Institution: University of Aberdeen

Unit of Assessment: UoA 4: Psychology, Psychiatry and Neuroscience

Title of case study: NeuroEyeCoach™: achieving the gold standard for eyesight rehabilitation at home and in the clinic.

Period when the underpinning research was undertaken: 2013-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Arash Sahraie	*Professor of Psychology*	*1998-present*
Amelia Hunt	*Senior Lecturer Psychology*	*2009-present*
Anna Nowakowska	*Research Fellow*	*2016-present*

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Researchers at the University of Aberdeen, led by Professor Sahraie, have developed and commercialised a new therapy for patients with sight loss following stroke: NeuroEyeCoach™. Each year, approximately 100,000 people in the UK, EU and US suffer sight loss due to stroke, resulting in sudden unanticipated disability that can severely impact quality of life. Previous therapeutic approaches lacked reach due to the necessity for numerous clinic visits and substantial clinician time investment. NeuroEyeCoach™ is accessed by patients at home or in clinics. It is adaptive to the individual's disability, allowing tailored training matched to the patient's needs. Data from patients accessing NeuroEyeCoach™ showed major benefits: improved vision and daily living activities – improving their quality of life. The therapy has regulatory approval in the EU and the USA and has been widely used to rehabilitate patients in these areas, as well as in the UK.

2. Underpinning research (indicative maximum 500 words)

Stroke often results in the loss of parts of or an entire half of the visual field of both eyes, meaning that the patient is blind in part of their visual field and cannot compensate for this loss by using the other eye. Although some spontaneous recovery may take place after brain injury, about 60% of patients have chronic deficits in eye movements, resulting in severely impaired visual exploration of the environment. These deficits can impede everyday activities, leading to lower quality of life.

Research has shown that if patients make eye movements into the blind area of their visual field, they can overcome some of these difficulties by directing undamaged areas of vision at the previously unseen locations. Patients rarely adopt this strategy spontaneously, but can be trained to do so, to compensate for their lost vision. Research conducted in Aberdeen has provided new insights into why patients do not spontaneously look into their blind areas and these insights have been applied to develop a new, effective vision training therapy: NeuroEyeCoach™.

Prior to the Aberdeen research, it was thought that impaired visual exploration after stroke was due to damage to neural circuitry controlling eye movements. The Aberdeen research has shown that the impairments found in patients are likely to be an exacerbation of problems in visual search strategy found in healthy adults. The research showed that healthy adults explore visual scenes inefficiently [**R1**], dwelling on areas with no targets of interest, rather than searching areas more likely to contain what they are looking for. This is akin to someone searching a drawer for a lost item repeatedly, even when they are perfectly aware that the item is not there, and mirrors inefficient search strategies found in patients after stroke. Using high precision eye trackers to change the visual display as an observer moves their eyes, the Aberdeen team simulated visual field loss in healthy adults [**R2**]. Just like stroke patients in prior studies, healthy participants did

not spontaneously move their eyes deep into the simulated blind areas, which would have compensated for their simulated blindness.

These studies [**R1, R2**] are the first to demonstrate that inefficient search behaviour found in brain damaged patients is similar to that found in healthy adults, and suggest that problems seen in patients are likely to stem from inherent inefficiencies in how healthy adults view and search scenes, rather than any stroke-related damage to the parts of the brain that control eye movements. This emphasised the potential benefits that training patients effectively in compensatory eye movement strategies might have for overcoming their difficulties, underpinning the development of NeuroEyeCoach™.

Systematic reviews show that eye movement training is the most promising approach to vision rehabilitation in stroke patients, with visual abilities being improved by training patients using visual search tasks. However, two problems arise from the visual rehabilitation available to patients before the therapy developed by the Aberdeen research team. First, training procedures were not standardised: effective training relies on making changes to task difficulty as the patient improves during therapy, but decisions about when to make these changes are based on subjective judgements by the clinician administering the training. Second, access to therapy was restricted to those patients living near one of only a handful of laboratories worldwide that have been developing training methods.

The Aberdeen research team focussed on solving these problems through **standardisation** of therapeutic approach and **ease of access** for patients whilst maintaining high efficacy. NeuroEyeCoach™ was developed in collaboration with industrial partners (NovaVision Inc., a provider of vision rehabilitation interventions in the EU and the US, together with Insiso Ltd, UK, a software company), as a multi-level (36 levels) vision training regime for patients, that adapts to the individual's abilities and progress throughout the therapy [**R3**]. NeuroEyeCoach™ uses copyrighted algorithms to automatically adjust stimulus parameters to the specifications of the computing device used by each patient, ensuring maximum stimulus efficacy. NeuroEyeCoach™ monitors the patient's speed and accuracy on each trial and automatically adjusts the task difficulty throughout the therapy to optimally stimulate learning behaviour in patients. This **standardisation** has removed reliance on ad hoc judgements and trial and error approaches by the clinicians administering the training. NeuroEyeCoach™ can be accessed in clinics or at home, allowing far-reaching **ease of access** to the therapy for patients.

In the largest-scale study ever conducted of the effectiveness of vision rehabilitation after stroke, NeuroEyeCoach™ therapy was shown to offer improvements to visual abilities in patients [**R3**]. Furthermore, research in Aberdeen demonstrated improvement in both visual abilities and quality of life in 296 patients using NeuroEyeCoach™ therapy, irrespective of the patient's age when the damage was suffered, their sex, which side of their brain was affected, or time since injury [**R4, R5**]. To promote open science and allow scrutiny of their work by other clinicians and scientists, the Aberdeen research team published open and free access to a large database of patients and all their behavioural parameters in the Open Science Forum [**R4, R5**].

3. References to the research (indicative maximum of six references)

The quality of the research is deemed to be at least of 2* quality as corroborated by the following peer-reviewed, international publications (with Google Scholar **citations**):

R1. ***Nowakowska A**, Clarke ADF, **Hunt AR** (2017) Human visual search behaviour is far from ideal. Proc. R. Soc.: Biol. 284, 27-67. https://doi.org/10.1098/rspb.2016.2767* (**24**)

R2. ***Nowakowska A**, Clarke ADF, **Sahraie A**, **Hunt AR** (2016) Inefficient search strategies in simulated hemianopia. J. Exp. Psychol.: Human. Percept. Perform. 42, 1858–1872. http://dx.doi.org/10.1037/xhp0000250* (**7**)

R3. ***Sahraie A**, Smania N, Zihl J (2016) Use of NeuroEyeCoach™ to improve eye movement efficacy in patients with homonymous visual field loss. BioMed Research International. Article ID 5186461. https://doi.org/10.1155/2016/5186461* (**9**)

R4. ***Sahraie A**, Cederblad AMH, Kenkel S, Romano JG (2020) Efficacy and predictors of recovery of function after eye movement training in 296 hemianopic patients. Cortex. 125, 149-160. https://doi.org/10.1016/j.cortex.2019.12.005* (**3**)

R5. ***Sahraie A**, Cederblad AMH (2018) Analysis of NeuroEyeCoach https://osf.io/2hvds/wiki/home/.*

Funding
NovaVision provided £80,000 for research grants (2011-2015) and £12,000 for consultancy (2017-2019).

4. Details of the impact (indicative maximum 750 words)

Impact on patient health and well-being has been achieved by providing an accessible therapy shown to measurably improve patients' visual abilities and also their everyday quality of life. NeuroEyeCoach™ was developed in 2014 with the Aberdeen research team's industrial partners (Novavision Inc., a subsidiary of Vycor Medical Inc. and Insiso Ltd.). This trademarked, copyrighted vision rehabilitation tool has regulatory approval as a Class I CE marked medical device in the EU and an FDA 510(K) exempt medical device in the US [**S1**]. NeuroEyeCoach™ addressed two of the major issues that had limited existing visual rehabilitation therapies: (1) it incorporates proprietary algorithms to standardise therapy [**R3**] and (2) it can be used in clinics as well as directly by patients at home, providing ease of access to therapy after stroke. Because the technology is commercially available as a regulated medical device and can be used in clinics or at the patient's home, it has extensive reach. As a result, NeuroEyeCoach™ has changed clinical practice for therapeutic care after stroke and has been increasingly recommended and used by clinical practitioners within the EU and US. Several press reports have reported on the novel technology having successfully treated effects of blindness [**S2**].

NeuroEyeCoach™ impact on patient health and wellbeing
The impact of NeuroEyeCoach™ on patient health and wellbeing was assessed in a recent large scale quantitative survey of patients undergoing NeuroEyeCoach™ therapy. Scores for activity of daily living (how much disability patients experienced when carrying out a range of everyday activities) were collected before and after the therapy to establish the effect of NeuroEyeCoach™ on quality of life [**S3**]. Overall, 66% of patients reported significant improvements in their ability to perform activities of daily living after therapy, enhancing quality of life; with therapy improving quality of life most for those with the most severe disabilities prior to therapy (80% of the most impaired patients before treatment showed improved quality of life after undergoing NeuroEyeCoach™ therapy). Improvements in quality of life were found irrespective of the patient's age, gender or the time since the brain injury was suffered, showing that the therapy is effective across a broad range of patients. This quality of life improvement was accompanied by improvements in the visual search task administered during the NeuroEyeCoach™ therapy, showing improved ability to search for and identify objects in these patients after therapy. These improvements were found irrespective of the severity of sight loss at the start of the therapy [**S3**].

Several patients suffering vision loss have attested to the positive impact of NeuroEyeCoach™ therapy on their lives [**S4**]. One stroke patient said "*In April 2016 I started therapy with NeuroEyeCoach, worked very hard and completed the training after about 2 ½ weeks. NeuroEyeCoach has helped me a lot…. I had massive difficulties with spatial orientation. When there were many people in a room, I was not able to find my way to entrance and exit... Just today I had a great experience of success: on my own, I took the bus into town for my appointment at the beauty salon! Until now I always needed my husband to accompany me. I was already convinced I could never ever go to town again on my own*" [**S4**].

A 'smart' tool for personalised therapy, setting the industry's gold standard
Despite decades of research in this area and development of prototype interventions to rehabilitate patients with post brain injury visual impairment, prototypes were restricted to patients living near the research laboratories. Such sessions required a clinician to monitor patients' performance and

adjust the therapies accordingly. No devices were compliant with Medical Device Directives in the EU and US, therefore access for patients was limited for research-only purposes.

NeuroEyeCoach™ is the only therapy for rehabilitation of sight after brain injury worldwide which is both a Class I CE marked medical device in the EU and an FDA 510(K) exempt medical device in the US, making NeuroEyeCoach™ the gold standard for eyesight rehabilitation – available to all and not restricted to research-only purposes. The system automates the required adjustments, to optimise eye training, tailored to each patient's needs, removing the need for daily clinical involvement. Therapy can be accessed directly by patients in their own homes, in addition to clinics offering the therapy.

An online easy-to-use tool for wide reach, remote access and cost-effective delivery

NeuroEyeCoach™ has reduced costs of delivery per patient substantially, making therapy affordable to most patients. Previously, costs associated with daily visits to a clinic over typically 2–3-week therapy duration as well as clinicians' time had been a major limiting factor for those needing rehabilitation. Patients can access treatment remotely using any personal computer device, at a cost of GBP250 in the UK [**S5**] which is a fraction of the cost associated with clinical visits required previously. To date, over 500 patients in the US and the UK have purchased and accessed the therapy online. NeuroEyeCoach™ therefore provides cost-effective, remotely accessible therapy, significantly widening access to patients [**S1**].

NeuroEyeCoach™ has enhanced supervised therapy in EU and US clinics

In Germany, Italy and Austria, post-stroke rehabilitation services are mainly provided at clinics where patients either stay for a number of weeks or attend as outpatients. NeuroEyeCoach™ is provided in clinics within these countries together with a suit of other therapies on a workstation, by the Aberdeen research team's industrial partner, NovaVision, to allow patients to complete the therapy whilst under clinical supervision. Since 2015, there have been 11 clinics in Germany; 2 clinics in Austria and 3 clinics in Italy that have been licenced to use NeuroEyeCoach™ [**S6i**]. In 2020, NovaVision signed a licensing agreement with a German company HelferApp GmbH that specialises in rehabilitation using digital technologies to provide NeuroEyeCoach™ in Germany, Switzerland and Austria [**S6ii**]. Collaboration between the University of Aberdeen, NovaVision Inc. and HelferApp GmbH, facilitated by a BBSRC funded Internship, has allowed preparation for submission of NeuroEyeCoach™ to the German Federal Institute for Drugs and Medical Devices, Digital Health Application (DiGA) agency, as the only vision rehabilitation considered for the health insurance reimbursement programme in Germany, with expected submission of March 2021, demonstrating the international impact of NeuroEyeCoach™.

One clinician in Italy has seen impressive results for the 30 patients treated with NeuroEyeCoach™ following brain injury, noting the ease of administration and patient tolerance, leading to improved everyday lives. Similar success was seen in other patients with parietal lesions treated with NeuroEyeCoach™ demonstrating broader potential for other patients. He said: "*There has been a clear need and demand for an effective intervention in clinics here in Italy and by the adoption of NeuroEyeCoach in my clinic, I am able to fully meet these needs*." [**S7i**].

In the US, Encompass Health hospitals (formerly HealthSouth), which owns 136 hospitals across 39 states in the US, provide this therapy [**S6iii**]. An occupational therapy assistant said of NeuroEyeCoach™: "*We've had patients come in with significant blurry vision, and they've been able to completely remove their eye patch by the time they leave" … "They're able to go safely home instead of to a nursing home, because now they can see and interact with the world visually.*" [**S7ii**].

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

S1. Letter of support from Industrial partner NovaVision Inc.

S2. Media coverage:

There has been considerable media coverage of the launch of NeuroEyeCoach, a summary list (with links) can be found at following website:

http://sightscience.com/press-said-new-clinical-neuroeyecoach-study/

New technology improves vision for brain injury patients - RNIB - See differently

Treatment for blindness successful in largest ever study | News | The University of Aberdeen (abdn.ac.uk)

Treatment for blindness successful in largest ever study led by Aberdeen researcher | Press and Journal

S3. Quantitative analysis of patient outcomes:
All data and analysis on 296 patients completing NeuroEyeCoach™ are available on the open science forum page: Sahraie, A., & Cederblad, A. M. H. (2018). Analysis of NeuroEyeCoach data. Retrieved from osf.io/2hvds

S4. Patient testimonials:
Patient testimonials on the effectiveness of NeuroEyeCoach™:
http://www.novavision.com/neuroeyecoach-testimonials/

S5. Email detailing the cost of NeuroEyeCoach™ in the UK

S6. Clinical uptake of NeuroEyeCoach™:
i) Email detailing the 11 rehabilitation clinics in Germany; 3 in Italy; and 2 in Austria using NeuroEyeCoach
ii) HelferApp GmbH deal June 2020

iii) *Uptake of NeuroEyeCoach by HealthSouth, a major US healthcare provider is detailed here:*
https://www.prnewswire.com/news-releases/vycor-signs-agreement-with-healthsouth-for-second-novavision-therapy-product-300095371.html
for example, NeuroEyeCoach is available at the
Encompass Health Rehabilitation Hospital of Altamonte Springs, FL, USA

S7. Clinical testimonials:

i) Testimonial letter - Verona clinician

ii) Blog by occupational therapy assistance: The role of vision therapy in rehabilitation | Encompass Health