Institution: University of Kent
Unit of Assessment: A4: Psychology, Psychiatry and Neuroscience
Title of case study: Reducing neurological disability via vestibular stimulation

1. Summary of the impact

The impact of this case study is the novel treatment of neurologically impaired individuals via vestibular stimulation, an emerging clinical therapy. The research has helped make people better, changed local clinical practice, and led to a commercial collaboration to produce a CE-marked (European Union safety compliant), home-based device that can be marketed and used across the world. The research has also raised awareness and understanding of neurological disease amongst healthcare practitioners and the general public.

2. Underpinning research

Despite recent advances in the ability to characterise and understand the aetiology of brain disease, effective treatments for the most common and refractory diseases remain scarce. The problem is growing because recent advances in acute medical care have increased the number of individuals who survive brain trauma but nevertheless have complex rehabilitation needs. The prevalence of other neurological disorders, such as dementia, has likewise increased given that more people are now living longer.

Within the last decade, emerging evidence indicates that a non-invasive and painless form of sensory stimulation known as vestibular stimulation may hold therapeutic value. The procedure involves either the electrical or thermal stimulation of the balance organs within the inner ear, and leads to increases in cortical activity associated with recovery.

Dr David Wilkinson (School of Psychology at the University of Kent 2005 – present, and also Honorary Senior Research Fellow at East Kent Hospitals University NHS Foundation Trust) and colleagues at both the University of Kent and East Kent Hospitals University NHS Foundation Trust are one of only a few groups world-wide to pioneer the development of this technique, producing research papers and attracting research funding from the Medical Research Council (MRC), British Academy (BA), Harvard University, a local NHS hospital trust, and the commercial sector. Dr Wilkinson started to develop the technique in 2003 while at Harvard Medical School where he provided evidence in one brain-injured individual that the procedure may alleviate face-blindness. Since arriving at Kent, he has continued this novel work by showing that the procedure may speed face recognition in neurologically healthy participants (Wilkinson et al., 2008), and, by means of single-case study and randomised, controlled trial, demonstrated safety and preliminary efficacy in a large group of stroke patients suffering from the common, refractory disorder of hemi-spatial neglect (Wilkinson et al., 2009; Wilkinson et al., 2013; Zubko, Wilkinson, Langston & Sakel, 2013). Allied work has shown, again for the first time, that vestibular stimulation can help relieve the co-morbid impairment of constructional apraxia (Wilkinson et al., 2013), and has also determined the frequency with which patients who present for treatment suffer from the complication of limb spasticity (Wilkinson et al., 2010). Dr Wilkinson has since acquired £114,000 from Scion Neurostim LLC, a medical device company based at Duke Medical School USA, and over £500,000 from external funders to diversify his group's work across several other troubling conditions that hitherto have not been subject to vestibular stimulation, including permanent vegetative state and migraine.

3. References to the research

Wilkinson, D.T., Nicholls, S., Pattenden C., Kilduff, P., & Milberg, W. (2008). Galvanic vestibular stimulation speeds memory recall. *Experimental Brain Research*, *189*, 243-248. doi: 10.1007/s00221-008-1463-0

Wilkinson, D.T., Zubko, O., & Sakel, M. (2009). Safety of repeated sessions of galvanic vestibular stimulation following stroke: A single-case study. *Brain Injury*, *23,* 841-845. doi: 10.1080/02699050903232541

Wilkinson, D.T., Zubko, O., DeGutis, J., Milberg, P., & Potter, J. (2010). Improvement of a figure copying deficit during sub-sensory galvanic vestibular stimulation. *Journal of Neuropsychology, 4,* 107-118. doi: 10.1348/174866409X468205

Wilkinson D.T., Sakel M., Camp S., & Hammond L. (2012). Patients with hemi-spatial neglect are more prone to limb spasticity, but this does not prolong their hospital stay. *Archives of Physical Medicine and Rehabilitation*, *93*, 1191-1195. doi: 10.1016/j.apmr.2012.08.024 (see REF2)

Zubko, O., Wilkinson, D.T., Langston, D., & Sakel, M. (2013). The effect of repeated sessions of galvanic vestibular stimulation on target cancellation in hemi-spatial neglect: Preliminary evidence from two cases. *Brain Injury*, *27*, 613-619. doi: 10.3109/02699052.2013.767938

4. Details of the impact

Clinical efficacy:

The findings of the prospective, randomised, controlled, and double-blind dose-response trial conducted by Dr Wilkinson to assess the efficacy of galvanic vestibular stimulation therapy are detailed in an end-of-grant report for the MRC (section 5, item 1), and have also been prepared in a manuscript which has been submitted for publication. Trial participants (N = 54) were allocated to one of three active treatment arms in which the number of stimulation sessions (1, 5 or 10) was manipulated. The key outcome measure, the Behavioural Inattention Test, showed a mean symptom reduction of 28% at one-month follow-up across all three treatment arms, and was associated with improvement on the Barthel Index, a measure of activities of functional capacity and independence. Together these data raise the exciting possibility that even a single session of stimulation may be sufficient to induce long-term relief from neglect.

The evidence emerging from this trial is corroborated by clinical testimony from a Consultant Physician at Kent & Canterbury Hospital (section 5, item 2), who notes that:

> All post-stroke patients are now screened with line bisection and other subtests of the Behaviour Inattention test and, where appropriate, offered his GVS [Galvanic Stimulation] treatment which has shown striking early success. Other patients with complex conditions involving Cerebellar balance disorder and language deficits have also benefitted from the procedure. This is especially important because these conditions are linked to length of stay and long-term disability in the community. The success of Dr Wilkinson's stimulation study with patients in persistent vegetative state is now enabling us to repatriate a number of patients from London to my Canterbury Rehab Unit, thus saving precious resources for the local health economy and reducing travel for relatives.

Patients interviewed by news agencies also provided striking anecdotal accounts of how much the treatment developed by Dr Wilkinson has helped them. Both ITV Meridian and BBC South East Today TV ran news pieces in their early evening bulletins featuring stroke patients who said that they had benefited from the treatment. These patients appeared alongside their consultant physician who confirmed that there had been an improvement in their functional capacities. This television coverage prompted the editor of the health section of the Daily Mail newspaper to investigate the potential impact of Dr Wilkinson's stroke research (section 5, item 3 summarises media coverage of the work). Below is an extract from the article (section 5, item 4):

> Stephen McClean, a former plasterer from Ramsgate who suffered a massive stroke to the right side of his brain three years ago, is one of the first to benefit from the new treatment. After six months in hospital recovering from the paralysis caused by the stroke, the 49-year-old father of two was left with little awareness of his left side, 'I couldn't drive because I would hit cars parked on the left side of the road,' he says, 'I wouldn't eat food on the left side of my plate or I would push the food on the left-hand side of the plate on to the table. It was frustrating.' Since having five sessions of treatment at home last year, he is much more aware of his left side. 'I no longer push the food off the left side of my plate. Also, when I painted some fence panels, I did both sides — which I wasn't able to do before.

Changes in clinical practice:

The hemi-spatial neglect studies conducted by Dr Wilkinson and colleagues have led to two recent changes in clinical practice within the local clinical units (section 5, item 2). First, galvanic vestibular stimulation is now prescribed under physicians' directive as an adjunct therapy to the standard therapy for post-stroke hemi-spatial neglect and cerebellar ataxia. Also, patients admitted in either permanent vegetative or minimally conscious state are, subject to the appropriate consents, given a 16 week programme of vestibular stimulation to help increase their arousal and awareness. Second, all stroke patients admitted to the East Kent Neuro-rehabilitation Service are now mandatorily screened for neglect. This change in routine diagnostic practice was prompted by Dr Wilkinson's recent finding that three-quarters of patients who present with limb spasticity also suffer from neglect (Wilkinson et al., 2012). Patients now receive targeted neglect therapy earlier within their treatment plan.

Commercial impact:

Scion Neurostim has provided brain stimulators free of charge for Dr Wilkinson's stimulation research and within the last two years have awarded him £114,000 to support his work on migraine and persistent vegetative state (section 5, item 5). They have utilised his findings to constrain the design, operation and clinical indications of a portable, vestibular stimulation device that they are developing. Throughout 2013-14, Dr Wilkinson is the chief investigator for the UK arm of their pivotal migraine study, data from which will support a CE application to both the US Food and Drug Administration and the UK Medicines and Healthcare Products Regulatory Agency. Once regulatory approval is obtained, the device will be marketed as an authorised clinical treatment for episodic migraine across North America, Europe and developing countries.

Increasing professionals' and the public's understanding of neurological disease:

To increase public awareness and understanding of these debilitating neurological diseases, Dr Wilkinson and colleagues have published articles in hospital magazines for NHS staff and patients (section 5, Item 6) and the local newspaper (section 5, item 7). In national recognition of the need for clinicians to identify and treat hemi-spatial neglect with procedures such as vestibular stimulation, Dr Wilkinson's MRC research study was included in the 2012 and 2013 editions of the Annual Parliamentary Report on Research and Development in Assistive Technology (section 5, item 8), published by the Department of Health for government decision-makers, health practitioners and service users. One reason why Dr Wilkinson's research has reached this level of prominence is the many talks that he has given to clinicians, patients and commissioners within the local healthcare community. In the last four years he has given over a dozen talks, including three keynote addresses (section 5, item 9).

5. Sources to corroborate the impact

Sources can be obtained by emailing psychref@kent.ac.uk.

1. MRC Developmental Clinical Studies – Does repeated vestibular stimulation induce lasting recovery from hemi-spatial neglect (MRC Ref: G1001222). Project End Report, 07/06/13.

2. Letter from Consultant Physician and Director East Kent Neuro-Rehabilitation Service, corroborating the local clinical impact of Dr Wilkinson's vestibular stimulation research.

3. Document summarising media coverage of Dr Wilkinson's vestibular stimulation research. These include appearances on ITV Meridian (09/05/11), BBC South East Today (24/08/11, 03/01/12) and BBC Radio Kent (25/08/11), see also http://tinyurl.com/ukcpsymed.

4. 'Help at last for stroke victims who are left with only half a life' (Daily Mail, p. 34, 23/08/11).

5. Letter from CEO and President of Scion Neurostim LLC. This corroborates the impact of Dr Wilkinson's research on the regulatory and scientific development of Scion NeuroStim's patented vestibular stimulation device. The company is using Dr Wilkinson's work to develop therapeutic protocols and is running a clinical trial led by him which will lead to a CE application, FDA registration, and eventually international marketing.

6. East Kent Hospitals University NHS Foundation Trust Quarterly magazine, p. 2, No. 22 (April/May), 2011.

7. 'Pioneering work leads to trial of new treatment', Canterbury KM Gazette (p. 12, 16/06/11).

8. 2011-12/2012-13 Research and Development Work Relating to Assistive Technology, Department of Health (p. 75). Presented to Parliament pursuant to Section 22 of the Chronically Sick and Disabled Persons Act 1970.

9. Invited (non-academic) lectures to the healthcare community (attended by physicians, nurses, carers, service chiefs / policy-makers and patients). Selected talks given below:

Jan 2012: 'Vestibular Stimulation in Low Awareness States', East Kent Hospitals Neuro-rehabilitation Service.

Dec 2011: 'Low awareness states: Pathogenesis, Diagnosis and Treatment', Royal Hospital for Neuro-disability, London, UK.

Oct 2011: 'Improving the visual perception of stroke sufferers via stimulation of the inner ear',15th Annual Conference of Recent Advances in Brain Injury Rehabilitation, Homerton University Hospital, London. Keynote speech (inc. honorarium).

Sept 2011: 'Galvanic Vestibular Stimulation: A new treatment for hemi-spatial neglect?' East Kent Hospitals Trust Annual Research & Development symposium.

Jan 2010: 'Vestibular Stimulation following Traumatic Brain Injury', East Kent Hospitals Trust Traumatic Brain Injury Research Symposium.

Oct 2009: 'The inner ear: A window into cognitive rehabilitation', East Kent Hospitals Annual R&D Research Symposium.

Nov 2008: 'The 2008 SUSTAIN Lecture: Galvanic Vestibular Stimulation and Acquired Disorders of Vision'. Keynote speech (inc. honorarium) given at the Kent & Canterbury Hospital 3rd Annual Stroke Conference.

March 2008: 'The Rehabilitation of Hemi-Spatial neglect', South East Stroke Research Network 2008 Update Meeting.