Institution: University of Southampton

Unit of Assessment: 15 General Engineering

Title of case study: 15-03 Restoring hearing with cochlear implants

1. Summary of the impact

Cochlear implants are the only successful treatment available for people with severe to profound deafness. Research into these implants at the Institute of Sound and Vibration Research (ISVR) at the University of Southampton has led directly to changes in health policy, including new guidelines by the National Institute for Health and Clinical Excellence (NICE). ISVR researchers have developed patient assessment questionnaires which are used internationally as a means of monitoring children with cochlear implants. ISVR pioneered research and clinical work bilateral cochlear implantations in the UK, yielding benefits for the estimated 9,000 bilateral cochlear implant recipients around the world (around 700 in the UK).

2. Underpinning research

Cochlear implants are the only successful treatment for people with severe to profound deafness who cannot benefit from hearing aids. They can completely change the lifetime prospects of a deaf baby, providing the ability to hear and understand speech. At the University of Southampton's ISVR, a team of researchers (Mark Lutman, Professor of Audiology since 1995, retired 2012; Julie Brinton, Head of the South of England Cochlear Implant Centre since 1996; and Dr Carl Verschuur, Lecturer in Audiology since 1999) have carried out crucial research into the benefits of bilateral implantation, providing tools for clinical service, and developing novel speech processors.

Cochlear implants can provide a striking improvement in quality of life for children with severe to profound hearing loss. But clinical examination, candidate selection and rehabilitation are much more difficult for children than adults, especially very young children. As part of clinical research to address these issues, Lutman and colleagues developed the Categories of Auditory Performance (CAP) rating scale **[1]**.This is a reliable scale used to predict the performance of paediatric cochlear implantation and rate outcomes from the treatment in everyday life **[1]**. In 2001 and 2002, they further developed the Parent Questionnaire (PARQ) to assess parental views and experiences regarding children with cochlear implants **[2]**.These questionnaires can be reliably used for infants less than 12 months old. To maximise the benefits of cochlear implants for children, Lutman and colleagues undertook research to decide the best age at which to implant. They found that children given implants early are far more likely to go to mainstream schools than those given implants when already in an educational setting (53% vs 6%). **[3]**.

ISVR researchers have been at the forefront of research into bilateral cochlear implantation. Until recently, individuals with severe to profound deafness in both ears usually received a single cochlear implant. ISVR's pioneering research trials with cochlear implant recipients helped to define the criteria of candidacy for cochlear implants **[4]** and showed definitive benefits of bilateral cochlear implantation for sound localisation **[5]**.Subsequently, ISVR was a partner – alongside the Institute of Hearing Research at Nottingham University and the implant producer, Cochlear® - in setting up and running a highly influential national trial of bilateral cochlear implantation which showed significant measurable advantages to providing two cochlear implants **[5]**. The trial ran from 2000 to 2004. Researchers at the ISVR (Carl Verschuur and Mark Lutman) ran the auditory localisation "wing" of the national study.

In parallel to the clinical research, the team conducted research to improve speech processing in cochlear implants. Between 2006 and 2011, Lutman and ISVR colleagues developed a novel speech coding strategy based on providing a simpler speech signal to the implant recipient, known as sparse representation **[6]**.The ISVR is a major participant a European-wide funded scheme to develop novel speech processing strategies for cochlear implants **[7]**.

3. References to the research

Selected ISVR publications (best three are starred)

[1]* Archbold S, Lutman ME, Marshall DH. Categories of Auditory Performance. Annals of otology, rhinology & laryngology. Supplement 166:312-314, 1995
http://www.ncbi.nlm.nih.gov/pubmed/7668685

[2] Archbold S, Lutman ME, Gregory S, O'Neill C, Nikolopoulos TP, Parents and their deaf child: their perceptions three years after cochlear implantation, Deafness Education International 4(1):12-40, 2002 http://eprints.soton.ac.uk/10641/

[3]* Tait ME, Nikolopoulos TP, Lutman ME. Age at implantation and development of vocal and auditory preverbal skills in implanted deaf children. International Journal of Pediatric Otorhinolaryngology 71(4), 603-10, 2007
http://www.sciencedirect.com/science/article/pii/S0165587606005362

[4] UK Cochlear Implant Study Group. Criteria of candidacy for unilateral cochlear implantation in postlingually deafened adults - I: Theory and measures of effectiveness. Ear and Hearing 25(4), 310-35, 2004. ISVR contributors included Lutman and Eyles.
http://www.ncbi.nlm.nih.gov/pubmed/15292774

[5]* Verschuur CA, Lutman ME, Ramsden R, Greenham P, O'Driscoll M. Auditory localization abilities in bilateral cochlear implant recipients. Otology & Neurotology 26(5), 965-71, 2005
http://eprints.soton.ac.uk/28305/

Patent

[6] Sparse stimulation for cochlear implant. UK patent number: WO 2009030909 20090312, Publication date: inventors: Mark Lutman; Guoping Li, 2009

http://patents.justia.com/patent/8290597

Grant

[7] Digital signal Processing in Audiology, European Marie Curie Initial Training Networks (ITN) European Framework Programme 7, 2008-2012, Mark Lutman. 2,950,000 €

4. Details of the impact

There are 10 million people with hearing loss in the UK and 0.2 million with severe to profound hearing loss may require cochlear implants. Around the world there are 220,000 people with cochlear implants. The research carried out at ISVR has had a direct impact on the lives of such people, as well as the quality of clinical service and national health policies for cochlear implantation.

The ISVR research described in Section 2 has had a substantial impact on UK national health policies. In 2009, the South of England Cochlear Implant Centre (now University of Southampton Auditory Implant Service) at the ISVR performed its first simultaneous bilateral cochlear implants, and since then about 150 patients have received bilateral cochlear implants nationally. The research led by ISVR on the benefits of bilateral cochlear implants, and research on educational outcomes for children with implants - with ISVR as one of main contributors - were cited in the guideline published by the National Institute for Health and Clinical Excellence (NICE) **[8, 9]**. Lutman was invited to contribute to this guideline on the basis of his expertise gained through the underpinning research. The guideline recommends bilateral cochlear implantation for all children and some adults.

The ISVR's research examining the best age for children to receive implants provided direct evidence for designing other guidelines for professionals dealing with deaf people, including national guidelines on cochlear implantation for children and young people **[10]** used by the 22

cochlear implant centres in the UK in their clinical work. Similarly, the guidance *Criteria of candidacy for unilateral cochlear implantation in post-lingual deafened adult*' (see section 3 of **[3]**) designed by several groups with substantial input from ISVR research and published in 2004, continues to be widely used in most cochlear implant centres in the UK.

The questionnaires developed by Lutman at ISVR have been widely used as research and clinical tools. The CAP questionnaire has been translated into at least 13 languages by The Ear Foundation of the UK **[16]**. It has become a standard assessment tool for patients with cochlear implants in worldwide clinical centres and is widely used for patient selection, performance prediction and outcome rating. Countries using the questionnaire in clinical studies have included Thailand **[11]**; in a study of 143 children, 164 children in Finland **[12]**; a study of 164 children receiving the devices; and a study of 44 children in China **[13]**. Both the CAP and the parent questionnaire, PARQ, have been used as indices in the cost-effectiveness calculation for cochlear implantation, which is a key factor influencing health policy **[17], [18]**.

At the patient level, ISVR has performed more than 500 unilateral implantations since 2008 and conducted the first pioneering bilateral implantation in the UK in 2009, providing very significant quality of life improvements for each of these patients and their families. More widely, ISVR's research has indirectly improved clinical services through the policies and guidelines mentioned above for about 11,000 existing and 1,000 new implant users per year in the UK. Patients report exceptionally high levels of satisfaction from clinical services provided by the ISVR. The following is typical of self-report from such patients: "I still can't find words to express how overjoyed I am with the result so far, and how appreciative I am of all the help and understanding I've been given. I can now take an active part in life again – truly "life after deaf". **[14]**

The life-changing nature of cochlear implants was celebrated and brought to the attention of a wider public through a highly unusual public event in Southampton in September 2012, a concert of musical works by Benjamin Oliver specifically composed for cochlear implant users, attended by over 100 people **[15].** The concert and musical piece led directly from work conducted by ISVR researcher Rachel van Besouw (lecturer in Audiology, working at ISVR since 2007) which has highlighted the difficulties cochlear implant users experience.

5. Sources to corroborate the impact

[8] National Institute for Health and Clinical Excellence Guideline: Cochlear implants for children and adults with severe to profound deafness. 2009.
http://www.nice.org.uk/nicemedia/pdf/TA166Guidancev2.pdf
http://www.nice.org.uk/TA166

[9] Health Technology Appraisal 166: Cochlear Implants for Deafness in Children and Adults
http://www.hta.ac.uk/fullmono/mon1344.pdf

[10] Quality Standards: Cochlear Implants for children and young people - Guidelines for professionals working with deaf children (British Cochlear Implant Group and the National Deaf Children's Society, 2009).
http://www.ndcs.org.uk/about_us/position_statements/cochlear_implants.html

[11] Kasemsuwan L, Cheewaruangroj W, Tungkeeratichai J, Bhongmakapat T, Lertsukprasert K, Thawin C, Tiravanitchakul R, Dara R, Orathai P Audiological outcomes of cochlear implantation in Ramathibodi Hospital. Journal of the Medical Association of Thailand 2011 Nov 94(11):1380-6.
http://www.ncbi.nlm.nih.gov/pubmed/22256479

[12] Lonka E, Hasan M, Komulainen E Spoken language skills and educational placement in Finnish children with cochlear implants. Folia of Phoniatrica et Logopaedica 2011;63(6):296-304.
http://www.karger.com/Article/FullText/326911

[13] Zhou H, Chen Z, Shi H, Wu Y, Yin S Comparisons of auditory performance and speech

intelligibility in children with cochlear implants placed using different approaches. Otology and Neurotology 2012 Jan;33(1):26-9.

[14] http://ais.southampton.ac.uk/personal-views/. This website provides an overview of reported personal experiences from users of the ISVR auditory implant service.

[15] http://www.southampton.ac.uk/mfg/current_projects/compositions.html. The website provides an overview of joint ISVR-Department of Music (University of Southampton) work to research music abilities in cochlear implant recipients and develop novel musical compositions focused on the listening needs of this population.

[16] Chief Executive, The Ear Foundation

[17] Chair of British Cochlear Implant Group, Yorkshire Cochlear Implant Service, Bradford Royal Infirmary

[18] Professor Quentin Summerfield, Department of Psychology, University of York