Scanning behavior in hemianopia: The Next Step
A study protocol

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ABSTRACT
Homonymous visual field defects (HVFDs) are the largest group of visual disorders after acquired brain injury. Homonymous Hemianopia (HH), the most common form of HVFD, occurs in 8-31% of all stroke patients. HH can have a large influence on daily living, quality of life and patient’s participation in society. People with HH mainly experience difficulties in reading, orientation and mobility. They benefit from training aimed to decrease the impact of the visual field deficit through optimizing visual scanning. Therefore, it is of utmost importance to inform patients about the way their scanning behavior relates to difficulties they experience in daily life and how they can improve their scanning behavior to overcome these difficulties. Knowledge about which scanning behavior in different situations is optimal, however, is mostly based on experiences and assumptions of professionals, and not supported by scientific literature and empirical data. The current project (September 2019 to September 2023) aims to examine the relationship between scanning behavior and performance on various daily life activities (i.e. mobility and search activities) in people with HH, people with simulated HH and a control group with normal vision. Innovative techniques such as eye-tracking and Virtual Reality (VR) will be used to examine scanning behavior in a standardized manner. Prototypes of these techniques, developed in a pilot project, were seen as useful additions to vision rehabilitation therapy by people with HH and rehabilitation therapists. Apart from providing insight into scanning behavior and its relation with different task demands, this project will help to develop innovative measures for scanning behavior that can be used in clinical practice. Data-collection will begin in the autumn of 2020 and will end approximately two years later. The current project is a PhD project, which means that it will result in a PhD thesis with at least four publications in international, scientific and peer-reviewed journals.

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1 RESEARCH OBJECTIVES
The primary objectives of the current project (September 2019 to September 2023) are to examine: 1) the differences in scanning behavior (for various activities, e.g. mobility, searching) between patients with hemianopia, people with simulated hemianopia and a control group with normal vision and 2) the relationship between scanning behavior and performance on various activities (e.g. mobility, searching).

The secondary objectives of the current project are 1) to examine if scanning behavior is associated with cognition, demographic (i.e. sex, age, education) and disease characteristics (e.g. lesion side) and 2) to use existing prototypes of innovative techniques (i.e. Pupil Labs mobile eye-tracking and Virtual Reality with built-in eye-tracking (HTC Vive Pro Eye)) and develop these prototypes into measures that can be used in clinical practice.

2 PROBLEM STATEMENTS AND HYPOTHESES
2.1 Problem Statements
The largest group of visual disorders after acquired brain injury are homonymous visual field defects (HVFDs), which refers to visual field deficits similar for both eyes and contralateral to the brain damage. Homonymous Hemianopia (HH), in which the left of right...
half of the visual field is not perceived, is the most common form of HVFD and occurs in 8-31% of all stroke patients [Feigenson et al. 1997]; [Gilhotra et al. 2002]. HH can have a large influence on daily living, quality of life and patient’s participation in society. People with HH mainly experience difficulties in reading, orientation and mobility [e.g. [Chen et al. 1993]; [Papageorgiou et al. 2007]] and they benefit from training aimed to decrease the impact of the visual field deficit through optimizing visual scanning [e.g. [De Haan et al. 2015]; [De Haan et al. 2016]). Therefore, it is of utmost importance to inform patients about how their scanning behavior relates to difficulties they experience in daily life and how they can improve their scanning behavior to overcome these difficulties.

Several studies examine scanning behavior in patients with HH. These studies mainly focus on the difference in scanning behavior between patients with HH and healthy controls [e.g. [Jahnke et al. 1995]; [Kennard 2002]; [Machner et al. 2009]; [Papageorgiou et al. 2012]; [Spitzyna et al. 2007]; [Tant et al. 2002]; [Zihl 1995]]. Although there is no large-scale review about these studies, generally, results indicate that search times and scan paths tend to be longer in patients with HH and that they make more fixations of a shorter duration than controls. In addition, patients with HH make shorter saccades than controls, and more saccades to the area corresponding to their blind hemifield.

This information, however, does not provide any knowledge on which scanning behavior is optimal for patients with HH in several activities in daily life. Current knowledge on this topic is mostly based on experiences and assumptions of professionals, and not supported by scientific literature and empirical data. Innovative techniques such as eye-tracking and Virtual Reality allow us to examine scanning behavior in a standardized manner. In the current project, existing prototypes using these techniques are being developed into measures that can be used in clinical practice.

### 2.2 Hypotheses

Differences between patients with HH, healthy controls and people with simulated HH are expected to be similar to previous studies’ results [Jahnke et al. 1995]; [Kennard 2002]; [Machner et al. 2009]; [Papageorgiou et al. 2012]; [Spitzyna et al. 2007]; [Tant et al. 2002]; [Zihl 1995]. The research methods used in this study (i.e. VR with eye-tracking) have, however, not been used for similar goals before in studies on patients with HH. Based on some previous studies and experience of rehabilitation therapists, it is expected that during mobility tasks, larger and more frequent saccades to the blind hemifield are associated with a better overview and better detection in patients with HH. During search tasks, less refixations are expected to be associated with better search times. However, given the lack of comprehensive studies on this topic, the nature of the present study is exploratory.

### 3 APPROACH AND METHODS

The study population consists of 50 patients of Royal Dutch Visio with HH due to acquired post-chiasma brain injury. In addition, a group of 100 matched (based on gender, sex, education) adults with normal vision is included. These people will be allocated to the simulation or the control group. The assessments comprise two sessions of approximately one hour. Participants will perform various mobility tasks while wearing a VR google with a built-in eye-tracker. For example, they will be asked to safely cross a virtual street with care at their own pace. Furthermore, participants will perform various search and mobility tasks while wearing a mobile eye-tracker. For example, they will be asked to walk in a hallway while avoiding certain objects (e.g. a trash bin). Apart from their scanning behavior, their performance will be measured (e.g. walking speed, number of missed objects). To evaluate user experience for VR and eye-tracking, three short questionnaires measuring presence, simulator sickness and system usability will be administered in participants and rehabilitation therapists.

### 4 PRELIMINARY RESULTS

Prototypes of the techniques (i.e. mobile eye-tracking and VR with built-in eye-tracking) were developed in a pilot project. These techniques were seen as useful additions to vision rehabilitation therapy by people with HH (n = 13) and rehabilitation therapists (n = 4). Based on this pilot study, the prototypes are currently being adapted by our external technical partner (The Virtual Dutch Men) to be able to obtain our research objectives. Ethical approval for a feasibility study was obtained.

### 5 BROADER IMPACT

Using innovative techniques, it is possible to relate scanning behavior to performance on various activities. This is of utmost importance to obtain the following goals in clinical practice:

- Inform patients, their caregivers and professionals about a patient’s current scanning behavior and the consequences of this scanning behavior for various activities in daily life.
- Determine whether certain scanning behavior fits with compensatory behavior for hemianopia or whether it is suspicious of other impairments due to brain damage (e.g. attention or visuospatial impairments).
- Inform professionals about the optimal scanning behavior during various activities (i.e. searching, mobility), which they can, subsequently, teach the patient.
- During training, give specific feedback about the consequences of the current scanning behavior on the performance of the training task, so that the patient can improve his/her scanning behavior.
- Examine before, during and after training to what extent the patient applies the optimal scanning behavior during a specific task (i.e. searching, mobility). This informs the professional and the patient about the starting level, and the relationship between the scanning behavior and the patient’s complaints (beforehand), the training progress (during) and the improvement after training. If scanning behavior is measured again long term after the training, the patient and the professional are informed about whether the acquired scanning behavior retains and whether a short refresher course is necessary.
6 PLAN FOR FUTURE WORK
Data-collection will begin in the autumn of 2020 and will end approximately two years later. Data-collection and analysis is planned to result in concrete recommendations for the application of this knowledge and the developed prototypes in clinical practice. The current project is a PhD project, which means that it will result in at least four publications in international, scientific and peer-reviewed journals. In addition, a PhD thesis will be written that contains these publications. During the project, the results will be presented at relevant national and international meetings, symposia or conferences.

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