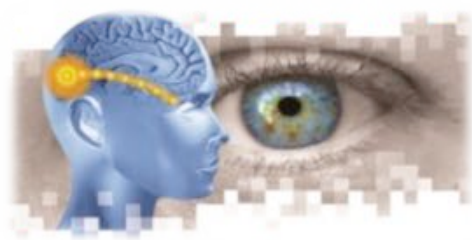**The Scientific Evidence for Efficacy**

It is evident that training with compensatory strategies is useful in helping hemianopic patients improve saccade parameters. The training techniques developed for improving oculomotor compensation are based on the so-called visual search paradigm. Patients have to search for a defined target stimulus (e.g. a shape or a letter) that is interspersed among non-target stimuli (distractors). The presence of the target stimulus and the number of distractors are varied to simulate unpredictable visual surroundings with different stimulus densities. The subject can practice and improve search performance until a predefined performance is reached. This improvement also results in the subjective reports of significant improvements in activities of daily living .

This PC-based treatment approach, originally developed by Zihl (1988/1990), has since been used with various modifications in 13 studies on a total of 551 patients with homonymous visual field loss and persistent visual disabilities (see Table 1)

Main Outcomes of Studies:

1. Significant improvement in visual search performance accompanied by more efficient oculomotor strategies
2. Reduction in visual disability as assessed with standardized questionnaires and behavioural measures. These include improvements in navigation skills and object finding
3. The treatment effects remained stable and persist after 4-12 weeks follow up
4. The efficacy of this treatment approach is superior to:
    a) Practice with reading (Schuett et al., 2012),
    b) Non-specific visual training (Roth et al., 2009)
    c) Standard occupational therapy (Mödden et al., 2012),
    d) Counselling with regards to coping strategies (Zihl, 2011)
5. Importantly, time since brain injury (Zihl, 2011) and age of hemianopic patients (Schuett & Zihl, 2012) do not play a significant role for the treatment effect
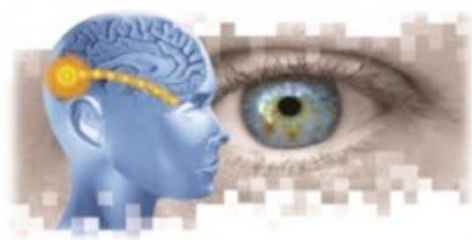
In conclusion, there is convincing scientific empirical evidence for the efficacy of the visual search treatment method. Average number of practice sessions was 21, with a range of 11-40 sessions. Sessions typically lasted between 30-60 minutes; in total, training comprised 14.2 hours on average (range: 7.5-35 hours). Thus, significant visual improvement was gained after rather short periods of practice; if a patient performs 2-3 training sessions per day of 30 min each, visual search training 8-12 days on average. Differences in training times between studies may reflect the modifications of the visual search method used. It is important to note that visual field borders did not change after the treatment, indicating that visual search training represents a compensatory technique and not a restorative approach .

SCIENCE BEHIND NEUROEYECOACH

Literature

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Nelles G, Esser J, Eckstein A, Tiede A, Gerhard H, Diener HC (2001) Compensatory visual field training for patients with hemianopia after stroke. *Neuroscience Letters* 306:189-192.

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Zihl J (1995) Visual scanning behaviour in patients with homonymous hemianopia. *Neuropsychologia* 33:287-303.

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Table 1: Publications on Treatment with Visual Search Training for Improvement of Visual Exploration (1990-2013)

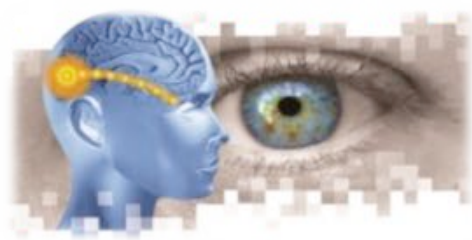| Author(s)	Cases	Sessions/Duration	Total Hours
Zihl, 1990	30	15/45 min	11.25
Kerkhoff et al., 1992	92	20/30 min	10.0
Zihl, 1995	14	14/45 min	10.5
Nelles et al., 2001	21	40/30 min	20.0
Pambakian et al, 2004	29	20/40 min	13.3
Nelles et al., 2009	11	20/30 min	10.0
Roth et al., 2009	14	30/30 min	15.0
Mannan et al., 2010	29	40/40 min	26.7
Zihl, 2011	157	10/45 min	7.5
Mödden et al., 2012	45	15/30 min	7.5
Schuett et al., 2012	36	12/45 min	9.0
Schuett & Zihl, 2012	38	11/45 min	8.25
Aimola et al. 2013	35	35/60 min	35

Total number of cases : 551
Mean number of sessions (range): 20.9 (11-40)
Mean duration of sessions (min; range): 40 (30-60)
Mean total hours of training (range): 14.2 (7.5-35)

Significant improvement of visual search performance can therefore be achieved by regular training (2-3 daily training sessions of 20-30 minutes duration each) within 12-18 days.

NEUROEYECOACH OCT 2016 STUDY

Clinical Study Supports NeuroEyeCoach® as The Gold Standard for Neurological Vision Therapy

A new rigorous peer-reviewed study published in *BioMed Research International* Oct 2016 shows improvements in visual search following the use of NovaVision's NeuroEyeCoach. The three-centre study was conducted by the School of Psychology of University of Aberdeen, the Neuromotor and Cognitive Rehabilitation Research Centre of University of Verona, and the Department of Psychology of University of Munich.

"This type of sight deficit can be massively debilitating for those affected by it", said Professor Arash Sahraie, head of the school of psychology at the University of Aberdeen who led the study. "Patients report a loss of confidence in their own ability to navigate the environment that can then manifest itself in the form of withdrawal from daily life. This is why it's important to develop techniques to help patients to improve as much as they can and this compensatory technique is yet another step forward in providing help and therapy for these patients.

The study concludes "NeuroEyeCoach can be used as an effective rehabilitation tool to develop compensatory strategies in patients with visual field deficits after brain injury" and that NeuroEyeCoach can be viewed as being the first evidence-based, vision-specific, clinical gold standard registered medical device accessible to patients at home or in clinical settings

Background:

Many patients who have a visual field deficit after suffering a stroke or brain injury also have difficulties with eye movements. They are less efficient at processing their visual field, moving their eyes around less, exploring more of the region they can see rather than trying to explore the "blind areas", and are less able to integrate information between the left and right hand side of their vision. Therefore, they have less awareness of things happening at the side of their visual field and are not able to grasp a scene as a whole, and as a result bump into objects or perceive a problem with their peripheral vision

Only about 20% of people are able to recover without clinical intervention. The use of visual search in improving the search efficiency of hemianopic patients was first reported in 1988. Other than its use in a limited number of research environments or rehabilitation clinics over the past 25 years, there has been a marked lack of an evidence-based, vision-specific medical device broadly accessible to patients, despite there being a large body of evidence including randomized control trials showing that patients benefit from systematic eye movement training.

Therapists and physicians in clinical practice have instead used a number of devices that originally had been designed to address other problems; these do not have a set of systematically developed protocols specific to visually impaired patients and are therefore sub-optimum for their rehabilitation.

The Key Study Findings

Three distinct **observational studies** were performed as part of the overall study:

1. The first objective was to confirm that NeuroEyeCoach did indeed provide at least as positive outcomes as the large body of clinical evidence upon which the program was based. The use of computerized visual search tasks as a rehabilitation tool to improve eye movements after brain injury had previously been used in 13 studies with a total of 551 patients with homonymous visual field loss and persistent visual disabilities. Each of the studies focused on different aspects however, in aggregate, the outcome of the studies demonstrated a significant improvement in visual search performance accompanied by more efficient oculomotor strategies and a reduction in visual disability as assessed with standard questionnaires and behavioural measures.

The first study concluded that patients showed similar improvements to prior studies with regard to visual search and reported functioning in daily life activities **with the added advantage of having set criteria for progression to different levels of difficulty**,

2. The second objective was to find out whether the program-inbuilt, self-administered outcome measures can be used to assess patients' NeuroEyeCoach therapy outcomes, whether this additional cohort of patients benefitted from visual search training and whether changes are measurable using the incorporated pre- and post-assessments.
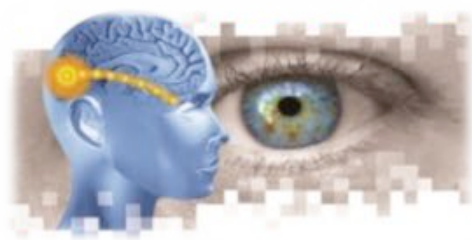
The second study concluded that this cohort of patients also benefited from eye movement training and that this benefit could be assessed effectively using the program's inbuilt outcome measures. **The training led to faster visual search times, reduction in the number of errors made, and improvements in self-reported activities of daily living.**

3. The third study focused on the comparison of changes in visual search in a group of patients with those of a similarly-aged control group of healthy subjects ("normal controls"), with both groups conducting the therapy under supervision at clinical rehab units.

The findings from this final study showed that the use of NeuroEyeCoach in patients can lead to more than **TWICE the magnitude of improvements** compared to normal controls. This evidenced that patients suffering from homonymous visual field benefitted far beyond simple program familiarity, but regained an effective scanning strategy to substitute for the lost visual field, which the study highlights as being a **crucial prerequisite for grasping the actual surroundings with high accuracy and speed.**

Conclusion

"NeuroEyeCoach is an effective compensatory approach for those with homonymous visual field loss. The training led to faster visual search times, reduction in the number of errors made, and improvements in reported activities of daily living"
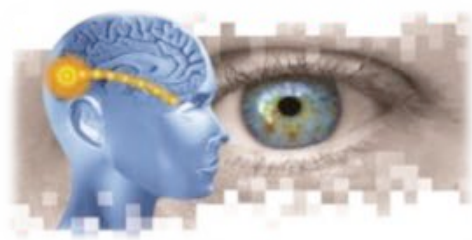
"It's important to develop techniques to help patients to compensate for their sight deficits and NeuroEyeCoach is providing a much needed step forward in providing therapy for these patients in order to improve the quality of life for the individual. We have used this type of compensatory technique in vision research for some time now and in NeuroEyeCoach, we have developed the research into an accessible treatment that can help patients achieve major improvements in their vision within about 2-3 weeks."

- Professor Arash Sahraie, Head of the School of Psychology, University of Aberdeen

Link to the study: https://www.hindawi.com/journals/bmri/2016/5186461/

Efficacy and predictors of recovery of function after eye movement training in 296 hemianopic patients

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A peer-reviewed clinical study published in Cortex, a high-profile Elsevier Publication, demonstrates **significant improvements in visual search** following the use of NovaVision's NeuroEyeCoach™. The study was led by the School of Psychology, University of Aberdeen, UK in conjunction with the Department of Neurology, University of Miami Miller School of Medicine, USA and is the largest study of its kind.

This study follows on from a 2016 smaller three center study conducted by the School of Psychology of University of Aberdeen, the Neuromotor and Cognitive Rehabilitation Research Centre of University of Verona, and the Department of Psychology of University of Munich. This earlier study was published in Biomed Research International and also had positive findings supporting the effectiveness of NeuroEyeCoach in improving visual search in patients with homonymous visual field loss.
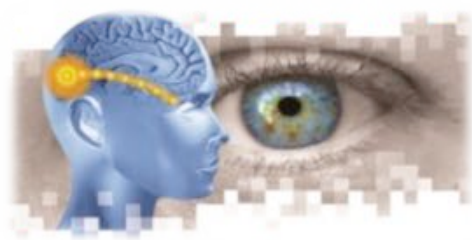
Background

People who have a stroke or other neurological damage often experience a visual impairment (as much as 60%) and half of those have a visual field loss.

With most other conditions that lead to vision loss there is a period of adjustment to the gradual visual impairment. Sight loss due to stroke or traumatic brain injury, on the other hand, is sudden and often occurs over only a few hours and without prior warning. Some spontaneous recovery may take place in the acute stage following injury, but the probability of natural recovery diminishes rapidly with time and very little recovery of sight is expected 3 to 6 months post injury.

Along with the loss of vision comes an inability for patients to systematically scan their environment. They effectively no longer can take in a picture quickly and efficiently.

Compensatory techniques rely on the patient's intact visual field for processing the otherwise unseen stimuli, by using eye movements to bring their image onto the intact field.

Although such compensatory approach is intuitive, spontaneous adaptation and development of an effective eye movement pattern is seen in only 40% of hemianopic patients (Zihl, 1995) and the majority of cases shows inefficient eye movements years after the injury. The pattern of eye movements in affected cases can be characterized as having smaller amplitude saccades, leading to requiring a larger number of eye movements to explore a given portion of the field, hence slowing down in time to explore and identify targets within the field defect (Zihl, 2011). There is also a more disorganized search strategy in that patients make more frequent between hemifield saccades. Disturbances of eye movement patterns extend to both sighted and blind hemifields.

As eye movements play a crucial role in visual perception and in the interaction of an individual with their environment, it logical to assume that improved eye movement efficiency should lead to a reduction in self-reported level of disability.

Hitherto studies had shown that eye movement training appeared to improve the speed and accuracy in which patients, with a visual deficit caused by stroke or TBI, could identify objects in their blind field. Other than its use in various forms in a limited number of rehabilitation clinics over the past 25 years, there has been a marked lack of availability of an effective evidence-based gold-standard registered medical device accessible to patients at home or in clinical settings. In clinical practice, this void has been filled by using a number of devices that originally had been designed to address other problems, hence being sub-optimum for rehabilitation of vision loss. Devices such as Dynavision (dynavisioninternational.com), or Sanet Vision Integrator (svivision.com) were originally designed for improving athletes' performance on visuo-motor tasks. In both cases there is the absence of a set of systematically developed protocols, specific to visually impaired patients. NeuroEyeCoach was developed to address this need, with Each aspect of the program is supported by clinical data.

Problems with previous clinical findings can be summarized into three broad categories:
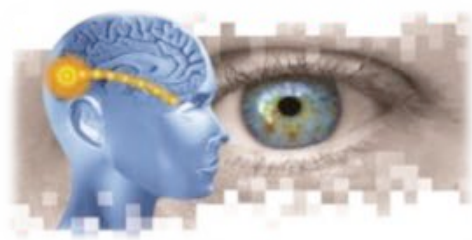
1. Studies were carried out on small clinical population making any detailed conclusions impossible due to the lack of data.
2. Studied lacked accessibility to a broad range of patients. Most eye training therapy studies have been limited to the clinical environment where the physician administers the training.
3. Interventions were not standardized making the data not applicable across a broader universe of patients

This study, which follows on from the earlier multi-center study done in 2016, utilizes NeuroEyeCoach to address each of the above issues.

Study Overview

The study which covers 296 consecutive cases of patients who have accessed and completed NeuroEyeCoach online is the ***largest cohort of patients studied to date***. An advantage of having a large dataset is that the range of performances reported is more likely to be a fair representation of that of the patient population as a whole. Patient data was available both on objective measures such as search times and number of errors but also on subjective measures such as their self-reported disability. ***Given the size of the study some very detailed conclusions were possible to be reached addressing previous limitations.*** In this study improvements in reaction time, errors and disability scores were analyzed in relation to age, sex, side of blindness, age at the onset of brain injury, and time elapsed between the brain injury and start of therapy.

NeuroEyeCoach is appropriate for use under supervision in clinical settings as well as being accessible for home use. To facilitate wider access to the therapy, it is internet deliverable and is self-adaptive by systematic adjustment of the time allowed for the visual search to reach predefined levels of accuracy. ***All the patients in this study conducted the therapy online*** in their homes at times that suited them and not in a clinic. The NeuroEyeCoach program can therefore be both used in clinical setting as well as by patients at home, thus addressing issues of accessibility.

NeuroEyeCoach was developed to provide a standardized protocol for clinical management of patients using a compensatory technique.

The therapy is based on the visual search approach and is adaptive to the patient's level of disability and the task difficulty is varied systematically through a combination of set-size and target/distractor similarity. The program has an algorithm to manipulate the task difficulty to ensure a systematic criterion for progression to the next level and hence the ***treatment is standardized*** and results can be compared across the universe of patients analyzed.

The Analysis of Patient Data

In order to ensure that the study objectives were not changed during the course of the analysis and hence reduce its validity, a detailed plan of the analysis to be conducted was developed prior to the application for study ethical approval. This plan was saved to the wiki entry for the project on Open Science Framework on 2018-11-08 (Sahraie & Cederblad, 2018). The wiki for this project "Analysis of NeuroEyeCoach data", can be found at: https://osf.io/2hvds/wiki/home/ and constitutes the totality of the pre-registration (Sahraie & Cederblad, 2018). Pre-registration was completed without access to data and as such the data is available for all to review and could not have been manipulated subsequently to its analysis.
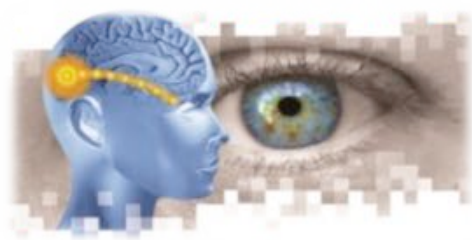
To assess the effect of NeuroEyeCoach, reaction time and accuracy in a visual search task as well as subjective ratings for an activity of daily living questionnaire was obtained before and after the therapy. The search task consisted of a practice session of 10 trials where the presence or absence of a black **O** amongst black **T**s and **L**s was reported using either of two mouse buttons. They then completed 4 blocks of 20 trials at set-sizes of 4, 8, 16, and 24 objects. The pre- and post-therapy reaction time was calculated as the mean of the median reaction times from all 4 blocks. The errors across all 4 blocks were summed to obtain pre- and post-therapy errors. Patients also reported their perceived disability on a 5-point scale for performing various activities of daily living. The nine questions were: difficulties seeing obstacles; bumping into obstacles; losing their way; finding objects on a table; finding objects in a room; finding objects in a supermarket; crossing the road; using public transport; or using a computer. The rating scale ranged from no difficulty at all, to having occasional, sometime, often, or severe difficulties. Patients performed all the assessment tasks once again after completing the NeuroeyeCoach program.

The Results

The paper demonstrates that NeuroEyeCoach is a very effective compensatory approach for those with homonymous visual field loss. The training of this large cohort of patients led to much faster visual search times, significant reduction in the number of errors made, and very positive improvements in reported activities of daily living.

Specifically, the analysis yielded very positive results; ***87% of cases demonstrated faster reaction times at post-therapy.***

The accumulated errors during post-therapy search times were also significantly smaller than those pre-therapy with ***80% of patients having a smaller number of errors*** in the search task at post- vs. pre-therapy. The study noted that errors were larger for target presentations within the blind field than the sighted field both before and after the therapy. However, there was a marked improvement in performance for blind field target presentations after the therapy to a level similar or better than those for the sighted field before the therapy.

In relation to disability scores, the study showed that across the board there was a benefit reported in average daily living scores, however the level of improvement depends on the level of baseline subjective reported disability. That is to say that patients who stated they had a high level of disability prior to NeuroEyeCoach stated they had the greatest post therapy improvement: 69% of cases with moderate to high pre-therapy disability reported subjective benefits, while for those who reported high pre-therapy disability, ***79% reported less disability*** post therapy.

Therefore, the results from this large cohort of patients undertaking a systematic compensatory therapy show that patients can improve in subjective and objective measures of performance.
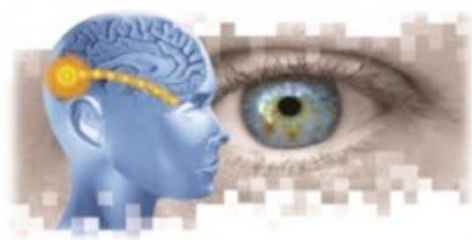
Further analysis led to the conclusion that the vast majority of patients benefited from the eye movement therapy irrespective of age, gender and side of brain injury.

These findings reported here are in agreement with the benefit of compensatory therapies shown in other much smaller randomized control trials.

Conclusion

*The conclusion of both the first multi-center study done in 2016 and this larger study released in 2020 is that NeuroEyeCoach can be viewed as being the **first evidence-based gold standard registered medical device accessible to patients at home or in clinical settings** which has a **significant impact on patients' ability to see things quickly with fewer errors leading to a meaningful improvement in their daily lives.***

Link to the Study: https://doi.org/10.1016/j.cortex.2019.12.005

Related Quotes and Testimonials

"Up to recently, there was very little treatment available to restore vision loss in this population, while stroke and TBI patients regain some vision on their own, very few regain it completely."

"Blindness among these patients usually stems from injury to the back of the brain where images are interpreted. Patients have very poor quality of life as they often bump into things, cannot drive or read".

- Jose Romano, Chief of the Stroke Division at the University of Miami Miller School of Medicine

"Our results show that rehabilitation of vision loss after brain injury is possible and can drastically improve patients'quality of life, we have found that there is no limit to the success of the treatment in terms of age, time since injury or gender. This is extremely encouraging and we hope will be of benefit to the tens of thousands of people who live with blindness after brain injury."

- Arash Sahraie, Professor and Chair in Psychology at the University of Aberdeen

"I just finished NovaVision's NeuroEyeCoach therapy program, to help tweak my field of vision. By the end of this program, I could tell improvements in "seeing" as I went about my daily routine in the house and on the road. My eyes are now more quickly picking out objects that I may have missing, or been slower to "see," prior to this electronic coaching.

"This is the second program I have used from NovaVision. Several years ago, after a stroke cost me my ability to read (a horrible feeling), a neurologist recommended NovaVision's Vision Restoration Therapy. I was reading again at the end of this months-long therapy. I recommend both programs."

- RH- Florida, U.S.- Patient Testimonial

NeuroEyeCoach Program Description

NeuroEyeCoach was developed to address this need and provide a standardized protocol for clinical management of patients using a compensatory technique. The program systematically increases the task difficulty from a simple "pop-out" search, to more complex search with multiple distractors, and finally conjunction searches where distractor number and target/distractor similarity are manipulated. The program has been designed to be highly intuitive, using simple on-screen and audio instructions, and automatically adjusting to the patient's ability and progress. This ensures that this therapy is appropriate for use unsupervised at home as well as under supervision in clinical settings.

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