the preparation of its companion Monograph, would be possible.

This year, we are indeed privileged to welcome as our 11th Orator, Professor Graeme Clark AC. Professor Clark initiated and led research at the University of Melbourne and the Bionic Ear Institute which resulted in today's ever-more-successful multi-channel cochlear implants (also known as the 'bionic ear'). From modest beginnings some thirty years ago, these now bring great benefit to many thousands of people of all ages, across the world. Internationally renowned for his work in this area, Professor Clark continues to contribute to research in this, and related areas of disability.

For his achievements, he has been widely recognised. Amongst these honours is Germany's highest award in neuroscience, the Zulch Prize from the Max Planck Society. He is a Fellow of the Royal Society, London, and an Honorary Fellow of The Royal Society of Medicine, and of The Royal College of Surgeons. In 2004 he received Australia's highest award in Science, the Prime Minister's Prize for Science. In 2006 he was awarded the Ian Wark Medal from the Australian Academy of Science. Honorary Doctorates have been conferred by five universities (both Australian and overseas), and Monash University has awarded him its highest honour, the Lifetime Achievement Award. In 2004, Graeme was made a Companion of the Order of Australia, Australia's highest civil honour.

There is undoubtedly no-one more qualified or able to talk to us about deafness, technology and the bionic ear.

Would you please welcome Professor Graeme Clark.

The Bionic Ear: from an Idea to Reality

Professor Graeme Clark AC



This is a summary of my personal journey that gave birth to the "Bionic Ear" or multi-channel cochlear Implant for severely deaf people. It has also given results beyond all my expectations, and has the potential for improvements beyond the present into the future.

My journey started when I was 11 years of age. I had a vision to help deaf people like my father. He was a pharmacist in a small town outside Sydney, and I was embarrassed when people would come in to Dad's shop and ask for confidential items. Dad would need to say "speak up", and all the other customers in the shop could hear what was wanted.


With good hearing the sound waves pass down the ear canal and vibrate the ear drum and the middle ear bones. These vibrations are transmitted to the inner ear or cochlea.

In the cochlea the sound vibrations pass along the basilar membrane and the vibrations are converted into electrical signals by the delicate organ of hearing or organ of Corti. The membrane filters the sound frequencies and high frequencies produce maximal vibrations in the basal end and low frequencies in the apical end of the cochlea.

The hairs of cells in the organ of Corti move to and fro in response to sound vibrations and convert the vibrations into electrical signals and these excite the nerves passing to the brain.

With deafness the hair cells and some nerve fibres are lost, and so there is no mechanism to convert sound vibrations into electrical responses, and transmit them to the brain.

In 1965 I reasoned that if I could understand how electrical stimulation of the remaining auditory nerves could be perceived as speech that might be the key to helping severely deaf people who received little help from a hearing aid.



However, most scientists around the world said it would not work, Merle Lawrence a leading US physiologist wrote in 1964 –“direct stimulation of the auditory nerve fibres with the resultant perception of speech is not feasible”.

In 1966 I accepted the challenge of giving speech to deaf people through electrical stimulation of the auditory nerve, and I left an ENT surgery practice in Melbourne with my wife Margaret and two young children.

I returned to the University of Sydney as a PhD student to see if electrical stimulation could mimic the way the brain codes sound.

The first important scientific question was: were the auditory nerve fibres in the cochlea too complex and numerous for electrical stimulation to reproduce the coding of sound frequencies?

With the time code, the brain cells fire in time with the sound waves. The time interval between nerve responses is important in conveying the frequency information and pitch.

On the other hand, with the place code the pitch of the sound depends on the place of stimulation. This occurs because the cochlea and brain pathways are arranged spatially so that a musical scale is preserved. But the relative importance of the time and place codes was not known.

My first research from 1967 – 69 was to see if it was possible to mimic the time coding of speech frequencies with electrical stimulation on a single channel. There was a marked fall in neural response from 1 pulse/s to 300 pulses/s. This indicated that a time or rate code using a single-channel implant would not be adequate for speech frequencies above 300 pulses/s.

There was thus a “bottle-neck” between the world of sound and the brain, for the time coding of the mid to high sound frequencies.

As the mid-to-high speech frequencies are of greatest importance for speech intelligibility and especially for consonants, I needed to see if they could be transmitted by multi-channel stimulation.



This required passing a number of electrodes into the inner ear and stimulating the different frequency sites in the brain on a place code.

So the next scientific question was: could electrical current be localized to separate groups of auditory nerve fibres for the place coding of frequency?

I was concerned too, that electrical currents in the cochlea might short-circuit through the fluid, and not pass through the nerve fibres.

But our research studies demonstrated that electrical current could be localized to groups of nerves if the current passed between two neighboring electrodes (bipolar stimulation) or between an electrode and distant ground (monopolar stimulation).

Then personal studies on a mould of the human cochlea in 1975 showed the electrode bundle would only pass upwards a limited distance around the tightening spiral, to lie opposite the nerves transmitting speech frequencies. The electrode lay against the outer wall and its upward progress was impeded due to friction.

This time the answer came on the beach. I picked up a turban shell which has a similar shape to the cochlea, and found that grass blades that were flexible at the tip and stiffer at the base went around quite easily. This biomechanical principle worked on the human inner ear, and has been the basis for all bionic ear designs since.

I then wanted to know: would intracochlear multi-channel stimulation for place coding be safe?

The safety issues for intracochlear stimulation were: would surgical trauma, and electrical currents damage the very auditory nerves we hoped to stimulate? And would the introduction of any infection during or after surgery lead to meningitis? For this reason I led at least 9 separate studies on the experimental animal to help ensure that it was safe.

The studies on preventing the spread of infection from the middle ear to the inner ear and then leading to meningitis were especially important for implants in young children as middle ear infection is very common in this young age group.

The studies on the experimental animal demonstrated that it was important to graft around the electrode where it enters the cochlea to help provide a biological barrier against the spread of infection to the inner ear.

The next question I had to address was, could an implantable stimulator be developed to evaluate speech processing strategies in deaf volunteers?

I was against using a plug and socket to connect people to test equipment, as my studies in the experimental animal had shown that infection occurred around the socket where it passed through the skin.

An implantable receiver-stimulator with information sent through the skin by radio waves was the safe solution. But this would cost some hundreds of thousands of dollars, and I did not have that amount of money.

Fortunately the owner of a Television station Sir Reginald Ansett in 1974 ran public appeals for 3 years for the work. But it meant I spent about half my time helping to raise the money including standing on the streets of Melbourne rattling a tin and asking for donations. The money enabled me to appoint two very able engineers Jim Patrick and Ian Forster to develop the first fully implantable cochlear implant.

The circuit required the equivalent of 6,000 valves or transistors and could not have been made small enough without the silicon chip. The silicon chips were bonded to gold plated tracks on silica wafers. The wafers were enclosed in water tight stainless steel containers used to send electronics to the moon and the power and control data were sent through the intact skin by radio waves to aerials on the outside of the package.

I also had to decide: How and where should the receiver-stimulator package be implanted? My decision was based on many anatomical dissections.

When all was ready just over 30 years ago on the 1st August 1978, Brian Pyman and I implanted our first patient Rod Saunders. It was also my moment of truth – I had gambled my career on the outcome. I could not afford a single failure or I believe there

would have been pressure for me to resign. We implanted the most complex package of electronics inserted in a patient. The electrode bundle with variable stiffness went an adequate distance around the cochlear to reach the speech frequencies.

But doctors thought the operation I was doing was dangerous and that added to the considerable pressure I was under. However, Rod recovered well from the surgery, and 6 weeks after surgery we switched the implant on. What did simple electrical stimuli sound like? We could hardly wait to find out, and that would also tell us about the time and place coding of frequency.

We first wanted to see if Rod could recognize melodies played on just one electrode. We got our answer with "God save the Queen". Immediately Rod stood up as was the custom, and he pulled all the leads out of his equipment. But we didn't mind as that was our first big step forward. He was then presented the tune for Waltzing Matilda our unofficial national anthem, and he recognized that immediately.

I then arranged for Rod to come regularly so that we could learn about the sensations he experienced with electrical stimulation. I was intrigued to find that with place of electrical stimulation, the sensation was perceived as timbre rather than pitch (timbre is the quality of the sound that distinguishes two musical instruments playing the same note, at the same intensity). The timbre varied from dull at the low frequency end to sharp at the high frequency end of the cochlea. However, the timbre could be scaled and used for the place coding of frequency.

But the really big challenge was: how could speech be understood? The speech signal is very complex even for vowels. How should we present the signal through the "bottle neck" to the brain?

The clue came when Rod said stimulating the electrodes gave different vowel sounds, and they did not sound just sharp or dull. Mid frequency electrodes gave an /e/, high frequencies an /i/ and /ea/ and low frequencies from a current spreading outside the cochlea to the auditory nerve, gave an /o/ and /or/. The vowels were the same as those that would be heard when exciting the same area of a normal ear with certain frequencies of special

importance for intelligibility called formants. Formant frequencies are due to resonances in the vocal tract. The resonances depend on the shape of the vocal tract.

And the relationship between length and resonant frequency is illustrated for organ pipes where long pipes emphasize the low frequencies, and short pipes the high frequencies. Vowels and to a lesser extent consonants are best identified by the two lowest formants, the first and second formant. This can be illustrated for the synthetic vowels in heed, hid, head, had, hard, hoard, and hood.

The absolutely vital question: was how could we code the sounds so that speech could be understood? We answered this question by developing a formant-based speech processing strategy. That strategy picked out the second formants and presented these to the appropriate electrodes on a place coding basis which were perceived as timbre. The sound pressure was coded as current level and perceived as loudness. The lower voicing frequencies were coded as rate of stimulation which was perceived as pitch. This strategy was developed on our large laboratory-based computer.

When this way of processing speech with 10 electrodes was ready, on 8th December 1978 my audiologist Angela Marshall did the crucial word test. At the time I held my breath – yes he got some of the words right. I was so overcome I crept into the next door room and burst into tears of joy.

But having made that breakthrough I left for Christmas holidays knowing that I had no money to continue the research unless the Australian government provided the finances to develop it industrially. Nevertheless, I put all concerns aside, and had a much needed holiday.

On my return I was ecstatic to learn that the Australian government had not let us down. In a press release on 1st February 1979 it was said that the government had made a grant of \$400,000 for its commercial development.

So in early 1979 I needed to 1) Confirm the second formant strategy gave speech understanding not only to my first patient but to other people; and 2) Establish that people still had memory for speech sounds after being deaf for many years so they could receive the benefit of the second formant strategy.



So later in 1979 on 17th July I operated on my second patient George Watson who had been deaf for 17 years. When George at his second test session was read to from the newspaper without help from lipreading he understood much of what was said.

Could the speech processing strategy be engineered as a wearable unit? I could not leave Rod and George with only a large laboratory computer. They wanted help in their daily lives. Peter Seligman and Jim Patrick designed a wearable processor the size of a binocular case in mid 1979. We hastened to film its use in Lois Martin's kitchen, and it worked beautifully.

I was keen to see many deaf people helped around the world so steps were undertaken to have it developed industrially. The Australian pacemaker firm Teletronics was chosen and established a small team of gifted people called the "Tiger team". They developed the Nucleus clinical trial device in the remarkably short time of 2 and a half years.


It was trialed in the US, Europe and Australia and in 1985 it was the first multi-channel system to be shown to be safe and effective for adults who had hearing before going deaf.

The next question was would the second formant/voicing strategy be effective for tonal languages? The second formant speech processor results were also remarkably good for a tonal language.

The next challenge was to determine what additional information could be transmitted through the "bottle-neck" for improved speech understanding? Our research showed the importance of transmitting the first formant as well as the second formant for vowels and then other sounds crucial for consonants.

There were progressive improvements in speech understanding through selecting additional formants and other frequencies and coding them as place of stimulation. The scores are at a level indicating that severely deaf adults can on average have fluent conversations on the telephone.

In 1985 after the good results for adults who had hearing before going deaf, I then turned my attention to the final big challenge – could we help children who had gone deaf early in life or were born deaf. Could children born deaf develop the right brain connections for speech understanding?



In 1985 and 1986 I operated on our first three children with Rob Webb and Brian Pyman. We inserted a smaller implant developed by Cochlear. It had magnets in the centre of the transmitting and receiving aerials to align them and hold them in place.

Following a world trial for the US Food and Drug Administration at a number of centers in the US, the Nucleus multi-electrode system was approved as safe and effective in 1990 for use in children from 2-17 years of age. It was the first implant of any sort to be approved by a world health regulatory body. We have all been very blessed in seeing at first hand how the implant affects the life of deaf children.

The next challenge has been: Can implanted children develop near normal language? Results of a recent study by Shani Dettman and Richard Dowell show language development for children with the implant 12 to 24 months of age just below the diagonal for good hearing, and normal if the child is operated on under 12 months of age then their language levels are normal.

Finally can high fidelity hearing be achieved with the bionic ear? In December 2007 just before my patient Rod Saunders passed away I asked him what he would like most. He said " as far as speech is concerned it is very, very close but as far as music is concerned it is way off". So the challenge is to produce better music perception and hearing in noise.

To make the fine connections needed for high fidelity sound an advanced electrode is needed. It will have many electrodes probably with fine wires or carbon nanotubes, the electrode will be steerable, and it will release therapeutic agents.

The latest fine electrodes we are studying at our centre at La Trobe University and ARC centre of excellence are shown next to a banded electrode in Figure 1. The carbon nanotubes are so small more than 1,000 can be stacked next to a human hair.

At our new centre at La Trobe University as shown in Figure 2 we are developing hearing implants through 1) Advanced electrode systems for better speech and music perception with cochlear implants and brainstem implants, 2) Also understanding the psychology and cognition for improved language in children, 3) Combining hearing and speech reading for speech perception especially in noise.



Figure 1



Figure 2

In looking back over my 42 years of research to develop hearing with electrical stimulation of the brain I can only restate that the results are beyond anything I expected. It has been a remarkable partnership between our research team members and industry as well as with others. I feel privileged to have led the Melbourne research for 35 years.

This oration is based on the opening address given by Professor Clark AC to the 7th International Symposium of EURO-CIU, The European Association of Cochlear Implant Users on 17th March 2009.



About the Deafness Forum

Introduction

Deafness Forum is the peak body for deafness in Australia. Established in early 1993 at the instigation of the Federal government, the Deafness Forum now represents all interests and viewpoints of the Deaf and hearing impaired communities of Australia (including those people who have a chronic disorder of the ear and those who are DeafBlind).

Structure

Deafness Forum is divided into four classes.

Consumer means an adult who is Deaf or has a hearing impairment or has a chronic ear disorder; or a parent of such a person.

- **Deaf** refers to people who see themselves as members of the Auslan using Deaf community by virtue of its language (Auslan) and culture.
- **Hearing Impairment** refers to a hearing loss. People with a hearing impairment (or who are hard of hearing) may communicate orally (sometimes described as 'oral deaf') or may use a sign language or other communication methods.
- **Chronic Ear Disorder** refers to such disorders of the ear as tinnitus, Meniere's Disease, Acoustic Neuroma, hyperacusis and recruitment. People with some such ear disorders may also have a hearing impairment.

All Consumers are entitled to describe themselves using whatever terminologies they prefer, and are asked to do so at the time of joining and each time they renew membership.

Consumer Association means an incorporated Association of, or for, consumers (as defined above).

Service Providers also include various other occupations that provide services to consumers who are Deaf, have a hearing impairment or have a chronic disorder of the ear.

Service Provider Association means an incorporated organisation, which has (as its principal purpose) the provision of services that promote the wellbeing of consumers (as defined above).



Objectives

The Deafness Forum exists to improve the quality of life for Australians who are Deaf, have a hearing impairment or have a chronic disorder of the ear by:

- advocating for government policy change and development
- making input into policy and legislation
- generating public awareness
- providing a forum for information sharing and
- creating better understanding between all areas of deafness.

Community Involvement

The Deafness Forum is consumer driven and represents the interests and concerns of the entire deafness sector, including:

- the Deaf community
- people who have a hearing impairment
- people who have a chronic ear disorder
- the DeafBlind community
- parents who have Deaf or hearing impaired children in their families

Libby's Story



Libby's story is one of courage and triumph over adversity by utilising the knowledge of her own severe hearing loss to help others.

Libby started to lose her hearing following a bad dose of flu in the English winter soon after her marriage in 1969. Having returned to Australia in 1970 she began to find difficulty in understanding conversation and instructions, particularly on the telephone which was very important in her profession of pharmacy.

In spite of advice to the contrary, Libby tried hearing aids and found they helped. Had she heeded the negative advice, Libby believed she might never have embarked on the road to self-help, which so enriched her own life and that of many others. She thought her two boys quickly learnt to sleep through the night and her friends remarked they had loud voices, which was the boys' mechanism for coping with a deaf mother!

The more the doctors said nothing could be done to help, the more Libby looked towards self help and so she learnt to lip read, a tool she relied on heavily in her quest to help others.

Libby's will to win led her, with the help of others, to get involved with the setting up of a support group, which became SHHH – Self Help for Hard of Hearing people. The American founder, Rocky Stone, was invited to Australia in 1982 and did a lecture tour entitled "The Hurt That Does Not Show" which cemented the bonds between the US and Australian groups and helped the local SHHH develop.

Libby, with others, then began SHHH News, a quarterly publication, and with Bill Taylor set up the first Hearing Information and Resource Centre at "Hillview", Turrumurra with support from Hornsby/Kuringai Hospital. This centre provided reliable information on, and demonstrated, assistive listening devices for hearing impaired people. Through this interest, Libby became an enthusiastic user of technology and with her handbag full of electronic aids was enabled to join in a full social life with family and public.



Libby became President of SHHH in 1986 and began to develop her role as an advocate for hearing impaired people generally.

She became involved in ACCESS 2000, under the Australian Deafness Council, and a member of the Disability Council of NSW. Her horizons broadened further as Vice President of the Australian Deafness Council and then as the first, and two terms, President of the newly formed national peak body in deafness, the Deafness Forum of Australia. In this latter role Libby made a huge contribution to bring together all the different organisations into a central body, and actively lobbied on behalf of Deaf and hearing impaired at the highest level – the archetype of a successful achiever despite her profound hearing loss.

For her work on behalf of hearing impaired people Libby was made a Member of the Order of Australia in 1990. Later she was appointed by the Government to the Board of Australian Hearing Services and was asked to represent the needs of hearing impaired on the Olympic Access Committee.

Unfortunately, Libby faced another hurdle when she was diagnosed with breast cancer in 1995. Following surgery, she continued her family and volunteer work with undiminished vigour.

She would wickedly show off her wig at public functions after her chemotherapy, and talked openly of her "mean disease". She died peacefully on 1 August 1998 and was honoured by hundreds who attended her Thanksgiving Service on 6 August.

In her own words, Libby related her outlook:

"I look back over these years since I became hearing impaired and realise that any efforts that I have made have been returned to me threefold. I have found talents I never knew I had, I have gained so much from the many people I have met and worked with to improve life for people with disabilities and through self help I have turned the potential negative of a profound hearing loss into a positive sense of purpose and direction in my life".

The Libby Harricks Memorial Oration

The Libby Harricks Memorial Oration program is supported by the Libby Harricks Memorial Fund of the Deafness Forum of Australia. Donations to this fund are tax deductible.

Donations should be made payable to Deafness Forum. Additional donation forms and general information regarding deafness can be obtained from:

Deafness Forum of Australia
218 Northbourne Avenue
Braddon ACT 2612

Tel: 02 6262 7808

TTY: 02 6262 7809

Fax: 02 6262 7810

Email: info@deafnessforum.org.au

Web: www.deafnessforum.org.au



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