Advancing Binaural Cochlear Implant Technology (ABCIT)

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Introduction

In 2012, a consortium of researchers and commercial partners in the UK, France and Germany secured €4M from the European Union's 'Framework 7' research fund to develop a research programme aimed at progressing bilateral cochlear implantation towards true binaural performance. This project - **Advancing Binaural Cochlear Implant Technology** (ABCIT) - had 5 main objectives:-

i) to develop the ability to exploit the full range of binaural hearing cues in CI, gearing stimulation strategies towards enhancing binaural information

ii) to develop a research platform, including a speech pre-processing module, to enhance the development of bilateral CI processors

iii) to adapt hearing-aid (pre-processing) algorithms to meet the special demands of implants

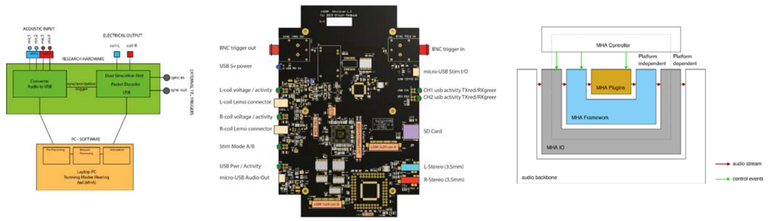
iv) to develop the means of measuring from the auditory brain signals that will provide an objective means of assessing binaural performance in CI users

v) to develop a low-power, wireless audio link between the devices at both ears so as to enhance users' access to binaural information

The programme of work was divided into work packages (WPs), each with a named lead partner. Critical aspects of of the programme were to ensure the successful delivery of the milestones and deliverables within each WP, and to ensure compatibility across WPs.

WP1 – Research Platform (R42, R43)

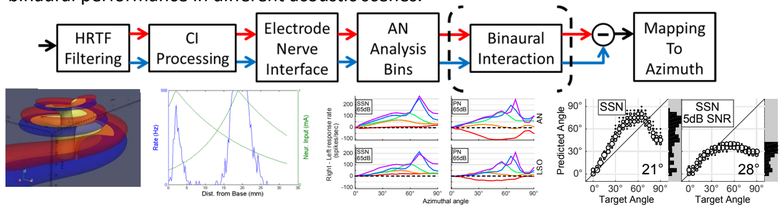
A portable, real-time research platform was developed, capable of processing signals from 4 microphones simultaneously. The interface between hardware and software is bi-directional *via* standard USB. The platform is well-suited to assessing sensitivity to interaural time differences (ITDs) in real-time, and supports instantaneously variable stimulation rates. Software processing can be changed on the fly.



The 'cHIRP' hardware handles 'real-world' signals and translating to and from these signals. (1) digitizing the acoustic input, (2) providing a first-in-first-out (FIFO) buffer and robust communication protocol for receiving commands, (3) producing the outputs needed to drive two CIs and (4) providing triggering and synchronization of all signals. The PC-side software is based on Hörtech's Master Hearing Aid (MHA).

WP2 – Simulation Tool (M16, R44)

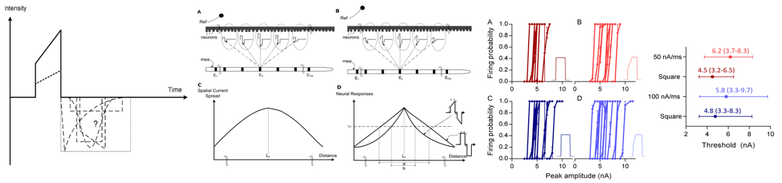
Developing the simulation tool was a two-stage processing, one involving development of a cochlear model of electrical stimulation and spread of excitation, and the other models of binaural processing based on neural firing patterns. Model outputs included predictions of binaural performance in different acoustic scenes.



Simulation of electrical spread and neural outputs, based on relative spiking of both brain hemispheres, was performed, and neuro-inspired binaural models tested in different listening situations, including in background noise.

WP3 – Stimulation Strategies (M55, R39, R46, R48, S20)

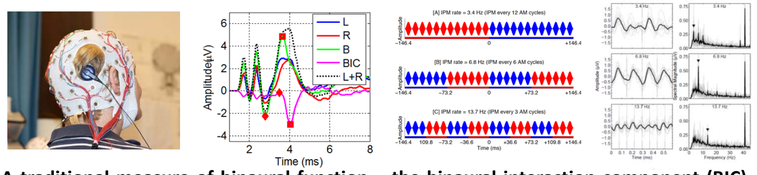
WP3 developed new stimulation strategies for CI, including strategies that take more-informed account of the biophysical properties of cochlear nerve fibres, and the potential for exploiting these properties to limit spread of excitation within the implanted cochlea.



The key feature of the new stimulation strategy is a ramped pulse shape, which theoretically will limit the spread of neural activation better than square pulses. Tested *in vitro* in spiral ganglion neurons, ramped pulses increase the dynamic range of the neural population, suggesting they can be used to enhance neural coding.

WP4 – Objectives Measures and Fitting (R39, R45, S20, W14)

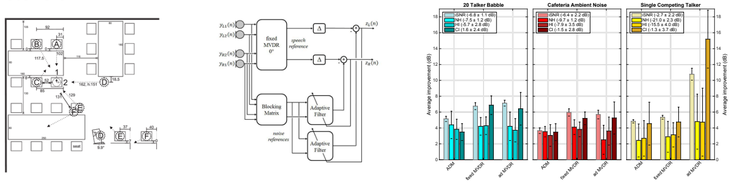
The purpose of WP4 was to develop objective measures of binaural function to improve fitting for monaural and binaural performance. By assessing objective measures using electro-encephalography (EEG) in normal-hearing listeners and CI users, potential diagnostic tools can be compared to subjective measures of performance.



A traditional measure of binaural function – the binaural interaction component (BIC) - was assessed in CI subjects to determine bilateral matching of electrodes. This objective measure was compared to subjective measures of pitch matching and lateralization tasks using ITDs. New stimulus paradigms were developed for distinguishing ITD and ILD pathways in the FFR of EEG signals. These are being tested in users of bilateral Cis.

WP5 – Pre-processing Algorithms (R39, R46)

The combination of bilateral CI technologies with pre-processing algorithms designed to enhance speech processing in noise has great potential for CI users. WP5 assessed the performance of these algorithms in an instrumental evaluation as well as in normal-hearing listeners.



Sounds were measured in real-life cafeteria conditions at Oldenburg University. Eight algorithms were assessed on a common real-time platform. Spatial unmasking of speech in simulated CI users was assessed for normal-hearing and impaired listeners, including those using hearing aids and cochlear implants.

WP6 – Binaural device prototype

An original goal of the ABCIT programme was to integrate information from WP1-5 into a formal prototype of a new binaural device**. With the purchase of Neurelec by Oticon Medical, we envisage a more direct route to clinical use for much of the information and technology developed by the ABCIT project**.

Conclusion

The ABCIT project has been an outstanding success in terms of the quality of the science it has generated, and the collaborative nature in which it was undertaken. It has provided an excellent opportunity for academics, engineers and commercial partners to work towards common goals and to help advance binaural cochlear implant technology.