Part 3. Other related visits

3.1. Visit by Dr. E. F. Evans to Department of Otolaryngology, University of Washington, Seattle (Tuesday to Friday, 11-14 October 1977)

3.1.1. N.I.H. Grant

This group, led by Dr. Josef Miller, is investigating the behavioural responses and histological changes in monkeys, and the physiological responses and histological changes in guinea pigs, to short- and long-term implantation excitation of electrodes in the scala tympani. Six principal investigators, plus technical staff, are supported by a N.I.H. 5-year programme grant which has been running for 1 year.

The first monkey was implanted in January 1977.

3.1.2. Electrodes and Stimulation

The group has had to make up its own electrodes for implantation into the scala tympani of the macaques. They have used electrodes analogous to those used in the early trials of the Los Angeles Centre i.e.: 4–5 platinum:iridium wires terminated in balls, insulated with teflon and overcoated with silicone rubber.

The electrodes are inserted into the scala tympani through the round window, via a mastoid exposure. They aim to place the implant about three-quarters of the way round the first turn, with 1 mm separation between electrodes.

The mode of stimulation has been both monopolar and bipolar; currently, bipolar pair stimulation is used entirely. The waveform used is the unprocessed analogue signal.

Direct electrical connection is made to the implanted electrodes via a percutaneous link.

3.1.3. Behavioural Data

(a) *Normal monkeys*

1. The reponse to acoustical stimulation is immediately transferred to electrical stimulation. One therefore infers that the response is genuinely auditory.
2. There is an optimal separation of the electrodes in a bipolar pair for minimal threshold to electrical stimulation.
3. The threshold for electrical (sinusoidal) stimulation is minimal for frequencies below 125 Hz. The thresholds rise at about 6 dB per octave for frequencies above 125 Hz.

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4. The threshold to electrical stimulation is minimal on the day of implantation. During the following few weeks, the thresholds rise; subsequently they fall towards the original threshold. These fluctuations in threshold can amount to some 20 dB.

5. The dynamic range for the intensity of electrical stimulation above threshold (measured with reaction-time techniques to estimate subjective intensity) amounts to 30–40 dB with sinusoidal stimulation at frequencies between 60 and 100 Hz, and 10–15 dB for frequencies up to 16 kHz.

(Unfortunately the possibility of electrophonic stimulation in these animals with initially intact organs of Corti makes a straightforward interpretation of these data difficult).

(b) *Monkeys treated with local neomycin at time of implantation*

These have so far been examined only as far as 2 months post-implantation. Their behavioural thresholds to electrical stimulation have so far been similar to those of normal monkeys. No histology on these animals is yet available.

3.1.4. Histological Data

Several implants in the monkeys have ruptured the basilar membrane, producing extensive damage to the organ of Corti and the spiral lamina.

In normal guinea pigs implanted with platinum:iridium electrodes embedded in a silicone rubber sheath tightly fitting the scala tympani (i.e. analogous to the San Francisco implants), total loss of hair cells has been observed in the region of the organ of Corti immediately adjacent to the implant. Apical to the implant, the scala media was found to contain non-differentiated debris. These changes occurred in the absence of overt damage to the basilar membrane, but it was possible that the tight fit of the implant in the scala tympani could have interfered with the cochlear blood circulation. This receives support from the finding that the venous system was collapsed under these circumstances. These changes in the scalae were accompanied by variable loss of ganglion cells in the region of the implant. Where the basilar membrane was damaged by the implant, then total loss of ganglion cells occurred.

3.1.5. Physiological Data

Recordings of single units in the inferior colliculus of implanted guinea pigs have confirmed findings in the literature from cats: (1) that the dynamic range of effective electrical intensities was restricted to 10–15 dB from threshold to maximum response; (2) that the spread of excitation from a bipolar electrode pair increased as the inter-electrode spacing decreased below 1 mm.

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The group has begun single unit and brainstem evoked potential recordings in the monkeys. So far, the major finding is the absence of effects of electrical cochlear stimulation on the behaviour of neurones in the vestibular nuclei.

3.2. Visit by Dr. E. F. Evans to Department of Otolaryngology, University of Oregon, Portland (Friday 14th—Sunday 16th October 1977)

3.2.1. Summary of Research

Dr. R. Walloch holds an N.I.H. 3-year grant for animal behavioural experiments relating to cochlear implantation. It has been running for $1\frac{1}{2}$ years, and supports a team of 3. They are training normal cats and guinea pigs, using positive reinforcement reaction-time paradigms, to respond to acoustic and electrical stimulation of the cochlea.

Thus far, they have been investigating the effects of varying parameters of the electrical stimulus. As expected, the longer the duration of the electrical stimulus pulse, the shorter the reaction time, equivalent to a higher acoustic intensity.

They intend to investigate the effects, on discrimination of the electrical stimulus repetition rate, of progressive loss of the cochlear nerve fibres.

In an earlier study on anaesthetized guinea pigs, using cortical evoked potentials, Walloch and Cowden (1974) had demonstrated that the electrode location producing the lowest electrical stimulation thresholds was in the modiolus; next, electrodes spanning the cochlear partition, or monopolar stimulation against an extracochlear reference. The highest thresholds were obtained from bipolar electrodes within the same scala. The mean threshold of modiolar stimulation was about 35 μA compared with about 170 μA for bipolar scala tympani stimulation.

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