An Essay On Hearing

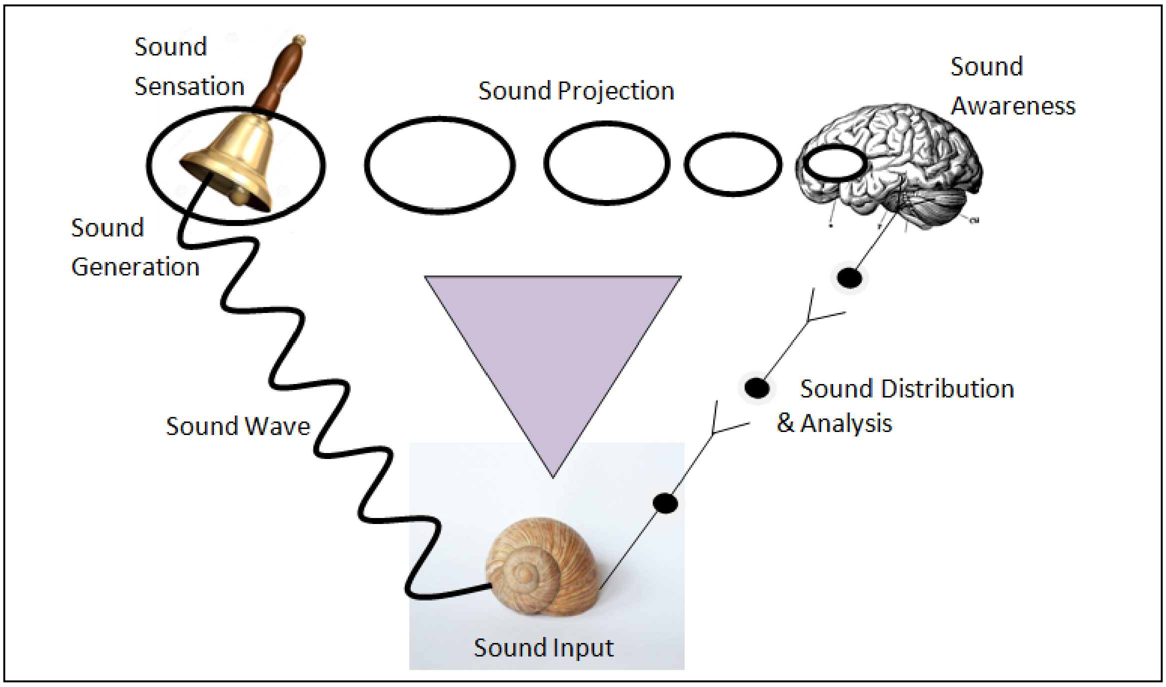
'He that hath ears to hear, let him hear.'
(The King James Bible, Luke VIII v.8 (1611))

This command, in the early modern English of the Age of Shakespeare, makes an apt introduction to an essay on hearing. It uses the word 'hear' twice and both usages carry different shades of meaning. Together they command the attention of the listener; and I hope the same message may invite the thought and attention of the reader. Prior to the invention of printing, our forebears were kept abreast of events by the town crier ringing his bell and crying in Norman French 'Oyez! Oyez!'. Shakespeare invited Caesar's enemies to the same effect with 'Lend me your ears'.

Part 1.

The series of major events involved in the process which leads to the sensation of hearing, and the different senses of the word 'sound' can be graphically and instructively arranged and presented in the shape of a triangle. (Fig 1) The three angles of the triangle represent the creation and two radical changes in the *form* of a piece of sound-in*form*ation. The three sides of the triangle represent the movement of sound-information in each of its three different *forms*. It moves unheard from its point of origin, through the ear and brain, and is finally sensed or heard, seeming subjectively to have come directly and instantaneously from its original point of origin. Thus the triangle is completed. To illustrate this in more detail the sound-in*form*ation generated by a bell ringing has been taken as a familiar example.

<u>The Auditory Triangle</u>



Form-change 1 – Sound Generation

During bell-ringing the energy input associated with the impacts between the bell casing and its clapper is redistributed – mostly by changes in the post-impact direction and velocity of their respective movements. But, critically, and providing also that the bell is not in a vacuum, some energy is diverted to disturb and re-choreograph the dance of the air molecules surrounding the bell.

Displacement 1 – Sound Wave

This disturbance spreads through the air as a pressure wave – the sound-wave – in which specific details of the *form* of the original impact are encoded. Thus preserved, the sound-in*form*ation radiates from the bell, through the surrounding air, diminishing in intensity as it spreads, but largely retaining the specificity of its *form*. A small sample of this sound-in*form*ation enters both ear canals of any hearing bystander. In the depths of ear canals the sound waves agitate the eardrum, passing the sound-wave onward and through the solid structures (the ossicles) of the middle part of the ear. Finally the sound waves reach a complex series of fluid filled spaces hollowed out of the dense bone which envelopes and protects the inner part of the ear. That part of the inner ear cavities to which the sound waves are most directly delivered resembles the shape of a snail shell. The Ancient Greek word for a snail was 'cochlea'; and this name is used to refer both to the spiral snail-shaped spaces and to their contents including the all-important spiral sound-trans*form*ing 'organs of Corti'.

Form-Change 2 – Sound Input

Within the inner ears the analogue nature of the in*form*ation carried by the sound-wave is translated and expressed in a digital form. As the sound-wave spirals up the cochlea, it creates a four-dimensional time-space distortion pattern in some 3,000 or so sensitive cells aligned on a delicate spiral membrane. The cells carry a fine array of hairs on their upper surface. Hence they are called 'hair cells'. Physical distortion of these hairs produces electro-chemical changes in the surface membranes of each individual sensory hair-cell as the wave of sound-in*form*ation passes by. Finally, and in the totally different digital electro-chemical language of neurology, the sound-in*form*ation is passed to the microscopic endings of nerve-cells which embrace the cochlear hair cells in a complex pattern. The 'ex-*form*ation' of the message has been radically changed but the 'in-*form*ation' persists.

Displacement 2 – Sound Distribution and Analysis

The electrical nervous activity of this newly re-encoded sound-in*form*ation spreads rapidly along the surfaces of some 30,000 individual nerve fibres from each cochlea, carrying the translated version of sound-in*form*ation from the hair cells of the inner ear to the brain, which is entered low in the hind-brain. Within the brain itself the pattern of the sound-in*form*ation is subject to an extensive assessment as it jumps from nerve-cell to nerve-cell, analysing, synthesising, reading and using the sound-in*form*ation. Initially this activity is limited to front-line collections of nerve cells in the lower or hind-brain – the cochlear nuclei. Immediately thereafter, and still in the same language, the sound-in*form*ation is rapidly and widely distributed throughout the entire nervous system via direct nervous pathways, networks and circuits, allowing for further complex analysis and synthesis, and integration.

A major element in this activity requires the passage of a pure sample of the encoded sound-in*form*ation directly to those higher centres in the forebrain which underpin not only the sensation and perception of hearing, but also the other sensory activities contributing to consciousness and including the neuro-physiological basis for emotional activity.

Form-Change 3 Sound Awareness

In these higher centres the neurological activity originating from both ears is trans*form*ed once more. There is awareness of sound-in*form*ation in the language of the mind – 'psycho-sound' it might be called, or even 'psycho-babble'.. The original output of the bell becomes audible. The mechanism of this final trans*form*ation, and the nature of the awareness of hearing which results, are as obscure and intriguing to us today as they were to the first philosophers nearly two and a half thousand years ago. The essayist Michel de Montaigne must have felt the same when he carved on a beam in the ceiling of his library, in Latin, the following inscription loosely adapted from Ecclesiastes, Ch.11 v.5

'You, who know not how the mind is joined to the body,
know nothing of the works of God.'

Displacement 3 – Sound Projection

However, although the neuro-psychological trans*form*ation which generates sound-awareness must have its physical basis in the higher centres of the brain, the conscious image of the bell's physical sound is heard neither in the brain nor in the ear of the listener. The psycho-sound image of the bell has to be projected and brought to coincide with the extended position of the three-dimensional psycho-visual image of the bell in space,

Hearing -Sound Sensation

It is suggested that this experience, the fusion of sound-awareness with sound-projection onto the three-dimensional locus of a sound's origin as calculated from the body's total sensory input, is a reasonable and defining description of the sensation of hearing. Logically, the mental activities of listening to (or perceiving), thinking about or reflecting on, and then understanding and acting on what has been heard, must follow hearing-sensation in that order. The precise nature and the boundaries of these terms and actions are used loosely. However that may be, logically one cannot listen to a sound until it has been heard. In sequence, hearing sensation precedes listening as listening precedes thought and thought precedes understanding. To hearers, to perceivers or listeners and to those who understand and act they all feel simultaneous. Perhaps they are, in the time concept of the mind.
In summary we may say:-

'In the belfry *(Projection)*
.....rings *(Sensation)*
....a bell' *(Perception)*

Is it joy, or else a knell? *(Thought)*
Is it ill, or is all well?
Up to heav'n? Or down to hell *(Understanding)*

! *(? Action)*

Common words such as 'hearing' are the units of formal and casual speech. They may also be used as technical or scientific terms each carrying a specific definition. Audiology – the Science of Hearing – implies and requires a clear definition of the word 'hearing'.

But human speech evolved primarily to meet the social demands of our remote ancestors; to co-ordinate or facilitate the performance of such activities as mating and rearing children; providing food and clothing; hunting and fighting; building shelters; complaining about the weather; and later conforming to the rules of custom and ritual; and obeying the letter of the law. Current spoken languages result from evolutionary processes within prehistorical and historical communities. The necessary mental activity associated with learning and keeping up with the changing content of language as it evolves, has been inherited and bequeathed across thousands of generations; and as the physical attributes of these generations change and survive through genetic activity, so speech and understanding have been received and passed down through the mediation of language. It is as a result of this chaotic and environmentally determined evolutionary process of natural selection, and within the widely varying linguistic and circumstantial contexts in which speech is delivered and heard, that the same words so easily come to be used with differing shades of meaning. (Take for example the name of the letter 'U' as spoken, and compare it with 'you', 'ewe' and 'yew'; or the French 'Je ne suis pas que je suis; car si je suis que je suis, je ne suis pas que je suis'.)

Simple yet comprehensive definitions can be difficult to formulate. The core meaning of words such as 'hearing' is so obvious that it hardly needs stating to an English native. But a definition, by definition, is not so much about the nuclear meaning of a word, as about the finite limits of meaning, beyond which it would be inappropriate to use the word at all. As with words, so it is with cells – the units of living material. Cells are defined, not by their living protoplasmic cell contents, but by the possession and extent of a limiting cell-membrane; and a prison cell by its stone walls and iron bars whatever the aspirations of its inmates may be. Defining a word using language is a tautological practice; language consists of words. Nevertheless, it is surely desirable for any speaker, in whatever circumstances, to be clear, at least in his own mind, what meaning is intended by the words he uses. If in doubt or ignorance, dictionaries offer some help towards clarification. However, dictionaries have to be concise. They also try to be comprehensive as to meaning. In attempting to balance these conflicting needs, there is room for lack of precision. Dictionaries can conceal the richness of meaning of some words as they are actually used in heard, spoken or written language. With his Context Principle Gottlob Frege, a founder of the Philosophy of Language, advises;

'Never look to the meaning of a word in isolation,
but only in the context of a proposition'.
(Frege 1884b; x – The Foundations of Arithmetic.)

In attempting to define the role of the ear in relation to hearing, in the days when audiology was entirely a matter of philosophical discussion, Plato offered an interesting exchange of words in one of his dialogues between Socrates and Theatetus, a bright Athenian lad.

Socrates -'Do we hear with *the ears, or* through *the ears?'*
Theatetus - 'I should think that it is through *which we perceive*
rather than with *which..' (Theatetus 184c-d),*

Socrates readily accepts this response. However, we do hear *with* the ears insofar as we cannot hear without them; but we must also hear *through* the ears if sound information is to reach and be heard by the psyche (as Socrates would have referred to the mind).

Soc:. So the whole lot (i.e. sensory experiences*) taken together you call perception?*
Thea: Necessarily! (ibid.)
*Soc: (*Understanding or*) Knowledge is to be found not in the experiences but in the process of reasoning about them. (ibid)*

Some two thousand years lam,ter our Jacobean philosopher Thomas Hobbes differentiated sound-generation and the hearing of sounds in these terms:-

The clapper hath not sound in it, but motion, and maketh motion in the bell.
So the bell hath motion and not sound'
'By hearing we have a conception called sound which is all the knowledge we have of the quality of the object from the ear.' (Human Nature (1640) Ch 11, paras. 9 & 4)

To Hobbes the bell produces only vibrations, which the ear and brain must change into sounds so that they can be heard. He was clearly aware of the essential mutability of sound-in*form*ation. A century or so later in the century of The Enlightenment, Dr Johnson in his dictionary defined 'hearing' as –

'The sense by which sounds are perceived'.

Another two hundred and fifty years and The New OED offers a definition of 'hearing' as:-

'The faculty of perceiving sounds'.

The later lexicographical authorities agree that 'hearing' is perceived. Yet we speak more easily of our 'sense of hearing', rather than of our 'perception (or faculty) of hearing'. Supported by my understanding of Socrates, and in my personal internal dictionary, sensation and perception are not synonymous. I prefer to think of them more as cause and effect?

Of the causes for the lack of precision in the meaning of words as they are encountered in ordinary conversation, primacy should probably be awarded to the way in which an individual acquires language. Our first sonic experiences are during the three or four months before birth when the structure and function of the hearing pathways are developing. The sounds of the maternal heart beat and placental circulation provide a constant rhythmic background to that process; and the mother's voice introduces muffled versions of the various rhythms and patterns of spoken language, albeit without visual context. (This contrasts with the foetal development of the eyes, and the visual pathways, which take place in darkness.) To a newborn baby all visual- and most sound-experience is meaningless. Yet those sound patterns resembling foetal sound-experiences do seem to have a pacifying effect, as when saying 'hush...hush' in imitation of the sound and rhythm of the placental circulation, or by the mother singing lullabies. Thereafter babies' exposure to social and other sounds increases; and yet, in the face of a bewildering acoustic and general sensory exposure, babies manage somehow to extract the concept of spoken and body-language, and later the semantic boundaries of the speech patterns of which their lifelong conversations and thoughts will be composed. It is in this way that, as adults, they can make manifest and exchange their thoughts and wishes, their intentions and instructions, and their questions and answers in acts of conversation. By a miraculous feat of memory, and with sufficient experience, this success is ultimately achieved by a hotch-potch of pattern-recognition, guesswork and the frequent correction of spoken mistakes. Milton, Hobbes contemporary, speaks to us with poetic charm.

Hail, native language, that by sinews weak
Didst move my first endeavouring tongue to speak;
And mad'st imperfect words with childish trips
Half unpronounced slide through my infant lips.

Language is constantly evolving. New words are coined to suit new circumstances. Old words are used with extended meaning. Obsolete words are discarded. Social groups such as scientists or teenagers take words in common usage, and change them, sometimes giving a radically new meaning. Consider for example the meaning of the word 'recruitment'. On the one hand the ordinary meaning is 'enlistment to military or other service'; and on the other the audiological meaning is 'abnormal growth of loudness'. How 'appropriate' or 'cool' an example was that?' One cannot do much about teenagers, but scientific communications, like legal documents, need to be expressed in a language whose meaning is clearly defined in universally accepted terms: except in an essay, there is little need for any expression of emotion, poetry or humour. There is no place for metaphors, similes, or figures of speech. In specialist fields of endeavour it is unfortunate that common words with universally accepted meanings are so often abducted and distorted, when sensible neologisms could so easily have avoided confusion and misunderstanding. Even dialects within and between English-speakers can change the shape and may confuse the meaning of words. As a boy, I was introduced to the introductory quotations as delivered by a west-country church warden at the end of a reading of the lesson in church in the following form - 'E that 'ath he-urrs to yurr, le' 'n yurr'. He taught me better than I knew, for later, as a consultant, having dictated that a patient had 'abnormal hearing in the left ear', I was surprised to read in the letter typed by a Derbyshire secretary that the patient had 'abnormal urine in the left ear'!

Excepting those born severely deaf and those who lose their sense of hearing in infancy, human beings are all well aware of what it means to hear. We are proud of the use we make of our hearing, allowing us, as it does, ready communication through the understanding and delivery of speech. As a citizen of an ancient Greek polis, Aristotle asserted that

'*Man is by nature a political animal'* (*Politics 1253a7*).

But, whether he was right or not, neither Aristotle's ancient polis nor the modern societies of our twenty-first century civilisations could have existed nor exist without the universal use of hearing-dependent language. Language is the powerful adhesive that bonds society. It is the facilitator of thought and memory processes, and of reasoning and understanding. It allows the expression of ideas and of concepts such as morals, justice and religion. It is used to indoctrinate and educate. Language skills provide us with a major and indispensible social capacity for which all credit is due to the discrete servility of our sense of hearing. Within the totality of consciousness, human hearing is normally far less intrusive than sight. However, its prominence increases when the mind chooses to listen, and it comes into its own in the dark, or when the eyes are closed, or for events of interest that are out of sight – behind the back, above one's head or round a corner. Whenever vision is diminished or absent, hearing effortlessly supplants the sensory hegemony of sight. To the blind, of course, hearing is a sensory life-line. In an effort to compensate for their visual loss, they become as acutely aware of sounds as the severely deaf become aware of visual events.

Part 2

It is the prime function of distance- or‘tele-senses’ to inform an individual of any movement in the environment, to indicate or warn where danger might exist, to say where food might be found or to advertise opportunities for reproductive activity. All sensory information is carried from both general and special peripheral sense organs directly to the brain via the cranial and other peripheral nerves. Two of the three ‘tele-senses’, those sub-serving the senses of smell and sight, access the most anterior part of the brain. The Olfactory and Optic nerves are therefore named the First and Second of the twelve Cranial Nerves, seeming to suggest that they serve the gold and silver senses respectively. By contrast the cochlear nerves of hearing are merely branches of the Eighth Cranial Nerves which they share with the Vestibular Nerves. The vestibular nerves also carry information from the inner ear about sensations produced by gravity and movements of the head – vitally important sensations, but sensations of which we, for the most part, are not normally consciously aware.

However, although, as a piece of anatomy, the nerve of hearing seems to have been treated very much as an ‘also ran’ as it creeps discretely into the hind brain; and although, as a contributor to the overall experience of consciousness, hearing generally and subjectively feels secondary to sight, it is above all in language dependent social settings that hearing blossoms. For human beings at home, in company, as a student at school or in higher training or education, and in the work place hearing effortlessly achieves supremacy over all the other senses. Watch the news on television without sound; and then listen to the news-reader without watching the screen. Is not the latter experience more informative?

Any deterioration in hearing ability is soon evident as a social handicap. It is a common, sad and inevitable accompaniment of the ageing process, impairing, as it does, those effortless communication skills on which the sufferer once depended. I first heard the following conversational exchange as a ‘yell’ round a scout camp fire. With the callous outlook of youth it seemed amusing.

Leader ‘*Old Bill bought a coat.’* Deaf chorus - *‘What? Old Bill bought a boat!’*
‘No. Old Bill bought a coat!’ *‘What? Old Bill caught a goat!’*
‘No. Old - Bill - bought - a - coat!! *‘What? Old Bill cut his throat!’*
‘Yes. Cut his bleedin’ ‘ead off.
(Today I might add a final put-down response - *‘So he won’t be needing his coat then!’)*

The increasing impatience and irritation of the hearing speaker is matched by the increasing desperation of the hearing-impaired listener. But, in this exchange, the conversational failure was due, not to the hearing-impaired listener, but to the impatience and intolerance of the hearing speaker. The problem is that, in conversation, the hearing participant finds himself handicapped as much as, if not more than, the hearing impaired listener. Indeed the latter can receive a small measure of protection from the abuse which they do not always hear. Normal hearing individuals resent having a conversational handicap imposed on them. All too often the elderly are pressed to wear ‘hearing aids’ by their exasperated families. But what are truly ‘ear-aids’ do not always realise the expected benefit in ease of conversation. In the elderly, neurological and mental factors other than a simple loss of ear function are likely to play a significant, or even a major role, in the genesis of the overall hearing handicap. To the question “Who’s going to do the washing up?” in pre-dishwasher days, my grandmother would seem deaf or reply with a non-sequitur; to the question “Who would like a glass of sherry?” she would reach instantly for her glass giving me a sly wink.

In the context of the social effects of hearing loss, the following account is illustrative. As a young consultant otologist, while on tour of a school for deaf children, the teacher conducting me was temporarily called away, leaving me, a stranger, in a class of about half a dozen profoundly deaf young children aged seven or eight. It felt as though I had been abandoned in a cage in a zoo alone with a group of inquisitive, mischievous and possibly aggressive monkeys. In the event they ignored me, playing with each other freely in the absence of authority. I suppose I might have seemed to them not unlike a trespassing elephant or hippopotamus. We had no conversation; but again, it was the hearing visitor whose performance failed. The children's lack of spoken language was my handicap – not theirs!

Compare this account with that of a visit about the same time to a similar class in a school for blind children. Whilst the teacher was speaking to them, they might have been a group of normal children. But once I had been introduced and informality was permitted, I was surrounded by the children, bombarded by questions – some verging on impertinence – and all demanding an audible response. In addition there was much more tactile (and possibly olfactory) communication than would normally be socially acceptable. They were readily able through hearing and language to mitigate their severe visual handicaps and to avoid any embarrassment on my part. There was no social difficulty in communication for them or for me. I felt sorry for their visual impairment. They didn't.

Human beings, being animals, and needing to survive, are egocentric. Their various spoken languages are inevitably anthropocentric. Other animals have ears, many of them not unlike human ears, and with broadly similar nervous structures and connections. However, because they lack human communication skills, they cannot tell us how they experience their sensation of hearing, nor how they interpret what they hear; nor can we ever know. We can only see how sounds affect their behaviour. How interesting it would be if, like Dr Dolittle, we could communicate freely with the animals. If we could walk and talk with them, what views on human language might a cat, for example, express?

Cats have greater hearing sensitivity than humans which undoubtedly enhances their hunting skills. Yet they show little interest in our language, and less in mastering it. They see human beings 'everywhere in chains' enslaved by their linguistic shackles. Humans are told in their mother-tongue what to do and what to think; and on the whole they do and think what they are told. Cats are especially fortunate in having no IT skills. Cats are not social animals, but independent and free agents. They regard the human race with disdain accepting their hospitality only because it comes conveniently with food, physical comfort and other material benefits. Cats scorn dogs who 'fetch' and 'sit' to order, despising such a display of canine subservience to mankind and to the bondage of the latter's spoken language.

Since the hearing of cats is at least comparable in frequency-range and sensitivity to that of humans, if not better, and since they have no use for language, how do they use their rich quantity of sound-information? How does such keen hearing contribute to their biological well-being?

McCavity, McCavity, there's no one like McCavity (T.S.Eliot)

Consider the two following feline encounters. On the first occasion, while walking along a village street, a sleek black cat strolled across my path about a dozen feet in front of me. I pursed my lips and made a quiet 'kissing' noise. Instantly the cat's trunk, legs and tail froze - one paw off the ground and the tail arched motionless in mid-air. At the same time, the cat's neck turned its head and eyes swiftly and unerringly to point towards me. The ears pricked and the whiskers bristled. However, it took well under a second for the cat to sum up the situation and the negligible significance of my caterwauling. The state of alert was cancelled and the cat resumed its stroll as though nothing had happened.

The second experience involved a cat named George. Of winter evenings we would sit in front of a warm fire; George, lying on the mat with her head resting on her out-stretched front legs and her tail extended in a straight line behind her trunk, and I, relaxing in a comfortable armchair. On one such evening, with the compulsion which I seem to have to communicate with cats, I happened idly to roll my thumb tip against the tip of my index finger. To me the act was silent. But the cat's ears pricked, her whiskers bristled, she opened her eyes, raised her head and looked straight at my offending digits. Seeing neither threat nor treat she resumed her somnolent posture. The audiometric procedure was repeated on several occasions with diminishing responses, and over a week or so they disappeared. She had adapted to my irritating digital habit. She seemed to sleep through my sound generating efforts. Not a whisker of movement. Nothing.... That is to say...... nothing at the front end. But then I noticed a slight twitch of the last inch of her tail. This fascinating response, (which might be described biologically as a post-anal myogenic response or PAMR), proved repeatable and much more resistant to adaptation.

The same acronym, PAMR, has an interesting and relevant audiological ancestor – the Post-Auricular Myogenic Response. A myogenic response has its origin in an actively contracting muscle. Any electrical reaction from the post-auricular muscles situated just underneath the skin behind the ear is large compared with that generated deep inside the skull by an active brain. In the early days of exploration and assessment of audiometric tests by investigating a variety of evoked electric responses to sound, the post-auricular myogenic response was briefly considered as the basis of a practical audiological test for infants and young children. In the performance of the test, sound-clicks, graded in intensity, were delivered to one ear. Only a few human adults can wiggle their ears voluntarily. These muscles generally waste away. But, more often than not, they are still electrically active in many young children. The electrical signals measured were large and easy to record in practice. The test was more sensitive in lively rather than passive or sleeping children. These factors gave it an attractive prospect as a clinical paediatric test. When present, the responses were generally found to be larger in the muscles on the side opposite to the test ear. Assuming that an evolutionary value of our auricular appendages is to facilitate optimum sound-detection and direction-finding it is clear that the ear opposite to the sound source needs to be more active and move more than the ear which is already directed towards to the sound. The latency (or time delay between the delivery of the sound-click stimulus to the ear and the detection of an electrical response in the muscle) was about 12-15 thousandths of a second. Of this time, only about 1-2 thousandths would be required for the rapid movement of sound information along the various nerve fibres. The delay in the passage of signals between one nerve cell and the next (called the synaptic delay) is of the order of 2 thousandths of a second. Arithmetically, this allows time for a maximum of about six synapses in the reflex pathway, of which three are accounted for by the peripheral sensory and motor elements of the pathway. This leaves very little neurological space for the provision of a basis for the brain activity involved in detecting and analysing a piece of sound information, and synthesising the appropriate response to move the auricles to an advantageous position.

Unfortunately only about four out of five normal hearing children responded to the test. A positive result indicated normal ear function and strongly suggested normal hearing. But absence of any response was not helpful diagnostically and generated considerable, and mostly inappropriate parental anxiety. Brain-stem electric responses (BSER) though much smaller, and technically more difficult to detect, were found to be far more sensitive as a measure of the function of the hearing pathways. As a result the Post-Auricular Myogenic Reflex test was dismissed as a practical prospect for routine clinical investigation. But while the clinical value may be limited, the Reflex provides an interesting neuro-physiological model. Its latency is about a quarter the duration of the latency of hearing awareness. The Post Auricular Myogenic Response is a pre-hearing phenomenon. The brain stem, though sensitive to sound-information, is not sensible, not consciously aware of it. Similarly a Brain-stem Evoked Response is a very useful objective test, being independent of active patient co-operation. It tests the hearing pathways but it is not a test of hearing.

Nevertheless, it is clear that brain-stem structures are still able to *Recognise* a significant input of sound information; to *Locate* its spatial origin with crude but useful accuracy; and to generate a purposeful *Orientation* of the ears towards the site of the sound's origin. The brainstem has the necessary information to do this while the mind is unaware of any sound. Sound-Detection, Sound-Location and Sound-Orientation, these are the first three orders of central audiological activity.

Part 3

In the earlier years of the last century, the rendering, by a young chorister, of Mendelssohn's solo 'Oh, for the wings of a dove' was popularly acclaimed. As a choirboy, and lacking the vocal charm of a soloist, I was only ever a small voice in the ensuing chorus. 'Hear my prayer, Oh God. Incline Thine ear.' Incline Thine ear! An imperative to the almighty! The sentence is poetical of course. But it is apposite, for it reflects the common and interesting observation that when we listen attentively to or for a faint sound or to a sound which is partially obscured by background noise we tend to turn one or other ear towards the sound source often alternating the ears. Inclination of the ear is frequent during tests of hearing measurement. The orders 'Incline Thine ear.' and Shakespeare's 'Lend me your ears.' are simply given and the responses simply observed. But while the acts may appear simple, their performance is only a part of a precisely coordinated programme of body-wide movement.

My particular interest in inclination of the ear emerged during a period when engaged in the preparation of medico-legal reports on the hearing of several hundred active or retired members of staff at Government Communications Headquarters (GCHQ), whose hearing problems might have been, in part at least, due to damage from exposure to loud noise at work. In such cases an independent assessment of hearing was necessary. Were one able to quantify absolutely the true extent of a deafened individual's hearing loss; and if one could identify indisputably a specific cause or causes to account for such a lack such as ageing or prolonged exposure to loud noise; and if one could assess the overall effects of such a lack equitably to achieve a fair basis for the assessment of any damage-liability or compensation, there would be no need for a medical opinion, nor for legal intervention, nor for an arbitrary judgement. However, nature and human nature being what they are, these utopian pre-conditions are unfulfilled. Indeed they are almost certainly unfulfillable.

Any medical report involving deafness is primarily a verbal document. It records an opinion – honestly and professionally – but an opinion and not necessarily the truth. Of the words used to describe the general extent of an individual's lack of hearing, those most frequently used are probably 'disability', 'handicap', 'loss' and 'impairment'. 'Of these words, the first two – hearing disability and hearing handicap – refer to the effects of damaged hearing on everyday life and at work rather than to the hearing sensitivity itself. Inevitably they correlate with the severity of the hearing disorder but within wide limits of variation. 'Dis*abil*ity' is an account of what an individual is un*able* to do because of a lack of hearing, whereas 'Handicap' is a more personal assessment of what is needed to overcome a lack of hearing, with the aim of making the deaf individual and a normal-hearing individual equal in respect of hearing *abil*ity. However, in practice neither term is easy to quantify: and although they come closest to a fair and practical assessment of an individual's problem, this lack of measurement criteria, mutually acceptable to both parties in a disputed claim, has resulted in the use instead of attempts to measure hearing sens*ibil*ity directly. Nevertheless to my mind, 'Dis*abil*ity' and 'Handicap' ideally offer the best measure of what should be compensated.

A 'Loss' occurs when one no longer has something one once had. To establish whether there is a loss, or to measure the extent of a hearing loss, it is necessary to know the hearing level before, as well as after the loss. To give an extreme illustration, a child born with an average hearing impairment of 60 decibels is very deaf. When adult, if he or she is still found to have an identical hearing impairment, although still very deaf, there is no measureable hearing loss. A single measure of hearing can neither confirm nor exclude, nor does it define the extent of a hearing loss.

The word 'Impairment' is a comparative term. The middle syllable 'pair' is derived from the Latin word '*peior*' meaning 'worse'; so that, by definition the expression 'hearing impairment' begs the question 'worse than what?' to which the answer is 'worse than it was!' But we usually do not know what it was. So we turn to Science who, in turn, must confer with Technology and Statistics – an association skilled in seeking credible answers to difficult or even unanswerable questions. A Pure Tone Audiometer is their solution. A pure tone audiometer is programmed to compare an individual's present hearing level with a statistical expression of normal hearing which has been derived from careful measurements of the hearing thresholds of a large population of young persons with no history ear disease. But the range of such hearing threshold sensitivities is fairly wide and statistical imprecision (or fudging) is still needed to arrive at the least-inappropriate best reference value; and this still doesn't take account of any inevitable hearing loss from ageing. Audiometers produce Audiograms which do not tell what the hearing was prior to any loss, but they do best-guess what it might have been. Pure tone audiometry is always a statistical statement and-:

'When it comes to statistical statements, the first point to note is that they always relate to classes. Even when the statement appears to be about an individual, there is always a tacit reference in it to some class to which the individual belongs.'
(A.J.Ayer. The Central Questions of Philosophy – Penguin edition ChVIII, p166)

Notwithstanding these limitations, pure tone audiometry has become the standard measurement of hearing impairment used in clinical and forensic auditory practice. At least it may claim to be a truly subjective test of the sensation of hearing, because only the subject of the test can know for certain whether he has heard a sound signal or not. It is necessary to ensure full subject understanding of, and compliance with the requirements of the test as far as possible, and to control rigidly the conditions under which the test is performed. By feeding sound information into each ear separately, a measure of the sensitivity of both ears is obtained in respect of their separate ability to convert physical sound-information into a hearing experience. It is a measure of the integrity of the entire chain of events from the access of sound-information to the body between the ear canal and the cortical regions of the brain where those processes underlying hearing-awareness are situated. The contribution of any mechanical disorder within the ear canal or between the ear drum and the hair cells of the inner ear is readily identifiable audiometrically as a 'conductive', hearing loss, the diagnosis of which is the province of a specialist in diseases of the ear – the otologist. However, between the inner ear and the hearing awareness centres there stand not only the hair cells of the cochlea and the cochlear nerve but also an entire and active brain. Although the most common causes of sensorineural hearing-impairment are cochlear, there are other factors central to the nervous system which can in various ways also moderate a subject's sensations and responses, and contribute to any hearing impairment.

When performed as described above with full subject-co-operation under carefully controlled physical conditions, and according to the well-defined performance protocol, the test measures the 'threshold' of sound, defined as that level of sound intensity where 50% of the test signals are just heard; so even the individual's threshold is a statistical rather than an absolute concept. It is not unusual for a subject to respond to an occasional signal which is quieter than the level eventually adjudged to be threshold. Despite these carping criticisms and caveats, and the fact that it measures an aspect of hearing which most people (unlike most cats) hardly ever use, pure tone audiometry, surprisingly, and not altogether without clinical utility, survives as the corner-stone of both medical and forensic audiometry.

Any deviation from the protocol laid down for the performance of pure tone audiometry is likely to invalidate the results as illustrated by the following experience. Once, as a trainee ear specialist I decided to check my own hearing since I was using this faculty regularly as a clinical reference. An audiometric test was performed. As far as I was aware it was done according to protocol. A threshold close to the middle of the normal range was established at a frequency of 1 kHz in the right ear. The test proceeded to the next frequency. I listened intently but heard nothing. I am sure that I would have been vigorously 'inclining my ears'. The audiometrician's face expressed surprise and I listened the more carefully. Still there was no audible signal. Eventually I detected a signal and cried out 'But it's in the left ear!' The audiometrician had inexplicably or inadvertently switched the side of the signal. The routine test procedure was then completed uneventfully to reveal hearing well within normal values at all frequencies in both ears. A comparison of the threshold eventually established according to the correct protocol at 2 kHz in the left ear, with that measured when I was concentrating on listening with my right ear, showed a difference of 25 decibels!

It ain't what you do; it's the way that you do it. (Oliver & Young 1939)

During routine pure tone audiometry, and, having been told which ear will be tested first, most subjects, if watched by an observant tester, do tend to turn slightly towards the side to be tested, together with some lateral flexion of the head on the neck. Many subjects also narrow or close their eyes during audiometry as though this might increase the sensitivity of the sense of hearing. When offered quiet signals at intensities close to their threshold, many subjects also make random inclinatory head movements. They seem to be seeking a particular position of the head at which such faint sounds might be best heard – not unlike tuning the aerial of an old fashioned radio. When told halfway through the test that the sound signals will now be heard in the opposite ear, most subjects not only adjust their head posture, but also change their whole body posture slightly, redistributing their body-weight on their seat – fundamentally re-focussing their attention as it were.

The random inclinations of the head just described were often noted among the cohort of subjects tested who had worked at GCHQ and its wartime and post-war service equivalents. By the very nature of their work they were all professional and expert listeners. They were chiefly concerned with the quality and sensitivity of their hearing – how good it was rather than how bad – and how this might affect their special skills and even their employability. They uniformly engaged conscientiously in the performance of pure-tone audiometry. They knew well how to listen for faint sound signals, and they had a refined ability to detect them with their educated sense of hearing in which they took some pride. However, it was also noted that several of these subjects, when being tested at intensities immediately below and quieter than their estimated hearing threshold, would make short sharp head movements each time one of these unheard or at least unacknowledged signals was offered. The accompanying facial expression was of increased concentration, of interrogation, of anticipation even. In these subjects the pattern of the response was consistently repeatable with no declared sensation of hearing. In such cases there seemed to be a significant difference between an objective threshold as judged by *movement* and the subjective response as judged by the acknowledgement of *hearing*.

In a medico-legal context, observations such as those just described would raise the questions of an exaggerated hearing impairment. 'Surely the subject must have heard the test sound.' 'Is he malingering?' 'Why otherwise should the head move in the way that it did?' 'Can the threshold measured be reliable?' There are of course many reasons other than deliberate falsification why a subject might fail to indicate the detection of a quiet, barely audible sound. Genuine uncertainty as to whether the signal had been heard or not; uncertainty as to whether what they had heard was a test signal or some internal head noise; lack of clear understanding of the test protocol; loss of attention during a boring procedure; and the intervention of external distracting noises – breathing through the nose can generate sufficient noise to mask a threshold-measurement. Even an assertive manner of testing can invalidate the test result by intimidation of the subject. However, notwithstanding the possibility of misleading responses, or of other factors detrimental to the proper performance of pure-tone audiometry, the individuals described understood well what was required of them, and seemed to be co-operating fully with the terms and conditions of the procedure. The difference between the thresholds of the observed movements and hearing was small - less than 5 decibels. But I believe that their responses were honest and as close to the truth as any biological measurement can be. If so, they confirm that the brain can respond purposefully to inaudible sound-information.

Anatomists have very commendably assigned internationally recognised names to parts of the body. Two such names relevant to hearing are 'concha' and 'cochlea'. The concha is the bowl-shaped central part of the outer ear, which collects and directs sound-information into the ear canal. Cochlea, as previously described, refers to the characteristic spiral shape of the shell of the common garden snail, and to objects having a similar shape; hence its apt anatomical use for that part of the inner ear cavity, and the correspondingly spiral sound-translating Organ of Corti which it houses. In the language of Ancient Greece concha and cochlea referred to species of molluscs. Ironically, the molluscs are an evolutionarily-related group of animals which have no sense of hearing. There is a riddle which asks *'What noise annoys an oyster?*' to which the conventional response is '*A noisy noise annoys an oyster'*. But the oyster, too, is a mollusc. It has no ears, no alternative organs of hearing, no sound-sensitive hair cells. Like other molluscs, it does have a gravity sensor and it may know which way up it is; but it is totally deaf. And what if an oyster could hear? It is protected from danger by its shell. Its nourishment is delivered by currents of sea-water. The same currents are the scene of generative activity. It is largely sedentary, lacking the motor organs to move quickly or purposefully. However noisy their environment, what possible use would hearing be to an oyster? What evolutionary advantage would accrue? Best not to hear the deafening crash of waves dashing against their shells. No use to sue the sea. Surely a neater response to the riddle would be *'No noise annoys an oyster; for an oyster knows no noise'.*

On the other hand, mammals, the evolutionarily-related group to which man belongs, do have sound-sensitive organs, they do have a sense of hearing, they can move quickly and they do so to some purpose. But the environmental sound-sources relevant to their survival can also move, sometimes very rapidly. A keen sense of the movements and whereabouts of these mobile external sound-sources is also essential if aggressive or defensive movements are to be planned and executed. To be effective, sound-information, having arrived at the front-line nerve-centres in the brain stem must be very rapidly analysed, organised and dispersed widely within the brain.

The Hearing Triangle (Fig. 1) illustrates only one such dispersal route – the audiological pathway – leading to an on-going, conscious evocation of the awareness and location of sounds; and, beyond simple sensation, to higher orders of hearing. But however important hearing may be to humans, however dominant it feels in our language-moulded minds and lives, it is but one of a range of essential functions served by the sense of hearing. Mammals other than man, lacking, as they do, any linguistic skills, must depend much more heavily on these other sound-related functions. There must be many occasions when the survival-value of such sound-information is equal to, if not greater than that of a conscious and intelligent hearing ability. The hearing pathway answers the question ‘*What can I hear*?’. The complementary sound-locating pathways primarily answer the question ‘*Where is that sound?*’ Even for human survival the question ‘*Where?*’ is sometimes more urgent than *What’*; and, being simpler, is more quickly answered. On a neurological time scale, language is a leisurely, lumbering affair, by comparison with ‘mental time’ which can almost instantly observe and share the real experiences of present-time within the flow of consciousnesss.

The act of inclination of the ear, as visually observed, whether human, feline or divine, can, like any other movement, be described within a Cartesian framework of co-ordinates. For inclination of the head and ear a vertical axis passing through the head, neck and spine, and two intersecting horizontal axes at the level of the inner ears, the one running from front to back, and the other laterally from right to left, provide the co-ordinates. Inclination of the ear is to hearing what oculo-motion or eye movements are to vision. But the eyes move independently of the head and of each other: whereas both cochleae are rigidly buried in the bones of the skull along with the vestibular organs of the inner ears (the utricles, saccules and semicircular canals). These, as noted above, provide the brain with essential information on acceleratory movements of the head and ears relative to the force of gravity and the surface of the earth. In describing the trajectory of any moving point Einstein recommends the need for a clearly defined reference ‘place-specification on a rigid-body’. With inclination of the ear, (or indeed with any other bodily movement, planned by the mover’s brain and monitored consciously by the mover’s entire sensory apparatus), the brain needs such a single point or place-specification on a fixed rigid body of reference.

Focus is the Latin word for the hearth – the central feature of a Roman house – the point from which fire would have projected light and warmth throughout the house. Spelt with a double ‘F’(to avoid lexical confusion), ffocus seems an appropriate word to adopt in order to define the body’s fixed place-specification, which alone enables the brain to plan and execute all bodily movements. And, what is more, in order to do this the ffocus must also act as a reference point – a fixed place-specification – for the recognition of the position and movement of all environmental objects and features; in short a point to which to refer and from which to project all mental images created from sensory experience.

Where might this ffocus be? It seems highly likely to be at the point where the axes of the Cartesian framework (described above) meet, at the centre of a straight line between the inner ears, where it also coincides with the lines of convergence of the orbital axes, more of less in the middle of the head. Descartes, (the inventor of Cartesian co-ordinates, who was also a mathematician and an optical specialist, as well as a philosopher), very reasonably thought that the pineal gland might be the seat of body-mind interactions. As defined above, the ffocus lies slightly anterior to the pineal gland, somewhere in Pons Cerebri.

To the brain, relatively speaking, when we ‘incline our ears’ it is not the ears or head which are inclined, but the origin of the sound itself. In effect the sound source is placed as favourably as possible to allow its location to be pin-pointed by the whole of the tele-sensory apparatus, so that the sound of voices a few feet away both come from, and appear to come from the visual image of a speaker’s mouth; and stars, whose light has travelled many light-years to reach the eyes, twinkle instantaneously as we project our visual imagery back to their origin in the night sky. The ffocus is where things heard and seen and felt are finally and mysteriously assembled before being projected timelessly, within or beyond the body’s physical boundaries, to create a phantom reproduction of the reality in and with which we live. The ffocus is the point where sensory experience begins, whether a pain in the toe or hearing the song of a lark ascending. It is the point from which these experiences are projected, accurately and instantaneously, to construct the various sensational elements onto the holograph of consciousness.

In matters of sensation, perception and intention the insensate brain, buried obscurely in the darkness and silence of the cranial cavity, mysteriously fuels the ffocus – the microphone-cum-receiver-cum-camera-cum-projector at the heart of consciousness. My skull and brain are stationary. They never move. They are motionless at the centre of my universe. When I walk, you see and hear me walk along the road. To my brain, when I walk, it is not me who moves; it is the road which is moved by my feet on my brain's instructions. 'I' am still. The sensate mind receives the ffocal output from the fixed insensate brain to create my image of my unique, universe.

Part 4

It is not easy to write or speak or even to think clearly about something that has no name. This is the *raison d'être* of language. The study of those effects and actions of the brain, other than conscious hearing, which are primarily evoked by the arrival of the very same sound-information, constitute so far as I am aware, such a 'something that has no name'. I propose to refer to these sound-effects as 'para-audiological' thus distinguishing them linguistically from the audible audiological effects of the same sound-information. Para-audiology could be seen as a 'missing link' between the different structures of the inner ear sensory organs of hearing and balancing. It fuses their functions of hearing and balance, explaining the clinical association of the symptoms of deafness and dizziness. In evolutionary terms it might even represent their common pedigree. For the present 'para-audiological' will suffice to cover those effects caused by the arrival of sound-information in its neurological disguise, but which is functionally diverted to matters of position and movement (or change of position).

'Music hath charms to soothe the troubled breast' (Congreve – The mourning bride)

Thus the poet with verbal rhythm pays tribute to St Cecelia. Music fills the ears with a rich bounty of sound-information. The defining features of music are melody and rhythm. On the whole it is the sweet melody that charms the mind, whereas the rhythm soothes, or sometimes ruffles the troubled breast. It is to the audiological melody that we join the language of the songs of happiness, sadness or love; whereas it is to the para-audiological beat of the rhythm that we tap the toes, nod the head, dance the tribal dance, the foxtrot and the rumba, and march to war, to weddings, and the grave. The intellectual pleasure of music is mainly in the melody; the passion is in the rhythm. In orchestral or choral concerts it is generally the sopranos or the violins who deliver the melody, whilst it is the basses (vocal and double), and the percussion who roll out the rhythm. But, as he or she silently brandishes his or her baton, it is the conductor or conductress – the only non-acoustic performer, the one purely para-audiological contributor – who receives the plaudits.

If 'awareness' best summarises the purely hearing aspect of the audiological sense, its para-audiological counterpart is 'loudness'. The sensation of loudness generally reflects the energy content of the corresponding sound-generating event. It is the quantity rather than the quality of hearing. As the head moves through a restless ocean of acoustic waves, the brain notices the varying levels of loudness-information in each of the two ears and the varying differences between the two ears. These differences allow the brain to determine the direction from which any particular element in the sound-source has come. The estimation is best made with two sound receivers on opposite sides of the head – an anatomical arrangement with which nature has favoured us; but even with one hearing ear and a mobile neck, more vigorous neck-turning ('inclination') can suffice to overcome the loss. To determine exactly where a sonic source is situated, in addition to direction, it is also necessary to know the distance between the source and the hearing ears. Here too relative loudness is a significant tool; but, by hearing alone, it requires considerable experience to be able to estimate this distance except at very close quarters; and even then the estimate is only rough. Normally we depend more on sight to judge distance, and how the distance is changing – whether towards or away from the ears. Bishop Berkeley's *'Essay Towards a New Theory of Vision.'* published in 1709, considers this aspect of sensory perception with reference specifically to vision and does so with remarkable prescience. In the dark the ears must do their best.

Broadly speaking para-audiological activity may be said to have two main roles. To understand the first role, it will assist the reader to refer again to the diagram and terms used in the Auditory Triangle (Fig 1). Although sound-*awareness* is created by and in the brain, the final image of sound-sensation must be *projected* to coincide exactly with the point where the original sound-*information* is deemed to have come from. Those elements of sound-*information* on which audiological-*awareness* depends, have to be synchronously combined with those corresponding yet different para-audiological elements of sound-*information*, from which sound-*location* is estimated. Only after achieving the precise re-combination of these two separated elements of sound-information can the image of sound-*awareness* be *projected* accurately, to furnish the *sensation* of sound, so that what has been heard and what may be perceived and understood, forms a spatially appropriate item,l; in an integrated picture of the total conscious experience. Compare this with the effect of inaccurate synchronisation of sound and vision when listening to and watching a television programme with speech and vision 'out of sync'. The experience is surprisingly distracting. By contrast, how easy and enjoyable it is to admire the skill of a ventriloquist as the dummy's mouth-movements are entertainingly aligned with the concealed speech of the entertainer.

The second main area of para-audiological function, relates to loudness as a moderator of all ongoing movement, encouraging some movements and opposing others in such a way as to move the body according to a perceived need. Of all movements, those most likely to be chosen are those needed to bring the head and eyes to face the direction from which any selected sound source has come (relatively speaking, that is to move the sound source in front of the face and eyes).This para-audiological skill, foreshadowed by the post-auricular myogenic reflex is well illustrated by the behavioural hearing tests performed on babies and young children in the early months and years of their life. When an interesting or unusual sound is presented, babies soon learn to search for it automatically performing a sound-evoked head turning survey: no doubt calling on the visual sense for fine adjustment. Under controlled conditions this response has been used to measure the threshold of hearing.

A lighter picture may be painted illustrating the synergic link between para-audiological information and movement. Whilst lying comfortably in a dark and silent bedroom, which of us has not on occasion been disturbed by the characteristic 'zizzziz' of a mosquito? With the light on, as we leap, scantily clad, round the bedroom, we curse the limitations of our sound-locating ability as opposed to the incredible aerobatic agility of the mosquito. In the dark, the only prudent purposeful movement is to hide under the sheet whenever the un-located sound gets threateningly loud: an action dictated more by fearing than hearing. But discretion is the better part of valour.

At various levels within the central auditory pathways nervous activity can moderate or control the perceived volume of sound intensity. For example, on entering a noisy room full of animated social conversation, perhaps with a musical background, we are assaulted by the sudden excess of noise which we describe (not entirely without justification) as 'deafening'. Yet within a matter of a minute or so, as our mood becomes relaxed, we become unaware of the previous level of loudness, and cheerfully add our own contribution to the 'cocktail effect'. On leaving such a room we initially find ourselves talking with raised voices. Ordinary sounds seem loud. And then, as quickly as we adapted to the noisy environment, we automatically re-adapt the intensity of our own voices, until speech and ambient sounds are heard comfortably once more.

In addition to this general ability to control sound volume the brain is remarkably able to select and direct the mind's attention to elements of speech or sound information from either or both ears. My experience, previously described, during pure tone audiometry provides a typical example. On that occasion, while listening for faint sound-signals in my right ear, I unconsciously, yet very effectively raised the threshold of hearing in my left ear; or, to put it para-audiologically and perhaps closer to the truth, I decreased the loudness sensitivity of my left ear. In the world of physics 'the present' is a point in time. It has position but no dimensions – no duration. For the brain it takes a measureable period of time for the events of the present to reach the brain as sensory information and then to pass through many individual brain cells to achieve awareness. It then decays cerebrally to be overtaken neurologically by the constant sequence of future sensed events. An image-of-the-present however can persist mentally over a period of several seconds allowing the present to be assessed in the context of the immediate past and future, and before passing as a byte of experience either into memory or oblivion. According to St Augustine:-

'The mind is too narrow to contain itself.'
and
'Memory is a vast, a boundless inner room whose depths none can reach.'
(Confessions Bk. 10 Ch viii)

I can recollect even now from my 'boundless inner room' the strange ill-defined experience of 'listening backwards'. I was conscious immediately after the event of the considerable effort that I had made to suppress and prevent the sound presented to my left ear from being heard. There was even a vague awareness of the suppressed sound-signalgvb itself.

There are a number of clinically distinct para-audiological disorders. Perhaps the commonest example is' recruitment' or 'abnormal growth of loudness – a problem associated with selective damage to the sound-translating inner-ear hair cells in the cochlea. It is most commonly encountered in association with degenerative ageing changes. Those inner hair cells nearest to the base of the cochlea are most prone to be damaged, and this is reflected in the pure tone audiogram as a hearing impairment more marked in the higher frequencies on which we depend for intelligibility of speech. The deleterious effect on speech reception is evident to anyone speaking to a listener affected in this way and any speaker (especially if male) automatically raises the volume of his voice, thereby distorting the frequency pattern of his vocal output, and, in particular, disproportionately increasing its low frequency content. The deaf listener can now hear what is being said. But the effect of the increased low frequency sound-information – the 'recruiting of *loudness*' – is such that the deaf listener traditionally cries ' There's no need to shout. I'm not deaf!'.

A quarter of a century ago, a lady of middle age, attended a clinic designed specifically to give advice and support in the management of tinnitus. She was seeking relief from her troublesome hearing problems. However, it soon became clear that, although she did indeed have tinnitus, it was in her view only 'moderate' in severity; whereas her primary and bitter complaint was of the less common hearing disorder called hyperacusis. In this condition, all sounds, even those which seem very quiet to a person with normal hearing, are perceived by the afflicted subject as uncomfortably and often unbearably loud. In this lady's case the combination of hyperacusis and tinnitus had resulted in a severe social and family handicap. On enquiry, in striking contrast to the hyperacusis and tinnitus, there was no complaint of any loss of hearing. This was confirmed by pure tone audiometry which recorded completely normal threshold levels at all standard frequencies in both ears.

In seeking for the cause of this particular patient's problems, her medical history was found to be very significant. The onset of the hearing symptoms accompanied a relapse of the disease Multiple Sclerosis from which she had been suffering. In this condition, for reasons which were then, and still are poorly understood, fairly small and discrete volumes of nervous tissue in the brain-stem are damaged. As a result, any functions mediated in or through the damaged brain tissue are temporarily or permanently impaired. In the present case it was clear that those elements of sound information which led to sound-awareness, and those which led to the para-audiological experience of loudness were functionally and anatomically quite separate within the array of brain stem nerve-centres. It follows that in higher auditory centres the precursor-activities leading to loudness and hearing need to be reunited if a single composite conscious mental image or idea is to be experienced. Furthermore it is only when finally perceived within the panorama of consciousness, that it is proper to use the words 'loudness' or of 'hearing'. Both experiences maybe born in the brainstem, but they only become conceptualised when balanced as part of a complex mental package alongside the emotions. When the balance is abolished, it is as though the brain asks the emotions to help find a reason, and as is the way with emotions, they can easily run wild.

It will be recalled that the patient, whose problems with hyperacusis have just been described, also complained of tinnitus, though with less bitterness – less emotion that is – than she accorded to the hyperacusis. There is a nonsense rhyme, one version of which starts *'Yesterday, upon the stair, I met a man who wasn't there...'* With minor adjustments and the substitution of 'sound' for 'man' the verse becomes:-

'Yesterday upon the stair
I heard a sound that wasn't there.
It wasn't there again today.
I wish that sound would go away'. (after Hughes Mearns)

The verse seems to encapsulate the experience of those who suffer from tinnitus. There are two main types of tinnitus – 'objective' and 'subjective'. Objective tinnitus is caused by real sound-information – noises which can be detected physically by a sensitive microphone. These are mostly sounds generated by movement of air or fluid or by muscular action inside the patient's body. They are of course inaudible to listeners, though audible to patients through their normal hearing mechanisms. Patient concern and clinical attention are best directed towards identification and silencing of the cause of the sound.

Subjective tinnitus occurs when there is no evidence of the generation of any audible sound-information in the form of sound-waves. The description 'subjective' requires that only the person subjected to the spurious sensation can hear it. No sound-information enters the body physiologically through the cochlear structures of the inner ear to account for the perceived tinnitus-sound nor for its loudness nor for its location. '*I heard a sound that wasn't there.'* Tinnitus might be described as anti-hearing.

It can be helpful, when counselling those with a distressing form of subjective tinnitus, to encourage them in various ways to consider as objectively as possible the perception of their tinnitus. Invite the sufferer to listen attentively, not to the noise of the tinnitus, but to answer the question, without any prompting, 'Where is the noise?' Another line of enquiry is to ask whether any general activities or bodily movements have been noted which change the quality and severity of the tinnitus perception – particularly movements of the head and neck, or of the eyes or jaws. Invite the patient to listen to his or her tinnitus while performing various movements and to listen objectively, not emotionally, in order to detect any change in loudness or in the quality of the tinnitus perception.

Consider the plight of a lady in her seventies who attended an audiology clinic. She had been unfortunate at that age to have suffered bacterial meningitis with total loss of cochlear function and total deafness – a clinical picture more often seen in infants and young children. She accepted the total deafness with fortitude, and, in this respect, with supportive therapy she had re-ordered her life constructively and admirably. However, she complained that, while she was able to accept the hearing loss, she did find the irony of noises in her ears particularly irritating. She added that she had also noted with surprise that *moving her eyes changed the quality and loudness* of the tinnitus.

Such movement-related experiences are not infrequently reported by patients with tinnitus – sometimes voluntarily, sometimes on direct questioning; occasionally, to the patient's surprise, during examination when asked to move the neck, eyes or jaws while listening to the tinnitus. Descriptions of such changes in tinnitus associated with movement include:-

'Putting my head back over the basin at the hairdressers increases my tinnitus.'

'I can double the volume of the hissing by clenching my jaws'.

'I always find my tinnitus is worse after cycling'

'When my tinnitus is bad I find it helps if I go for a brisk walk'

'If I protrude my lower jaw I hear a high pitched squeal. It stops as the jaw relaxes.

To this list may be added the almost universal experience that 'tension makes my tinnitus worse'. In this context of course 'tension' refers primarily to a psychological feeling associated with emotion. But there is always some accompanying physical muscular tension. Tensing is what muscles do.

All these examples strongly suggest that para-audiological activities play a significant and sometimes major role in the genesis of subjective tinnitus, especially in the most distressed patients. In such patients the explanation for the origin of the tinnitus sensation is likely to be multi-factorial. Even when a superficial view of the clinical picture suggests a cochlear disorder as the most likely cause, it is always possible, perhaps probable, that the abnormal sound-information, whatever its true source, is at least partly the result of secondary disturbances in the balance of audiological and para-audiological activities within the brain. The confusion caused by the arrival of conflicting or unintelligible messages in the higher brain centres leads, not only to the useless sensation of tinnitus, but also to the generation of the emotionally enriched perception which so often dominates the clinical picture.

From hearing to tinnitus, from alpha to omega, whatever the subject, an essay is based on personal opinions and experience. Michel de Montaigne – the progenitor of the essay as a literary form – gave his only guiding principle with regard to content, simply, and in his native language as 'Que sais-je?', 'What do I know?' He named no bounds as to form or content. He allowed himself a wide degree of freedom of expression and, with admiration, his style has been adopted. In one sense, essay-writing has to be a form of self-indulgence. But, by re-examining and retesting one's personal thoughts and experiences, it also provides a satisfying measure of self-education – self-purification even. It is to be hoped that the words and thoughts, with which the subject of hearing has been clothed, may at least have interested and entertained, if not purified the reader.

Epilogue

An elderly man developed a social hearing-loss, accompanied by an intrusive species of tinnitus. He was provided with a hearing-aid of modest performance which was of great benefit. It gave in good measure the hoped for improvement in the clarity of conversational speech; but also, unexpectedly, surprisingly and whenever the hearing aid was in use, it also gave a welcome relief from the tinnitus. In the fullness of time the old man died. He was still wearing his hearing-aid and it was still switched on. Sadly and symbolically his son removed the hearing aid and switched it off. Finally denied existence, released from his sense of hearing and freed from the burden of his tinnitus, he now rests in peace.