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HEARING AIDS - FUTURE DEVELOPMENTS

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It is often convenient to describe the application of hearing aids from three diverse viewpoints, which may be labelled as performance criteria, measurement technology and rehabilitation. This diversity is both a strength, in that it encourages expertise of particular kinds to concentrate in specific areas, and at the same time a weakness, in that findings which may be truly valid only in one defined context sometimes become dubiously transposed to others. An example of this is the way in which performance curves measured under arbitrary conditions are applied, for lack of more life-like data, to real fitting situations - where they are frequently compared with pure tone audiometric threshold measurements.

One of the more important, if unspectacular, developments in the technology of hearing aids has been the move towards more realistic methods of performance measurement. A hearing aid in use is worn upon the head or the body, where it is subject to baffle and diffraction effects. Its output - if it is an air-conduction aid - is delivered via a tube of uncertain length to a soft-walled cavity of unspecified volume. The technique of measuring performance by placing the hearing aid in isolation in a test enclosure and terminating its output by a hard-walled cavity of fixed volume is therefore only an approximation to a real-life condition. However, it is a very necessary approximation which has enabled effective quality control measurements and certain comparisons between models to be made quickly and repeatably. Difficulties arise when measurements made in this manner are applied to individual patients, for the techniques of correcting these somewhat arbitrary measurements to allow for i) real-life conditions of use, and ii) variations between individuals, are imprecise. Details of the work on development of life-like ear simulators and on test techniques using head and torso simulators have been described elsewhere; the anticipated effect of employing these devices in hearing aid measurement will be a greater compatibility between the measured performance under test conditions and the achieved acoustical performance with the real ear. This in itself should resolve many of the anomalies now encountered in hearing aid fitting and enable the application and fine adjustment of hearing aids with a wide variety of frequency-response options to proceed on a more scientific basis.

The use of an ear-like termination device for measurement purposes will not resolve all the problems of defining the hearing aid output, however. It is still necessary, in a standard ear simulator, to adopt modal values for cavity volume and impedance. Individual variations will still have to be allowed for and protocols for this need to be determined. The acoustical properties of the earmould are of particular significance here. Various research workers are studying the acoustic output system, in particular for the post-aural hearing aid, with a view to improving its design characteristics. This output system may typically consist of an earphone of small volume, coupled through an adjustable length of 2mm bore tubing to an earmould, which in turn couples to a residual meatal cavity of uncertain volume. Attention is being focussed on this system in transducer design, in studies of the frequency response of the whole system terminated by a lifelike ear simulator and, more recently, in studies of the matching of the earmould into the residual volume of the individual meatus. Success in this area of work should lead to a greater precision in the fitting of hearing aids, especially in the use of acoustic filter elements and earmould vents.

The promise of greater precision in the quantitative description of real-life hearing aid performance of course requires a corresponding improvement in the determination of an individual patient's requirements: much of the value of carefully validated performance measurements is lost if trial and error techniques play a significant part in hearing aid fitting. The question of performance criteria and the establishment of optimum design parameters is open once again - not having been studied on a large scale since the MRC 261 work of 30 years ago. The Health Departments and the Medical Research Council are collaborating on a new study of the psycho-acoustic characteristics of hearing-impaired people in relation to hearing aid specification. This study will lay emphasis upon the needs of those with sensori-neural impairment. One objective will be to determine, for each definable type of sensori-neural hearing impairment, the characteristics of a hearing aid which will present information to the impaired ear in a form in which it can be best utilised. In as much as profiles of hearing impairment have to be defined and categorised for the purposes of such a study, it is to be expected that indications and rules for hearing aid fitting will also emerge. In the course of this study, it is likely that various means of processing the acoustic signal will be explored in the search for optimised levels of received intelligibility. Work is already in hand, in several laboratories, to develop techniques for dynamic range compression. The amplitude input-output function appears to be highly critical in many forms of sensori-neural impairment, but conventional hearing aid practice is restricted to applying signal limiting either at the input or the output. Electronics technology now offers the possibility of providing a graded compression in a wearable hearing aid, with the objective of overcoming the problems of loudness recruitment with minimal perceived distortion. Another possibility presented by the development of micro-electronics techniques is that of digital signal processing. While this must be regarded as still on the horizon, as far as hearing aid applications are concerned, it has many attractions particularly in flexibility of function and avoidance of feedback.

If inner ear degeneration is severe, the provision of an amplified input even with sophisticated compression systems will not restore intelligibility. One technique, which has been the subject of inconclusive discussion for the past decade, seeks to overcome this fundamental difficulty by transposition of the higher frequency components of the signal to a lower frequency region, where some residual hearing acuity is usually to be found. In an attempt to determine whether this technique has advantages in practice, controlled trials of a recoding system are being carried out.

A radically different approach to the problem of transmitting information via the severely impaired cochlea is that of direct electrical stimulation. Although the techniques are still in their early stages and the problems of multi-channel cochlea implants have yet to be solved, experimental evidence exists which shows that even a single channel implant can, in some cases, give useful information cues to a person who would otherwise 'hear' nothing at all. There is extensive activity on this particular topic in many parts of the world and, although it is not in any sense a 'cure' for deafness, there is the possibility of offering some alleviation in the future to a number of profoundly deaf patients.

One of the difficulties in applying hearing aids is to determine the extent to which fine adjustment of the aid is warranted before the rehabilitation process begins. For most patients newly fitted with hearing aids, a process of re-learning is necessary. It is of course possible to adjust or change the aid during the learning process if progress is unsatisfactory. Clearly it would be preferable to start by fitting the optimum hearing aid, if that can be specified when commencing any rehabilitation programme. Service developments in the National Health Service are placing more emphasis on rehabilitation guidance for hearing aid users but this is not intended to encourage 'ad hoc' changing of hearing aids, which will help no-one. The Health Department/MRC study has been referred to: another aspect of this which is likely to be a necessary feature of the experimental protocol will be the means of measuring benefit from use of a particular hearing aid system. It is perhaps not unreasonable to expect that an indication of probable maximum benefit could be obtained; at which point efforts to improve the hearing aid fitting would, for the patient concerned, cease to be worthwhile.

Advances in transducer design and electronic component technology are producing steady improvements in hearing aid performance and reliability. Reductions in size and cost of micro-electronic packages are likely to make more advanced circuitry available to hearing aid designers. One major limitation however will be the power source. Button cells with an electro-motive force of about 1.5 volts are used to power the smaller aids. Higher voltages may in the future be obtainable by using electro-chemical pairs based on Lithium but there are no suitable Lithium cells available at the present time. More imminent developments will be seen in the growing use of Manganese Dioxide-Alkaline cells instead of Leclanché in pocket hearing aids and the emergence of the zinc-air button cell as a challenger to the mercuric oxide cell in postaural aids. Given adequate reclamation schemes, the amount of mercury released into the environment from hearing aid batteries can be kept very low but, in view of the problems of handling mercury, there is a growing tendency to limit its use wherever satisfactory alternatives can be found. In this context, the performance of the zinc-air button cell will be watched with interest.