Newsletter Supplement
to Edition no. 65

We are delighted to bring you this supplement to our newsletter covering a variety of presentations that have taken place at various conferences this year

Let's start on a musical note ....

Dr. Valerie Looi is both a clinically-certified audiologist and a registered music therapist. Her PhD research investigated the music perception skills of cochlear implant (CI) recipients compared to hearing aid users. She is currently the Asia Pacific Research Manager for Advanced Bionics. Her research has focused on the music perception and appreciation of CI recipients, and more recently, on developing music training programs for hearing impaired adults.

Dr. Looi has provided this follow up to a presentation she gave at the EURO-CIU symposium in Helsinki, Finland in April 2017.

MUSIC FOR ADULT CI USERS: CI CAN!

It is well accepted that speech perception in quiet is generally excellent for adult cochlear implant (CI) recipients, with most being able to communicate well in quiet. However, many struggle when it comes to more-complex stimuli or in challenging listening environments such as with pitch perception, music perception, and listening in noise [1-8].

There are four basic attributes to musical sounds - pitch, duration, loudness, and timbre [9]. Music perception primarily involves pattern perception, be it rhythmic, pitch, loudness, or timbral variations [10]. Different pitch patterns or sequences make up 'melody' and 'harmony', whereas different duration or temporal patterns make up 'rhythm'. Variations in loudness are often referred to as dynamics, and differentiating between different timbres lets you tell what instrument is playing[9]. However, although these attributes are separate entities, it is the combinations of, and interactions between them that constitute music as we tend to know it. For example, listening to a melody requires you to both perceive the pitch and the rhythm together. You don't tend to process them as separate elements. In addition, differences between individual listeners, such as personal music experience, prior training, listening preferences, age, culture, or demographics, may also affect music listening.

Speech and music have some similarities, but they differ in many ways as well. The frequency (pitch) range is a lot larger for music than for speech. For example, the fundamental frequency (F0) range for a male speaker is from approximately 85-180Hz, and 165-255Hz for a female speaker. However the F0 range for a piano is from 27.5 Hz to 4186.01 Hz[11, 12]. Further, the loudest sounds of speech, even when shouted, tend to be less than 85 dBSPL, and are more often around 75 dBSPL; general conversational speech approximates 60 dBSPL. Irrespective of the style, the louder components of music are often in the range of 100 dBSPL to 110 dBSPL, sometimes getting up to 118 dBSPL [13]. Also, when you listen to speech, e.g. in a conversation, you have a lot of additional cues to help you. You don't have to hear and understand every word accurately, or every syllable in the word, to follow the conversation. Visual cues such as lip reading, the context and facial/body expressions can help. However, for music, there is less 'redundancy', e.g. hearing one note may not help you accurately hear or guess the next note.

Speech and music also differ in their broader functional roles, as well as in the processing skills required for interpretation. We tend to listen to them for different reasons. Speech is a discursive form of communication with individual words largely having a predefined meaning. Music, on the other hand, is often more abstract and non-discursive in its role, not necessarily having a clearly defined semantic function. For example, when you are in a conversation, you are trying to hear and understand the words that are being said, so that you can follow the conversation and/or actively participate in it.

In contrast, when you listen to music you may not listen with the same level of attention or focus; you might just listen to the music to enjoy it, and/or let it 'wash' over you.

The sound percepts from a CI are different from acoustic hearing as the CI stimulates hearing electrically. The sound from the implant's microphone is divided into a fixed number of wide filter bands (e.g. 22 for current Cochlear CIs; 12 for the MED-EL; 16 for Advanced Bionics), unlike with normal hearing (NH) where the filter bands are overlapping with continuous centre frequencies - that is, many, many more filter bands. Once filtered, the sound is processed by the speech processing strategy, and converted to electrical pulses. These pulses are sent to your electrodes to stimulate hearing. In addition to the implant itself, a sensorineural hearing loss can affect the perception of loudness, pitch, and timbre. For example, recruitment is a common occurrence, where the rate of perceived loudness growth is steeper than usual, which reduces one's dynamic range. Also, those with a significant hearing loss have wider auditory filter bandwidths, which affects the perception of pitch and timbre ([14]). As a result, CI recipients (and hearing aid users as well) tend to be poorer than NH adults on pitch- and timbre tasks. This includes musical pitch perception, melody perception, and instrument identification. Western music requires discriminating frequency changes of 6% (1 semitone).

It is well accepted that adults with CIs perform similarly to adults with NH or HA users on measures of rhythm perception, however the collective findings across a range of studies indicate that CI users score significantly lower than NH on pitch-based tasks. For example Sucher & McDermott [15], compared the abilities of 8 CI and 10 NH adults on a pitch-ranking task and found that CI users were significantly worse than NH at ranking both 6-semitone (½ octave) and 1-semitone intervals, and were unable to discriminate between 2 notes, 1-semitone apart. Looi et al.[4]compared CI and HA users with similar levels of HL in a pitch-ranking task (1, ½ and ¼ octave intervals). They found that the CI users were significantly worse than HA users and unable, as a group, to differentiate between notes ¼ octave (3 semitones) apart.

It is important to keep in mind, though, that the HA users were not as good as NH listeners (the HA users scored around 76% for ¼ octave interval, whereas NH would score close to, if not at, 100% for this interval).

Another key feature of music is timbre. Unlike pitch and loudness, timbre is multi-dimensional, related to differences in sound spectra. It's the feature that enables us to differentiate between two different instruments playing the same note at the same level. Gfeller and colleagues [16] compared CI users and NH listeners in their recognition and appraisal of 8 different instruments. The CI users scored significantly lower than NH listeners, and also rated music to sound less pleasant. Higher-frequency instruments (e.g. flute, violin, piano played in its upper registers), were perceived by CI subjects to be noisier and duller than NH subjects. Looi et al.[4, 5] compared CI and HA users in their identification of 12 instruments and 12 ensembles, and found no significant difference between the CI and HA users. Interestingly, the CI users rated music to sound more pleasant than the HA users, and CI users rated music to sound better with the implant when comparing back to pre-implantation when they had a significant hearing loss and were using HAs[4, 5, 17].

What about recognising melodies? Gfeller et al.'s study [18] reported that their CI users were only able to identify 19% correct of 12 well-known melodies, with 66% of these correctly identified items having been pre-classified as being 'rhythmic' in nature. That is, rhythm is an important cue for melody identification. Looi et al. [4] compared CI and HA users on a closed set melody recognition task incorporating 10 melodies with rhythm cues, and the CI group (average score - 52% correct) significantly poorer than HA group (average score - 91% correct).

In summary, the research indicates that CI and HA users score similarly to NH listeners for rhythm tasks, but are poorer on pitch, timbre and melody tasks. This is also reflected in appraisal ratings, with music reported to sound empty, rough, tinny, unpleasant, and disappointing. However there is a large degree of variability with no single variable or explanation. Importantly, time with the CI does not improve music perception; incidental exposure to music is NOT enough. You need to do more.

So What Can I Do?

Music training, and focused listening practise has been shown to help both identification and appreciation [19-22]. In lieu of a formal music training program, you can still 'self train' to work at your music listening skills. Although sound processors may limit pitch and timbre perception, research has shown that some aspects of music listening can be improved with training - both identification and appreciation (see[3]).

So how do I do this? Where do I start?

Here are some considerations for self-training:

- Frequency: 'spaced' sessions better than 'massed' practise [23]. Aim for 30min sessions, 2-3 times a wk [24].
- Duration: A longer time frame better [23]
- Difficulty: Too easy does NOT enable optimal learning; difficult tasks result in more robust learning [23]. Start easy, but build from this. Make sure you challenge yourself, so you improve.

Tips for reintroducing yourself to music:

- Start simple - i.e. 1 instrument/singer, or a small number of instruments
- Start with music you know or remember
- Start with music with words
- Start with music with a strong rhythm/beat
- Suggestions of music to start with:
    - children's or Xmas songs as they are simple, with a clear beat, have words, not too fast, have 'catchy' tunes, and are easily remembered
- Try to have visual cues avail. (e.g. Score, lyrics, DVD or video)
- Use good quality equipment if possible
- Optimise the listening environment
- Don't be afraid to experiment
- **DON'T GIVE UP!!!**

Maximise your listening environment:

- Quiet; no background noise.
- Non-reverberant (non-echoey) room (e.g. carpet over wooden floor or tiles).
- Play music at a medium or comfortable volume.
- Use good quality recordings, good quality speakers or earphones, or direct audio input.
- Experiment with your listening environment. e.g. try putting your stereo in different rooms, reposition the stereo and/or speakers within the room, rearrange the furniture or where you sit when listening to music. Just like you would for communication, be an active listener and be proactive about your listening environment:
    - Can you reposition/move yourself if necessary, or is there anything you could change to make it better for you? If you're in church, concert or in a hall, are there better seats available closer to the front?
    - At a party, can you move away from the music source if it's affecting your communication?
    - Can you move toward the music source, if you're wanting to listen or concentrate on the music?

Things to consider…

- Using a HA if you have some hearing in the other ear (i.e. use your CI with the HA). Even if you don't normally use a HA, or it doesn't help speech, try it for music. Research has shown that it can help with pitch as well as the overall sound quality.

- Remember that the CI was designed for speech perception.
  Speech and music are very different. The CI was not designed to provide a precise representation of some music features such as pitch.
- Keeping a listening journal
- Slowly developing a music 'library' or listening list for yourself, of pieces or recordings you've heard and enjoy. If you like a piece of music/song, find out 'What is it?' (i.e. name of the piece, singer/group/composer) - and write it down!

Why don't you try:

- Listening to different music - e.g. Eastern or Asian music. It uses a different scale system, requiring less precise pitch differentiation. Western music divides an 'octave' into 12 different notes. Many Eastern pieces use a pentatonic scale which only has 5 different notes per octave.
- African music - highly rhythmic.
- Karaoke versions - they're subtitled, and you can follow exactly where the piece is up to. They have a clearer beat, and aren't too fast.

But don't ....

- Expect too much of yourself.
- Have too high expectations of how music will sound through the CI/HA.
- Have presumptions of how certain pieces or styles should sound.
- Expect to be able to understand all of the lyrics.
- Be put off if you read or see promotions that children, or other adults, love music and think that it sounds great with their HA or CI. Everyone is different, and how the device impacts on music is different for everybody.
- Shy away from trying different types of music- e.g. rock, rap, or country & western. These styles are sometimes simpler, have a clear beat, and have words.
- Have pre-formed expectations. You never know…! Some people's musical preferences completely change after a CI. Experiment!

Remember:

- People with NH find some aspects of music difficult to understand, and may not follow all of the words in a piece, and they don't enjoy all types of music.
- To keep an open mind – you don't have to know a piece or instrument/singer to enjoy it, nor do you have to have listened to that style before to enjoy it.
- It takes time and practise.
- How much 'practise' you get for listening to speech everyday, vs. how much music you listen to a day.
- How much attention you pay to speech (or the speaker) when in a conversation vs. how much attention you pay to music.
- How often you hear speech and how much you're indirectly practising listening to speech vs. how much you practise listening to music. When your CI was first switched on, many things such as speech, everyday noises etc. sounded different. It's the same for music.

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Inge Doorn studied Sociology in the Netherlands and is now working as a policy advisor at FODOK, the Dutch Federation of Parents of Deaf Children. One of her three daughters is deaf with two cochlear implants. She is also involved in OPCI, the independent platform for cochlear implant users. She has provided *a summary of a poster presentation she exhibited at the EURO-CIU symposium at Helsinki in 2017.*

E-HEALTH APP FOR COCHLEAR IMPLANT USERS IS ON THE WAY!

Technical progress makes new developments in cochlear implant (CI) care possible.
Until now CI implant users have been very dependent on their audiologist for information, counselling, rehabilitation and testing. Hardly any data is available for the users themselves, but this is about to change.

During the last three years Cochlear (Sweden and Belgium), Otoconsult (Belgium), the VU University Medical Center Amsterdam, (The Netherlands) and OPCI (CI user group - The Netherlands) have worked together in a European funded project. The SHiEC (Supporting Hearing in Elderly Citizens) project has an overarching goal to develop a prototype digital health platform that supports elderly users to maximally benefit from their hearing implant by:

- Empowering them, i.e. by providing them tools by which they can take care of their hearing and their hearing device themselves.
- Bringing them remotely in contact with their professional care givers, i.e. the audiological staff in the specialized clinic or the ENT doctor, by means of cloud based solutions.

To make sure a useful app was developed, OPCI was asked to bring in the users' perspective. In order to do that OPCI carried out several tests and questionnaires in each phase of the project.

Our research (questionnaire for Dutch users of a cochlear implant) showed that 79% of the users are (very) satisfied with their CI. In a one-on-one situation in a quiet room nearly all (93%) indicated that they hear fairly to very well. In all other situations, for example, a conversation with several people, a business meeting or a party, their speech understanding diminishes rapidly. There are, however, a lot of possibilities to improve their speech understanding. Using these possibilities will enable them to participate more and better in their daily life activities and will enhance their independency.

At this moment CI users have to find out a lot themselves, and not many people are actively looking for answers for the problems they face. Currently CI care is organized in such a way that for all adjustments and questions, CI users are referred back to their cochlear implant team. Hence, they do not have instant answers to their questions, as they have to make an appointment and travel back and forth to the hospital. In our research CI users indicated that they would be interested in a website or app where they could find their own personal data and information about their specific CI.

From May 2014 till April 2017 the SHiEC project concentrated on developing tools in order to better support senior CI users. The developed prototype of the E-Health app gives the cochlear implant user information about their CI and allows them to solve small CI issues themselves, without the need of a specialized CI centre. For example, they can find subtitled instruction videos about changing a battery. Also personal information about their own sound processor is given. Furthermore, the platform provides self-tests enabling elderly people to evaluate their own hearing.

The prototype has recently been evaluated by 20 CI users. Most of them found the app very motivating and were enthusiastic about it. They really appreciated the fact that they have more insight into the functionality of their device and they highly regarded the possibilities to do their hearing tests at home in their home environment. These results are more than enough reason to further develop this tool. There is no doubt that it will be available in the future, but as all these type of developments take time, we don't expect its release in the very near future.

For more information about this project, please visit www.shiec.eu

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Wayne Ellis qualified with a Masters degree in Audiology in 2005 and completed his clinical training at the Royal Berkshire Hospital, Reading. He has since worked as a Clinical Scientist in the Auditory Implant Teams at St. Thomas' Hospital and currently at the Royal National Throat, Nose and Throat Hospital, London. He has provided the following summary of his presentation at the BCIG Annual Meeting in Birmingham in 2017.

THE CI22M COCHLEAR IMPLANT - OVER 30 YEARS ON

Released in 1985 by Cochlear™, the CI22M was the first commercially available multi-channel cochlear implant with currently over 18,000 registered adults and children worldwide[1].

The Royal National Throat, Nose and Ear Hospital (RNTNEH) Cochlear Implant Programme, established in 1982, was the first of its kind in the UK. A total of 137 adults and children were implanted with the CI22M device between 1985-1997 and is one of, if not the, largest cohorts of CI22M users in the UK.

We conducted a retrospective review of our CI22M recipients to see how many implants were still functioning, the number of recipients requiring re-implantation, the reason for re-implantation and subsequent outcomes. Table 1 shows a summary of our clinical population.

Total implanted	137 (average recipient age 35.5 years, range 2.5-73 years)
Total re-implanted	24 (17.5%) (average recipient age 48 years, range 11-86 years)
Age of CI22M at re-implantation	Average 13 years, range 2-22.5 years
Existing CI22M users at RNTNEH	94 (mean implant age 22.5 years, range 20-32 years)
Transferred to another centre or deceased	19

Table 1 – Summary of RNTNEH CI22M statistics

Whilst some recipients required re-implantation, it was very encouraging to find that over 80% of our CI22M recipient's devices were still functioning some 20-30 years after implantation.

As can be seen from Figure 1, the main reason for re-implantation was a drop in performance, namely speech perception, and abnormal integrity test results (i.e. electrodes functioning outside the manufacturer's specification). This was normally found to be due to microscopic tears in the silicone insulation surrounding the electrode wires. A few recipients, however, required re-implantation for reasons unrelated to the device itself, such as infection. Interestingly, there was evidence of only one total device failure and one trauma-related failure over the 32 year period, thus highlighting the general robustness of the CI22M implant.

[1] Cochlear Nucleus Reliability Report (Cochlear, January 2017)

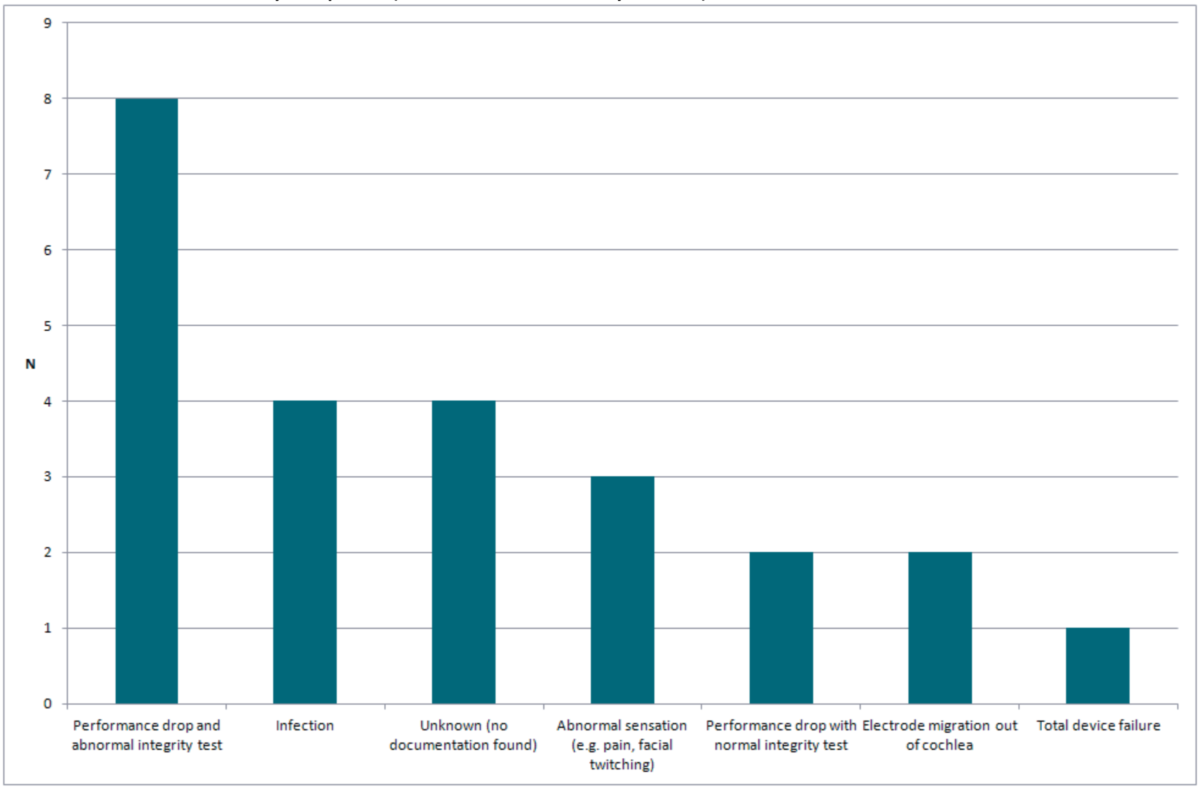

Figure 1 - Reason for re-implantation

Nearly all recipients requiring re-implantation received an updated device (see Figure 2). There was one recipient that was re-implanted with another CI22M implant as it was still the only device available at the time. In the majority of cases, a full reinsertion of the electrode array was achieved (see Figure 3). Three recipients had a partial reinsertion due to bony growth within the cochlea and one recipient was implanted in their other ear.

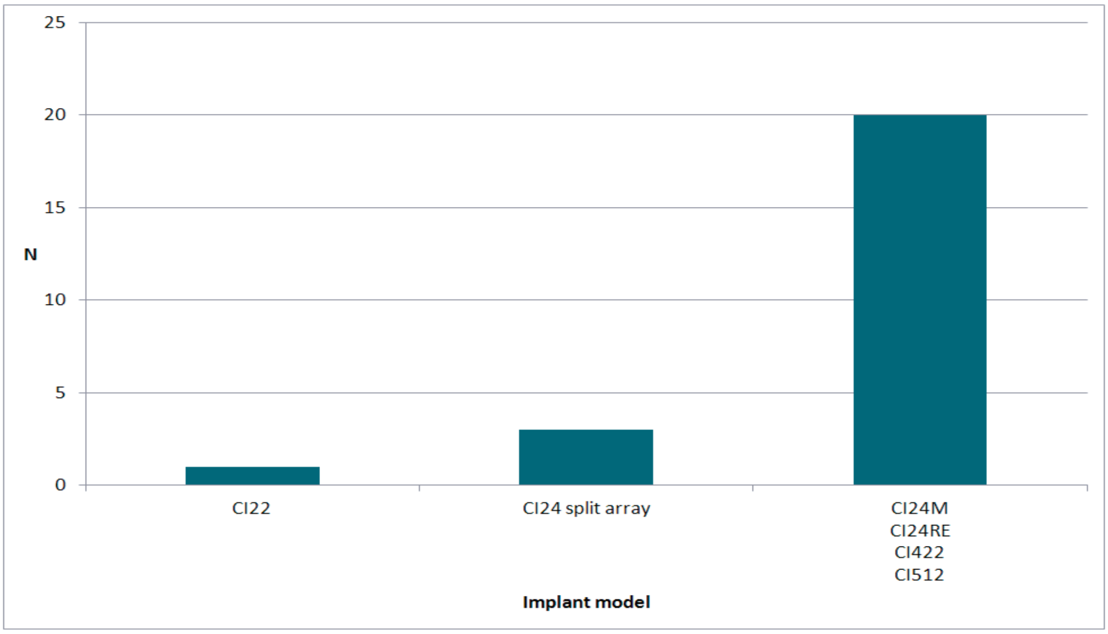

Figure 2 - Re-implanted model type

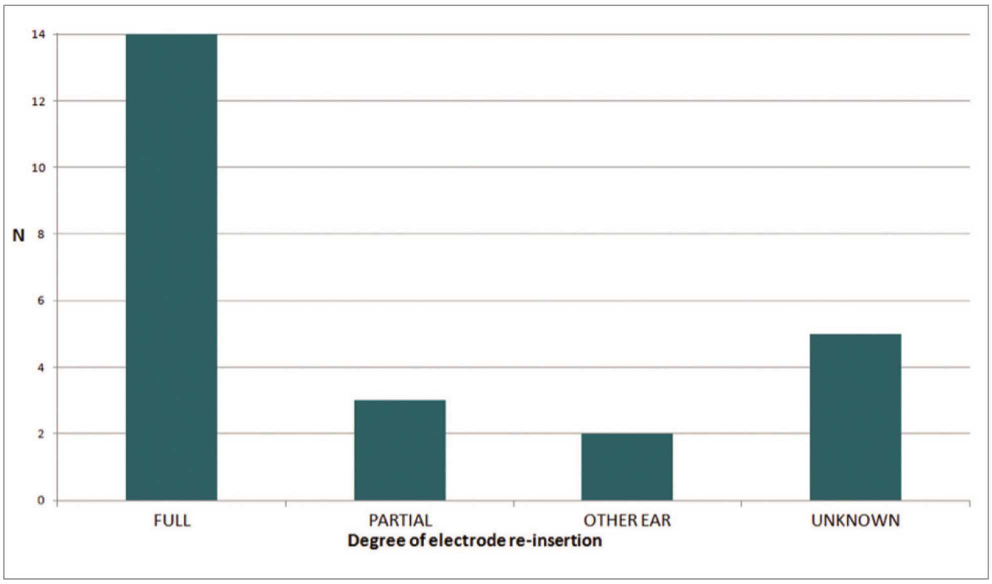

Figure 3 – Degree of electrode re-insertion

In terms of speech perception ability, many recipients achieved comparable or improved scores after re-implantation (Figure 4).

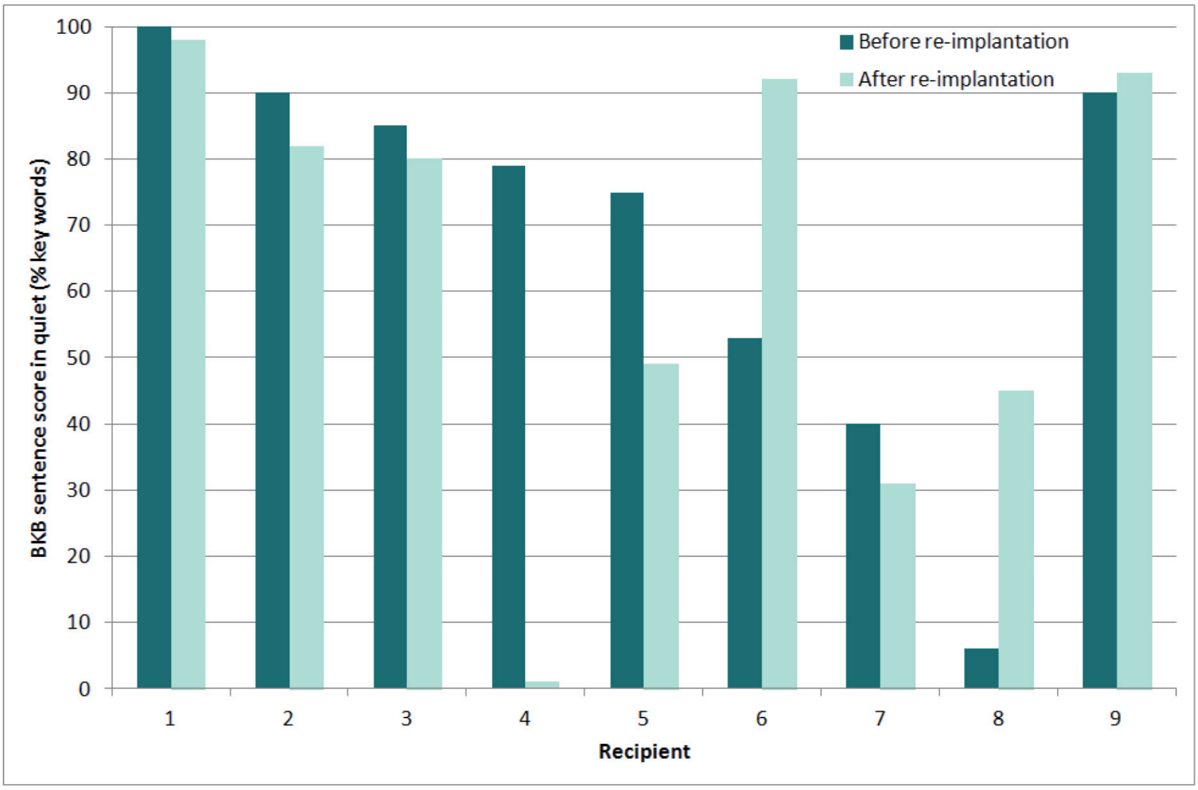

Figure 4 - Best BKB sentence scores in quiet. A change in score of 15% or more is typically considered clinically significant.

Notes:

Recipient 1:	the reason for re-implantation was actually a drop in their speech-in-noise score (from 100% to 42%) and 4 electrodes functioning outside the manufacturer's specification. After re-implantation their speech-in-noise score bounced back up to 94%.
Recipients 2 & 3:	comparable scores, despite being only 6 months after re-implantation.
Recipient 4:	re-implanted due to severe facial twitching and pain that could not be overcome through fine-tuning. Required a split electrode due to bony growth inside the cochlea, and not all electrodes could be inserted, so performance unfortunately dropped.
Recipient 5:	drop in performance, but this was thought to be due to cognitive factors.

Recipients 6 & 8: dramatic improvement as they were able to go from a partial to a full insertion of the electrode array.

Recipient 7: went from a full to a partial insertion due to bony growth.

Recipient 9: achieved comparable score only 3 months after re-implantation.

Conclusion

In summary, a large majority of our CI22M recipients are still going strong and continuing to receive significant benefit from their devices some 20-30 years after implantation. For those that required re-implantation, a full insertion of electrode array was typically achieved, along with comparable or improved speech perception ability, although this cannot be guaranteed.

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Sari Mykkänen's works at Tampere University Hospital Hearing Centre as a specialist in diagnostics and rehabilitation for hearing impaired people. She has provided the following summary of a presentation she gave at the EURO-CIU symposium in Helsinki in 2017.

BILATERAL COCHLEAR IMPLANTS FOR WORKING ADULTS:
Indications, results, and some ideas for the future

For some years already, cochlear implantation has been a standard practice in the rehabilitation of severe-to-profound bilateral sensorineural hearing impairment. In Finland, adults receive a cochlear implant when hearing aids do not provide sufficient help in coping with work and leisure activities. In most cases, such patients have severe or profound hearing impairment (pure tone average 0.5 - 4 kHz 70 dB or worse).

A speech discrimination percentage of about 50–60% is generally considered poor enough to warrant implantation. Bilateral implantation has been standard for children in Finland since 2007, but adults are still typically implanted only on one side. The benefit of bilateral listening is demonstrated systematically both in normal hearing and in hearing-impaired listening. Binaural listening enables sound localization and benefits speech understanding in noise in more complex listening situations.

There is much research on bilateral cochlear implantation for adults. At Tampere University Hospital, Kati Härkönen et al. carried out a prospective study in which 15 patients received a second cochlear implant. Their hearing was tested before and after the second implantation in the quiet and in background noise, and they were also interviewed about their working performance and work stress before and after implantation. In addition, the patients completed a quality of life survey.

In the study group, working performance was much better with bilateral implantation compared with single cochlear implantation, and the patients reported being more alert after a working day when bilaterally implanted. Binaural listening had a slight positive influence on the patients' career planning.

Furthermore, their sound localization was statistically significantly better, and after 12 months of binaural listening, there was also a statistically significant performance increase in speech discrimination. The sequential cochlear implant had a greater difference on the quality of the study patients' lives than they had ever thought. Indeed, the impact was almost as significant as the first cochlear implant. Even reported depression and distress decreased significantly. At Tampere University Hospital, we implant working adults with bilateral severe-to-profound hearing impairment bilaterally if they do not achieve a satisfying result with bimodal hearing (i.e. one ear implanted and the other ear using a hearing aid).

We consider discrimination percentages greater than about 70% to be satisfactory. Possible bilateral implantation also depends on the hearing requirements of the patient's job.

Although the benefit of a second cochlear implantation has been clearly demonstrated, cost-effectiveness is still raised as an issue. There is clear evidence about the cost effectiveness of bilateral cochlear implants for children: educational outcomes improve and education costs are reduced.

Now there is ever more research indicating the benefit of a second cochlear implant for adults. Saunders et al. have demonstrated the cost-effectiveness of cochlear implantation compared to no intervention at all. The cost-effectiveness of bilateral implantation compared to unilateral implantation was borderline, and it improved through long-term gains. Smulders et al. have shown bilateral implantation to be cost-effective if the patient has a life expectancy of 5 - 10 years or greater after the second implantation. One of the best ways of improving cost-effectiveness would be ensuring the reliability of the devices. The cost of faulty cochlear implants is paid by patients, employers, and society. Every re-implantation also uses the valuable time of specialists and creates tremendous psychological distress for the patient.

For children, access to care is excellent after neonatal hearing screening. With adults, however, referrals for cochlear implantation are surprisingly rare. Adult utilization is low everywhere, and GPs and family doctors are unfamiliar with hearing rehabilitation. Even otorhinolaryngologists are not aware of the indications for cochlear implants. This is a huge challenge for audiological rehabilitation teams and peer support organizations!

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Tony Murphy, Phonak's Communications Specialist, has provided the following article which discusses a recently published a detailed technical study by OFCOM (the Office of Communications). OFCOM Is *the communications regulator in the UK. It manages the TV, radio and video-on-demand sectors, fixed-line telecoms, mobiles and postal services, plus the airwaves over which wireless devices operate.*

OFCOM'S STUDY INTO THE COEXISTENCE OF 4G MOBILE PHONES AND ASSISTIVE DEVICES

Background

Wireless technology is increasingly being used in many areas of modern day life. We take for granted using our mobile phone or GPS to navigate our way through the world or send a picture of our holiday, instantly to a friend or family member in a foreign country. Various wireless technologies are also increasing their prevalence in the medical world. There is a growing number of wireless systems that can be used to benefit us medically. They can remotely monitor our health or help us to hear in difficult situations. The number of such systems is set to increase dramatically in the coming years and promises huge benefits for hearing instruments (cochlear implant and hearing aids) wearers. Some of these technologies such as Telecoil and FM have been around for a long time. For example the first use of Telecoils was reported as early as the 1920's. It is still used today and is the only currently available, truly universal system. However, it is an old technology and can be prone to interference, so hearing instrument manufacturers are increasingly developing more advanced digital technologies, that can automatically adapt to different environments and communicate with other devices.

This creates a problem, as other manufacturers in other industries are also utilising wireless technologies.

All wireless technologies hence have to be managed. Any wireless technology from a radio telescope to a computer mouse is allowed to use specific frequencies and these are all assigned in what we call the Radio Spectrum. It is a strange concept but this Spectrum is actually a finite resource such as water or gas and needs to be managed to optimise its best usage, to avoid conflicts. There are only so many frequencies that can be used, and some need to be prioritised for emergency services, some are needed for science and some are used for mobile phones. We do not want our mobile phone calls to interfere with emergency services. Hence the Spectrum needs to be managed. There are international laws that govern this, and local country specific laws for individual countries. In the UK our Spectrum is managed by OFCOM (Office of Communications).

With increasing demands for the next generation of mobile phones to exchange information, at ever increasing speeds, OFCOM was asked, by the UK Government, to look at identifying some areas of the Spectrum that could be used for proposed mobile phone technologies. The issue was that these frequencies were close to frequencies that are currently being used for hearing aids and cochlear implants. i.e. 2.4 GHz band. The concern was that these new devices may cause interference with hearing instruments. This was a particular concern in education as a child may not necessarily be able to report an issue. However this is not a purely educational issue as mobile phones are used in all theatres of human activity. In fact there are now more mobile phones on the planet than human beings, which is a another strange thought!

Testing

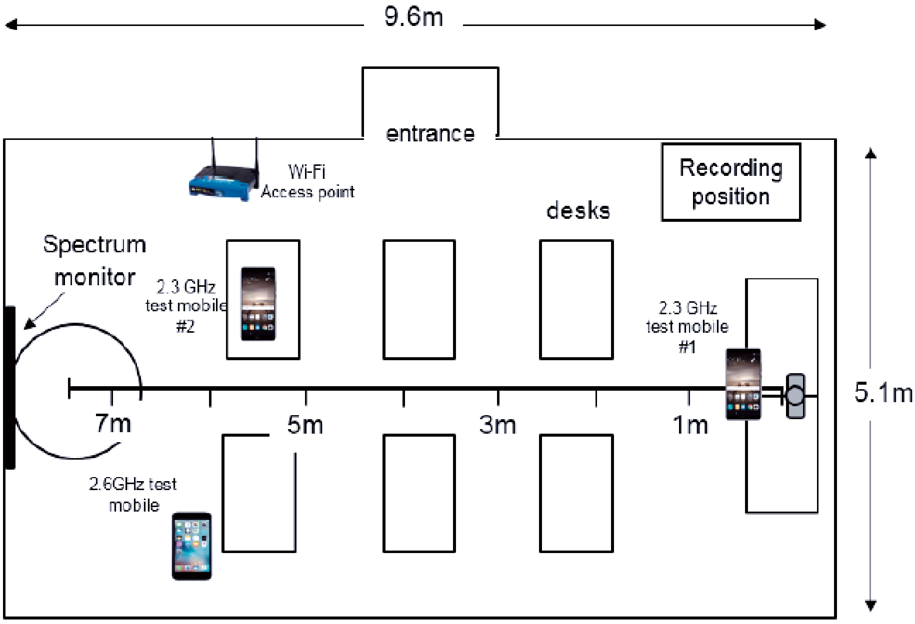
A theoretical model of these new phone systems and their interaction with hearing instruments concluded that there may be a slight probability of interference but it was unlikely. However, after discussion with all manufacturers it was decided that "any possible degradation of signal" is potentially harmful, particularly in the educational environment.

Hence OFCOM met with the main hearing instrument manufacturers, leading charities and The Children's Working Group. As a result of this consultation, OFCOM then developed a test protocol to simulate real world scenarios. These simulated the main use cases that a child would be likely to experience in their normal activity. These protocols were also accepted as being realistic representations by all the manufacturers and charities involved.

The other major complication was that there are a vast number of different technologies in use - from cochlear implants to hearing aids. Also there are multiple devices that can be connected to them. OFCOM used the most extreme testing scenario they could, to ensure that as much as possible we were testing at worst case scenarios.

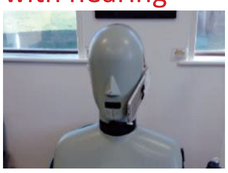
OFCOM created a model classroom (Fig 1), and pushed multiple phones using the real phones signals at maximum power, to their limits. A body simulator was also used to mount the hearing instruments on (Fig 2). It is impossible to test on multiple hearing instrument users as everyone's hearing is different. Hence this simulator or "Phantom" as it's referred to, represents the human body.

Fig 1: The layout of the classroom



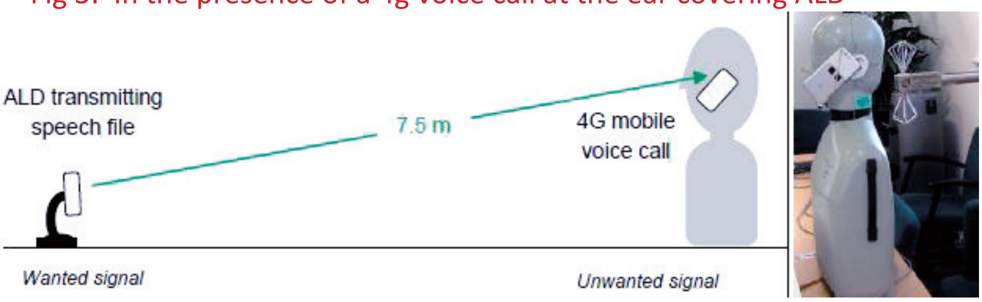
To test for issues an internationally recognised speech signal was sent to the hearing instruments via the wireless technology. This was recorded and analysed to see if there was any break up, or distortion of the signal. These recorded signals were then listened to via a panel of independent witnesses as the human ear can sometimes detect subtle issues that the mathematics cannot.

Fig 2: body simulator with hearing



Another concern was the 'latency'. Digital electronics take time to process all the information and this can create a delay in the signal (Fig. 3). This is not an issue if you are talking to someone in another room or country on a mobile phone.

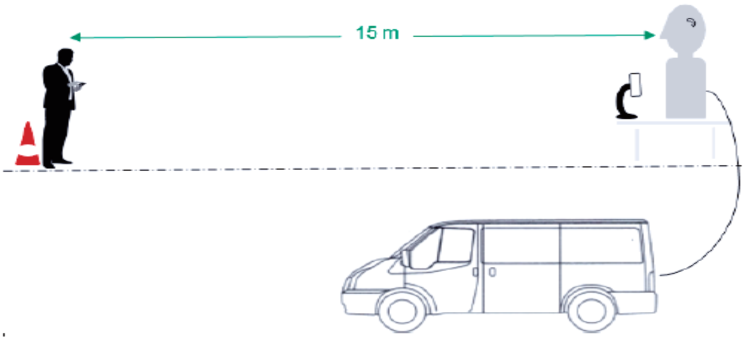
Fig 3: In the presence of a 4g voice call at the ear covering ALD



However, this can be an issue if you are also using lip reading as the electronic signal will be out of synch with the person's mouth, which will obviously be confusing. Generally it is aimed to keep this below 30 milliseconds or 0.03 seconds or 1/30th of a second.

Tests were also conducted at distance to simulate horse riding, a school assembly or a sporting activity to ensure this would still be possible (Fig 4). This varies according to the system but generally you would hope to get at least 10 to 15 metres range, from a system. This distance may increase for the more arduous situations up to in excess of 20 metres. Hearing instrument accessories are personal communication devices and generally used for face to face communication. As such it was agreed that a 10 to 15 metre range would be acceptable as testing levels.

Fig 4: Outdoor testing at 15m range



Results

Due to the huge number of different manufacturers' systems and accessories used with them and the time to perform each test it such a large amount of time and resources to this project. This work was undertaken voluntarily by them in response to lengthy consultations with The Children's Working Group and individual manufacturers for their specific testing requirements. The full OFCOM testing report is freely available to download from The OFCOM website.

Reference: study into the coexistence of 4G mobile phones and assistive listening devices (ALDs)

This also includes the sound samples should you wish to listen to them. You will not find manufacturers' specific model reference as this is sensitive information. However, the good news is that all the manufacturers' systems that were tested passed the various battery of challenging tests.

There were a few anomalies, but these were considered more related to the test methods. As this had never been done before, tests that were developed in other sectors were utilised which are generally used for testing conventional speech. Hearing instruments can sound 'odd' to normal hearing users so this was reflected in some of the quality measurements. However all manufacturers and charities agreed that the test protocol was realistic and that the results were sensible.

Diagrams provided by OFCOM

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The NCIUA is grateful to the professionals who have kindly provided the articles for this supplement which we hope you have found interesting and enjoyable reading.

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