Problems with Music

We are all aware that many of us implant users have problems with listening to music, quite apart from any issues on performance with telephone usage and still further the basic requirement of speech communication. As reported in the Summer Edition only 40% of users regularly listen to music and 35% never bother at all presumably because of their poor reception and lack of enjoyment. So why is this?

We're told that it's all down to the technicalities of trying to digitally reproduce the fine detail of music that is contained within the temporal envelopes of the waveforms that we receive and this affects the the ability to perceive pitch. When many people are speaking at the same time we already have problems in segregating the different streams of information that overlap and occlude each other. With music it is worse because we have to deal with multiple streams of information from differing instruments. We are aware that all the manufacturers are striving to improve their processing strategies in order to overcome these problems. Yet it is worth considering some of the fundamental matters that are concerned in this subject.

A key characteristic is the frequency range of all the sounds that a normal hearing person is capable of recognising. For young people this can range from as low as 25 Hz up to 18,000 Hz, a very wide spectrum indeed. Figure 1 shows frequency ranges of various instruments that are used to create music. For example the standard piano ranges from 27 Hz up to 4186 Hz and the cello from 70Hz to 700 Hz. For human singing voices the range is from 80 Hz to 500 Hz for men and 230 Hz to 1100 Hz for ladies.

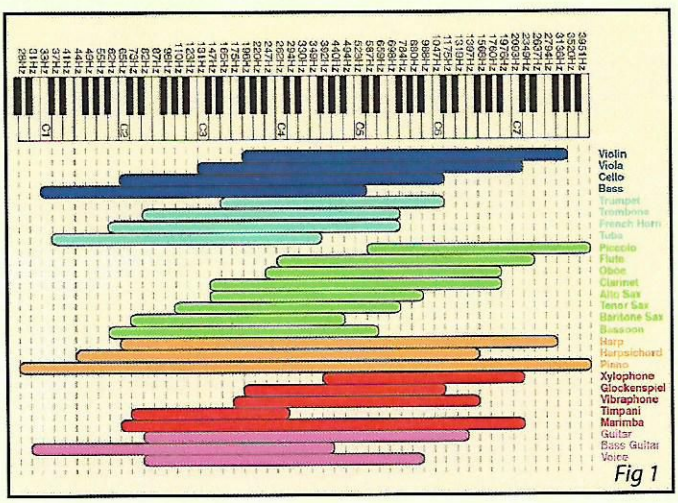
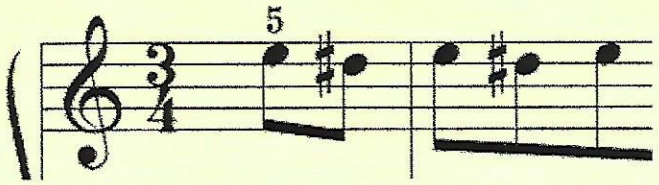


Fig 1



There are however, some basic limitations which must be recognised in our current processor systems. Firstly the frequency range of the microphone which varies, between manufacturers, from a low of 100 Hz up to 8700 Hz. So immediately we've already lost some low frequencies (see below) and a lot of the higher frequencies where the harmonics of musical instruments feature.

Different frequencies are located at different lengths along the human cochlea which, curled like a snail, has a linear length of some 31mm with the higher frequencies been detected near the round window, adjacent to the middle ear, and the lower frequencies at the innermost end of the cochlea. The first complete turn of cochlea is at a depth of 18 mm which corresponds to a frequency of 700 Hz, the second turn is at the depth of 26 mm which corresponds to a frequency of 180 Hz and the final turn ends at 31 mm being the lowest frequency. The distribution of these frequencies along the cochlea is not however linear but logarithmic. The band 20,000 Hz down to 7000Hz occurs in the first 3 to 4 mm! The active length of the implanted electrode array varies, between manufacturers, from 17 mm to 26 mm.
The area next to the round window where the insertion begins is often the most damaged from the trauma of the operation with a loss of neural survival here so the first active electrode point is typically placed at about 3 mm, a frequency point of some 7000Hz.

CI users can usually identify different instruments when each is played alone. Problems arise however with multiple instruments. Every musical instrument has a basic sound or pitch which is known as its fundamental and all instruments are capable of generating harmonics which are multiples of the fundamental. It is the interplay of these harmonics not just by one instrument but with a group of instruments that generates complex waveforms which gives music its wonderful richness and depth of expression which produces such gloriously pleasurable emotions.

Music preceded speech in evolution according to Darwin and our minds and brains are the product of millions of years of evolution. The sensory perception of sound developed in primates before vocalisation, still less speech. Sound perception is part of our primordial origins. The cochlea is fully formed at 22 weeks of gestation and illustrates the early evolutionary need for a hearing system.The brains music system appears to operate with functional independence from its language system. Music is hard wired into the brain and music listening engages nearly every area of the brain and involves nearly every neural system.

Music is part of the fabric of everyday life. As stated by Confucius "Music produces the kind of pleasure that human beings cannot do without ". If beauty is in the eye of the beholder then music is in the ear of the listener.No known human culture at any time in recorded history has lacked music. What goes into the ear comes out of the brain and even for normal hearing people, without memory that would be no music.

Music is organised sound as, based on experience, as we expect certain pitches and rhythms.The frequency of a sound wave is a physical measurable quantity (Hz) whereas pitch is a subjective quality. Pitch is an internal quality of the perception of the frequency of the sound waves from vibrating molecules of air. Pitch is one of the primary means by which emotion is conveyed.

Music is concerned with information so why does some music move us so yet others leaves us untouched. Some people are said to be tone deaf and have difficulty in relating to music. And fewer still proportionally suffer from amusia in that they find music actively unpleasant. It is the impact of overall sound rather than the lyrics, the chords or the instruments that engages our attention.

Pitch - is the frequency of a sound; its note; its tone

Rhythm - refers to the length of a series of notes

Timbre - is the tonal colour of an instrument or voice

Loudness - is the volume strength measured in dB

Contour - is the rise and fall in pitch

Tempo - is the pace of the music- its pulse

Melody - is the main theme of a musical piece

Fig 2

The seven major elements of music are pitch, rhythm, timbre, loudness, contour, tempo, melody; music is based on the relationship of these elements- see Figure 2.

The contour of a melody — how it rises and falls in pitch — is one of the most important clues for memory and recognition. Variations in contour can identify a piece of music through melodic motion, whether the pitch goes up (U), down (D) or is repeated (R). The sequence of U, D and R is known as Parson's Code and has successfully identified tens of thousands of musical works within a pattern of just 15 such notations (URURUDD etc).

The fundamental frequency is the vibration of a system as a whole. Where there are several simultaneous modes of vibration, the note of lowest pitch is the fundamental which is overlaid with harmonics. The brain can resolve a complex tone into its harmonic components. Grouping is an automatic brain process in which the auditory system exploits the harmonic series in grouping sounds together and pitch is a strong factor in grouping together with tempo and timbre.

The brain can create a 'missing' fundamental by restoration. Because of the non linearity of the ear, it is capable of creating subjective tones which arise when two different frequencies are heard simultaneously and the difference between them is heard a separate frequency. So a 400 Hz and a 500 Hz tone are heard together with a 100 Hz tone. Complex tones are built up out of harmonics and in some cases the fundamental may be missing but the ear will create its own subjective fundamental. Thus the ear can 'fill in' the frequencies which are outside the limits of one's CI processor.

So what does this all mean for us implant users who no longer have a natural hearing mechanism. We have microphones which receive sound waves which are digitally processed to excite electrodes within the cochlea which stimulate nerve endings and generate a sensation of sound within the brain. The important word here is the brain. Although we have lost our natural hearing function our brains are still capable of experiencing sound and for those who are deafened (as opposed to being born deaf) the historical memory of sounds and the music remain in one's brain and are capable of being regenerated if appropriately stimulated.

So being aware of these technical limitations by the microphones, electrodes and CI processors should we give up on music if initially it is not enjoyable? The answer must be a resounding NO because as with all things it takes time for the brain to learn how to adapt to the new environment of stimulated hearing. We need to practice constantly in order to develop this ability. Some users say it has taken them 5 years before they began to enjoy any music and others are fortunate enough to make this claim within their first year of usage. We need to practice, practice and practice listing to music. The best approach is just to deluge oneself with sound (not just the spoken word) using simple repetitive music with a beat and preferably of songs or styles which you have enjoyed the most previously. There have been presentations of our meetings and articles in these columns about how to approach the subject of learning to listen to music and these will feature again. Meanwhile we should take advantage of the support which the manufacturers give us in order to develop these talents and as shown below there are a range of options available and they should all be explored and utilised.

This article will probably be of little use to those born deaf without any musical memories and I regret that. I would like to hear from such people and from teachers of music for the deaf so that another more suitable article could be prepared. And finally can you identify the melody of URURUDD ? – Ed

Music Support

AB (Advanced Bionics) - Musical Atmospheres

AB's latest music rehabilitation tool for teenagers and adults is now online. This unique program aims to introduce musical experiences through a positive and new method in listening with a cochlear implant.

With Musical Atmospheres you can explore the wonderful world of music. New music is discovered through three hours of recorded musical examples, each containing increasing levels of complexity in musical appreciation, helping to establish a firm foundation for musical memory. Musical Atmospheres can be used at home for the individual exploration of all aspects of music, or in groups to explore a variety of motivating areas of musical experience. Go to **http://tinyurl.com/2cpfwmq** (the exact page on AB's website of their website **www.BionicEar.eu**) and try it out.

Cochlear UK - *HOPE Notes Music workshop*

Learning to enjoy music isn't just about listening; music appreciation can really be improved by participation so going to concerts, learning an instrument or attending a workshop can all really help.

Richard Reed, who worked as a professional musician but sadly lost his hearing, developed HOPE Notes. Richard was inspired to develop the package after receiving his cochlear implant as a way of helping other people to re-learn how to enjoy music. Hope Notes is available as a rehabilitation resource for both parents and professionals alike. It is geared toward teenagers and adults, but parents and carers of young children could possibly use it for music games or dance time.

You can order a copy of HOPE Notes and or get more information by going to **http://tinyurl.com/287gsoh** (the exact page of their website at **www.cochlear.co.uk/rehabilitation**)

There is also a dedicated page on listening to music which can be seen at **http://tinyurl.com/2956zeg**

If you would like to register your interest for the next workshop please contact Sian Jones – **sjones@cochlear.com** or check online for up coming events **www.cochlear.co.uk**

MED-EL - *Noise Carriers DVD*

"Noise Carriers" is a DVD and CD recording of a live performance of an entire evening of music composed especially for cochlear implant users. The 13-movement composition is based on the works of Robert Burns. It includes a special set of instruments selected according to current research about CI users' music preferences. Listeners experience these instruments in isolation as well as in small and large group ensembles designed to suit CI users' music listening needs.

"Music Tips for Adults" is a brochure that offers a brief summary of the key issues involved in music listening training. It outlines various tips to help adult CI users gain better access to music, covering topics such as choice of music, familiar songs, listening environment and equipment. The brochure is available as a free download from **www.medel.com.**

For more information about MED-EL UK's music projects, contact **customerservice@medel.co.uk.**