Institution: University of Aberdeen

Unit of Assessment: 4 - Psychology, Psychiatry and Neuroscience

Title of case study: 'Physiotherapy for the eyes' – development and commercialisation of new therapy for rehabilitation of sight loss after brain injury

1. Summary of the impact

Research carried out at the University of Aberdeen has directly resulted in a new therapy for stroke patients who have suffered partial sight loss. The sight rehabilitation device developed through the research has so far been used to treat around 300 UK stroke patients, who reported significant improvements in their quality of life. The therapy has been publicized by the UK Stroke Association and at national and international events. The research also led to commercial impacts through the creation of a spin-out company, Sight Science Ltd, which was later acquired by its only worldwide competitor, NovaVision Inc, protecting jobs and forging a long-term commercial partnership.

The specific impacts on commerce have been: substantial industrial investment in research and development, job creation and protection within UK industry, commercialisation of a new product, and long term partnership contract with industry with provisions for commercialisation of future products.

2. Underpinning research

Each year, around 7,500 people in the UK suffer sight loss due to a stroke, with 56,000 affected across the European Union and 37,000 in the US. The pattern of sight loss most commonly seen in stroke patients is a loss of the right or left halves of the visual field of both eyes – meaning that the patient cannot compensate for this partial loss by using the other eye. Up until now, there have been few effective treatment options.

It is on this type of sight loss and new ways of treating it that a team led by Arash Sahraie, Professor of Psychology (at the University of Aberdeen since 1998) has focused a series of research projects. Funded by a Chief Scientist Office grant, the research involved an interdisciplinary team at Aberdeen including Dr CT Trevethan (Psychology), Dr MJ MacLeod (Medicine and Dentistry), and Dr J Olson (consultant ophthalmic physician) alongside Dr R Coleman (NHS Grampian) and Prof L Weiskrantz (University of Oxford).

Between 2001 and 2004, Sahraie et al conducted a systematic investigation of residual visual abilities within the blind visual fields of a cohort of stroke patients. The studies primarily involved psychophysical investigations of visual performance under controlled laboratory conditions. Initially, 15 stroke patients underwent a range of clinical investigations to determine the extent of their sight loss. This was followed by psychophysical tests to detect and characterise any residual visual sensitivity within the field defect, to find the optimum visual stimulus parameters that can be detected after brain injury. These tests revealed the existence of a channel of visual processing with well-defined spatial [3.1, 3.2] and temporal [3.4] characteristics. Crucially, the laboratory-based research techniques were also able to reveal evidence of neuronal processing, even when patients were not aware of being able to see the visual patterns they were shown. Establishing the type of visual patterns that could be processed - in the absence of patient awareness - was a key step towards devising a novel rehabilitation intervention.

A subsequent study investigated and established the impact on visual sensitivity following daily visual stimulation using visual targets matching the optimum channel properties in a group of case controlled stroke patients [3.3]. The results showed that repeated exposure to appropriate visual stimuli can lead to improvements in visual sensitivities in the very depths of the field defect.

These findings led to the development of a novel patent-protected medical device (Vision Rehabilitation Program$^{CE\ TM}$) aimed at rehabilitation of sight loss, which has been shown to improve

visual sensitivity in stroke patients with impaired vision [3.5]. The computer-based device, tailored to each individual's specific visual field defect, can be used in the patient's home environment. Patients spend approximately 30 minutes daily in front of a computer screen where specific visual patterns are shown in the damaged areas of the patient's visual field. The patient's task is to indicate the presence of the patterns using button presses. The intervention was shown to have had a positive quality of life outcome in 76% of cases [3.6].

3. References to the research

[3.1] Sahraie A, Trevethan CT, Weiskrantz L, Olson J, MacLeod MJ, Murray AD, Dijkhuizen RS, Counsell CE & Coleman R. (2003). Spatial channels of visual processing in cortical blindness. European Journal of Neuroscience, 18, 1189-1196. (21 cites)
This was the first study to move away from single case reports and show that a group of patients with blindness after brain injury, show similar characteristics in being able to detect coarse rather than fine structures presented in their field defect. This sensitivity to what is known as low spatial frequencies is retained and was used for developing rehabilitation strategies.

[3.2] Trevethan CT, & Sahraie A. (2003). Spatial and temporal processing in a subject with cortical blindness following occipital surgery. Neuoropsychologia, 41(10), 1296-1306. (5 cites)
Prior to this paper, there had been a long standing debate on what underpins the residual visual processing in the blindfield, with many arguing for so called islands of surviving vision. This study showed the existence of preferential low spatial frequency processing in a patient with partial surgical removal of the occipital lobe, settling the debate.

[3.3] Sahraie A, Trevethan CT, MacLeod MJ, Murray AD, Olson JA, & Weiskrantz L. (2006). Increased sensitivity after repeated stimulation of residual spatial channels in blindsight. Proceedings of the National Academy of Sciences of the USA, 103, 14971-14976. (46 cites)
This is the first study of the use of low spatial frequency targets for repeated stimulation of blindfield, leading to improved visual sensitivity in a cohort of patients with brain injury.

[3.4] Sahraie A, Trevethan CT, & MacLeod MJ, et al. (2008). Temporal properties of spatial channels of processing in hemianopia. Neuropsychologia, 46, 879-885. (11 cites)
This paper brings in a new dimension into the debate by showing that in addition to changes in space (low spatial frequency) the way a visual target is presented in the time domain also plays an important role in whether or not it is detected. Again, a group of patients were studied and the findings in relation to the temporal parameters were consistent across the patient group.

[3.5] Sahraie A, Trevethan CT, & MacLeod MJ. (2010). Improved detection following Neuro-Eye Therapy in patients with post-geniculate brain damage. Experimental Brain Research, 206, 25-34. (8 cites)
This is a recent paper, but brings in a technique from the well-established "learning" literature, into the field of neuropsychology of vision. It shows the role of continuous positive feedback throughout a visual training session, leading to faster learning and improvements.

[3.6] Trevethan CT, Urquhart J, Ward R, Gentlemen D & Sahraie A. (2012). Evidence for perceptual learning with repeated stimulation after partial and total cortical blindness. Advances in Cognitive Psychology. 8(1), 29-37.
This latest paper demonstrates that learning and increased sensitivity after repeated and systematic stimulation can take place even in patients with total cortical blindness. It also shows that the exact location of visual stimulation and improvements in visual fields are directly related.

Relevant grant funding:

Sahraie, A. Detection and evaluation of residual vision and visual rehabilitation in cortically blind patients. Chief Scientist Office. £126,793. 1/09/01 to 31/08/04

Sahraie, A. Visual rehabilitation device for cortically blind patients. NESTech (Scottish Universities Challenge Fund), £29,995. 1/07/05 to 31/12/05

Sahraie, A. Residual abilities of blindsight. Dr James Mearns Trust. £48,255. 1/10/05 to 30/09/08.

4. Details of the impact

The therapy based on the research has led to improvements in patient health and quality of life, as well as commercial impacts through a spin-out company that was later taken over by a large competitor. Sahraie and his team have also worked to raise awareness and understanding of sight loss following stroke among practitioners and the general public.

Patient health and quality of life:
Since the new therapy became available in 2009, around 300 stroke patients in Britain have benefitted from it – all of them private patients, as the treatment is not yet available on the NHS. In addition to increased visual sensitivity, patients reported improvements in their ability to cope with daily living, including improvements in mobility and interactions with the environment [3.3, 3.5, 3.6]. The patients also scored higher in questionnaires which measured well-being [3.6]. Thus, the new therapy led to a better quality of life for these patients, indicating the considerable significance of the therapy for them. Patient testimonials confirm these results [5.1], with patients reporting "a massive step forward" and feeling "almost back to my normal self and lifestyle," as well as being able to resume daily tasks like walking alone, crossing the road, and even driving [5.1].

Following these successful treatments, in 2010 the UK Stroke Association, which supports stroke survivors and their families, began to include information on how to access the new therapy in its annual factsheet [5.2].

Commercial impacts:
In 2009, Sight Science Ltd was spun out of the University of Aberdeen to take the new therapy to the marketplace. In 2012 the company was acquired by its only worldwide competitor, NovaVision Inc, which is part of a US Stock Exchange-registered medical device company, Vycor Inc. The acquisition has resulted in job protection and formalised a partnership with the University of Aberdeen for commercialisation of all future vision-related products. Sahraie is funded by the Vycor group for a minimum of five years, taking the role of Chief Scientific Officer in NovaVision with the aim of further developing new techniques and building on the science base in order to work towards the next generation of vision therapies. [5.3].

The commercial aspects of the technology are protected by UK priority patent Sahraie (No. 0513603.1; 30/06/2005), subsequently granted in the UK, Germany, France, Switzerland (No 1906907; 17/11/2010) Singapore (No. 138426 14/01/2010) and pending in the US and Canada. [5.4]

Raising awareness and understanding:
Sahraie and his team have introduced health practitioners and the general public to this particular type of vision loss seen in stroke patients, and the new way of treating it, through active public engagement both in the UK and abroad. UK events where they presented their findings included:

- the UK Stroke Forum 2009 in Glasgow, organised by the Stroke Association and attended by rehab workers, stroke physicians and similar health practitioners [5.5]
- the Moray Vision Awareness Day at Elgin in 2010, staged by NHS Grampian and involving a number of local sight loss charities;
- the Scottish Vision Strategy Spring Conference 2011 in Stirling, again an event mainly attended by health practitioners [5.6];
- Café Scientifique in Aberdeen, where around 60 members of the public attended Sahraie's talk in March 2013.

Internationally, Sahraie et al presented their findings at:-

- the University hospital in Geneva, Switzerland, where Sahraie addressed an audience of neuropsychologists and ophthalmologists in 2009;

- the *Hanse-Wissenschaftskolleg*, an independent research foundation and debate forum in Delmenhorst, Germany, where he presented his findings in 2010 and again in 2011;
- the 2012 conference of the Association for Research in Vision and Ophthalmology (ARVO) in Florida, whose members include clinical practitioners [5.7].

Feedback from these events has included enquiries from centres in Cambridge and Ireland who expressed an interest in using the new therapy.

In February 2010, the University of Aberdeen publicised the launch of Sight Science and the new therapy. Media coverage achieved during that month included stories on STV News (featuring a stroke patient benefitting from the new therapy) [5.8]; a large feature in *The Sun*, Britain's biggest selling newspaper [5.9]; and reports in other local and regional print and broadcast media. The media coverage stimulated public debate and generated increased numbers of enquiries from members of the public. The acquisition of Sight Science by NovaVision was covered by the *Ophthalmology Times*, a specialist clinical magazine, in January 2012.

Therefore the impact, as defined by REF, was that the invention has impacted on health and welfare as a new therapy has been developed. The invention has had impact on commerce as new products have been successfully commercialised by the University of Aberdeen spin-out, leading to its acquisition by a major international company.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] http://www.sightscience.com/3/12/Neuro-Eye-Therapy/Success-stories.html *Patient testimonials.*

[5.2] http://www.sightscience.com/assets/pdf_docs/F37_Visual_problems_after_stroke.pdf *Stroke Association leaflet mentioning Sight Science and the treatment available there on pages 3 and 7.*

[5.3] *Chairman, Vycor Medical Inc. (parent company of NovaVision Inc)*

[5.4] UK priority patent Sahraie (No. 0513603.1; 30/06/2005). Patents granted in the UK, Germany, France, Switzerland (No 1906907; 17/11/2010) and Singapore (No. 138426 14/01/20110).

[5.5] http://www.docstoc.com/docs/14670053/15 *UK Stroke Forum 2009 programme; Sahraie's contribution on page 11.*

[5.6] http://www.chss.org.uk/education_and_training/documents/SVS_2011_Draft_Prog_and_Booking_Form.pdf *Scottish Vision Strategy Spring Conference 2011 programme; Sahraie's contribution on page 3.*

[5.7] http://www.abstractsonline.com/Plan/ViewSession.aspx?mID=1668&sKey=10ff1e9f-b539-42cd-a554-6915505924ef&mKey=%7BF0FCE029-9BF8-4E7C-B48E-9FF7711D4A0E%7D *ARVO 2012 abstracts including Sahraie's contribution.*

[5.8] http://www.sightscience.com/5/17/News_and_Media/Media.html *STV coverage of the new therapy, February 2010.*

[5.9] http://www.thesun.co.uk/sol/homepage/news/scottishnews/2852291/Struck-blind-but-now-we-can-see-again.html *Coverage of the new therapy in The Sun, 12th February 2010.*