Journal of Clinical & Experimental Ophthalmology

Knaapi et al., J Clin Exp Ophthalmol 2015, 6:6
DOI: 10.4172/2155-9570.1000493

Research Article Open Access

Detecting the Physiological Blind Spot with Reaction Time Perimeter

Laura Knaapi[1,2], **Eija Vesti**[2] **and Markku T Leinonen**[3*]

[1]*Department of Ophthalmology, Satakunta Central Hospital, Pori, Finland*

[2]*Department of Ophthalmology, Turku University Hospital, Turku, Finland*

[3]*Ocuspecto Ltd, Turku, Finland*

[*]**Corresponding author:** Markku T Leinonen, MD, PhD, Ocuspecto Ltd, Läntinen Pitkäkatu 17 B 2, 20100 Turku, Finland, Tel: +358 40 5283644; E-mail: markku.leinonen@ocuspecto.com

Received date: Sep 16, 2015; **Accepted date:** Nov 13, 2015; **Published date:** Nov 16, 2015

Abstract

Objective: To study the ability of a novel reaction time perimeter to detect a physiological blind spot.

Methods: The location of the physiological blind spot of 11 healthy volunteers was determined with two independent methods, first by Octopus custom-made blind spot visual field program, and second by Fundus photography with a method previously described by the authors. With reaction time perimeter saccade triggering stimuli (STS) were shown in predetermined locations of the visual field in order to initiate saccades. An STS was followed by an FO (fixation object) i.e., an arrow head pointing either to the right or left at the same location as the previously shown STS. The recognition of the FO was reported by pressing a correct button (right or left respectively) thus verifying accurate fixation by the fovea. Time intervals between button presses were recorded. Reaction times for detecting the STS within the blind spot area were compared to those for detecting the STS in other locations of the visual field.

Results: Reaction times within the blind spot area were longer compared to those in other locations in 10 of 11 subjects (Analysis of variance), $p<0.001$ in 9 subjects, $p<0.006$ in one subject).

Conclusion: A physiological blind spot can be detected with reaction time perimeter.

Keywords: Reaction time; Visual field; Saccade triggering stimulus; Scotoma; Blind spot

Introduction

The ability to move the eyes towards an object perceived in the peripheral visual field in order to fixate with the fovea is a fundamental feature of the visual system. Visual processing speed, which is defined as the time needed to make a correct judgment about a visual stimulus, is commonly studied in behavioral research by measuring reaction times [1]. Visual field defects can be quantified by standard automated perimetry (SAP), but it has limited power to predict the impact of disease on the ability to perform activities of daily living [2,3]. The testing situation in SAP involves maintaining a steady fixation whilst keeping the head still on a head rest making it very unnatural compared to real-world viewing tasks.

In this pilot study, our purpose was to determine if reaction time perimeter allowing free head and eye movement and thus simulating the normal features of the visual system can be used to detect a physiological blind spot.

Subjects and Methods

11 volunteers aged 23-44 years were recruited amongst the friends and colleagues of the first author. The subjects had no diagnosed diseases, systemic or ocular. The left eye was chosen to be examined. Ametropia ranged from -7.9 to -0.5 D (spherical equivalent). Maximum astigmatism was 1.75 D. Informed written consent was given by all participants after the explanation of the nature and possible consequences of the study, according to the Finnish Ethics committee of Turku University Hospital (ETMK 52/180/2012). All research adhered to the tenets of the Declaration of Helsinki.

The centre of the physiological blind spot of these 11 subjects to be used as a reference point was located first with Octopus perimeter by custom made blind spot visual field program (1° oval grid of 139 test points) and second with Fundus photography by calculating the theoretical location of the physiological blind spot based on the mathematical formula of Bennett et al. [4,5]. The results of these two independent methods came close [5]. In this study, the location of the blind spot was defined as the centre of the blind spot determined by Octopus custom made Blind Spot visual field program ± 2.5°.

A microcontroller driven reaction time perimeter (Ocuspecto Ltd, Turku, Finland) comprised of a 35° arc (radius 54 cm) was constructed including 15 LEDs (diameter 0.6 mm) compiled in six 3 × 5 arrays for displaying both the (saccade triggering stimulus) STS and the (fixation object) FO. The STS, which were nearly equivalent to stimulus size of Goldmann III (diameter 0.4°), were formed with a flash of an array of 3 × 3 LEDs lasting for 100 ms. Viewing distances 54 cm and 48 cm were used and checked with a measuring tape. The size of the STS did not change with different viewing distances. However, this was considered to be insignificant.

A single STS was immediately followed by an arrow head figure pointing either to the right or left serving as FO (Figure 1). The

recognition of the FO was reported by the subject by pressing a correct button of the remote control (right or left respectively), thus verifying fixation with the fovea. The intensity of the FO was only 3-5 dB above the individually predetermined foveal threshold in order to prevent parafoveal recognition of the FO. After correct recognition of the FO, a new peripheral STS followed by another FO was displayed in a different location of the visual field in order to initiate a reflex saccade towards the STS. Time intervals between button presses were recorded.

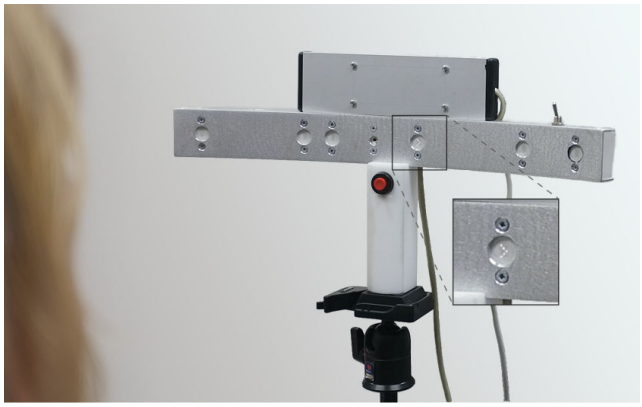

Figure 1: Reaction time perimeter showing the six visual stimulus units (large openings in the aluminum arc) constructed from 3 × 5 LED arrays assembled on a printed circuit board capable of displaying the STS (size Goldmann III) and an arrow head figure (< or >; see the inset picture) for the FO. The small opening in the centre of the aluminum arc is for an ambient light sensor for measuring the intensity of room lighting. The remote control (not in the picture) for reporting the recognition of the fixation object is connected to the perimeter by cable. Data transfer to computer was done after the test using USB cable.

18 locations (up to 28° temporal, 20° nasal) along the meridian 8° of the visual field of the left eye were tested three to six times. This meridian was chosen for it allowed more locations to be tested within the blind spot area than in meridian 0°. The reaction time perimeter has an electronic sensor with which the correct tilt for studying the chosen meridian (8 degrees) was adjusted. The visual field program did not proceed if the tilt changed. However, this did not occur once during the study. The number of locations that were situated within the blind spot area varied from 3 to 5 (mean 3.5) and depended on the location of the individual´s physiological blind spot. Reaction times for detecting the STS displayed within the blind spot area were compared to reaction times at other locations. The study time depended on the reaction times of a given individual and varied between 1-2 minutes for each distance respectively. Statistical analysis was made with analysis of variance (AOV) procedure of IBM SPSS Statistics program (version 22).

Results

Reaction times within the blind spot area of all the individuals studied were longer (mean 1751 ms vs. mean 987 ms) and showed more variability (SD 706 vs. 366) compared to other locations in the visual field. In 10 of 11 subjects this difference was statistically significant (Figure 2).

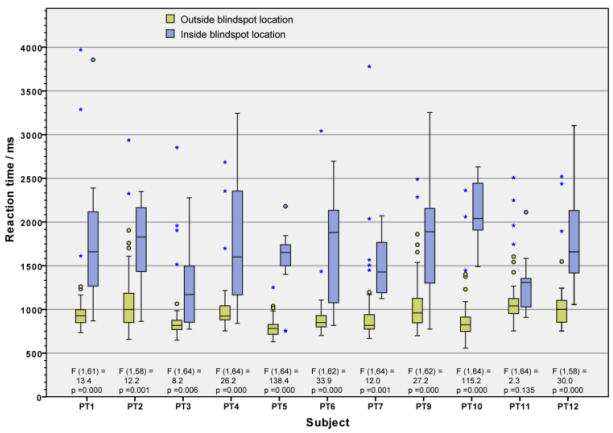

Figure 2: Box plot figure showing reaction times in subjects 1-12. In all subjects examined except one (PT11) the reaction times within the blind spot area were significantly longer than in other locations of the visual field.

Discussion

In this study, we used two independent methods for reference, Octopus perimeter custom made blind spot visual field program and Fundus photography for calculating the theoretical location of the physiological blind spot based on the mathematical formula of Bennett et al. [4], in determining the location of the centre of the physiological blind spot. The results from these two methods came close [5]. The results from the Octopus perimeter by custom made blind spot visual field program were chosen to define the location of the centre of the pysiological blind spot. In all individuals but one (PT11), the reaction times for stimuli displayed at the physiological blind spot measured with reaction time perimeter were longer than for stimuli displayed in normal visual field (mean 1751 ms, SD 706 and mean 987 ms, SD 366 respectively). Hence, we were able to show that reaction time perimeter is capable of finding the physiological blind spot within normal visual field.

We hypothesize, that there are two possible reasons for the reaction time perimeter being unable to find the physiological blind spot in one subject (PT11). First, the predetermined location of the blind spot was wrong, although we think this is highly unlikely because there were two independent methods for determining it, the results of which were 16.5 and 15.7 degrees, respectively [5]. Second, it is possible, that the subject was so bright that she very quickly learned that when the STS was not immediately seen, the FO could be found in the temporal visual field, thus reducing the time it took for her to find it.

Shorter reaction times and also smaller variability for stimuli displayed outside the scotoma area result from a reflex saccade that is initiated by the recognition of an STS in the peripheral visual field. This allows rapid turning of the eyes towards the STS and visualization of the FO with the fovea. When the peripheral stimulus is displayed at a scotoma area, and therefore not seen, the test subject is forced to perform visual search for the FO. However, depending on the location of the FO and the direction of the first saccade(s), occasionally by chance, the fixation object can be detected rapidly. Further, it is possible that sometimes learning from previous experience that the FO

is located in the temporal visual field when the STS in not seen can speed up the search for it. The effect of learning and other features of the novel reaction time perimeter are currently under investigation.

We hypothesize, that in the future, reaction time perimeter can offer advantages compared to standard automated perimetry. An external fixation control apparatus is needed in standard automated perimetry, because fixation losses can occur and they potentially weaken the reliability of the study [6,7]. In contrast, with reaction time perimeter correct fixation is monitored by using fixation objects recognizable only by the fovea. In certain subgroups of patients such as children, visual field examination requires learning and can be subject to error. It has been discussed that for children the most demanding requirement for automated visual field examination is to maintain stable fixation on a central target, while at the same time paying attention to peripheral stimuli [7]. The advantage of the reaction time perimeter is that it allows physiological visual reflexes to direct gaze towards a peripheral stimulus in order to further detect it with the fovea. Hence, it neglects the need to maintain prolonged stable fixation and thus can be of great benefit. Future research is needed to gain knowledge of the advantages and disadvantages of the novel reaction time perimeter in the investigation of the visual field.

Acknowledgement

Grants and sources of support: This study was supported by the Nissi foundation, the Kaukomarkkinat Oy fund, the Esther and Gustaf Nikula fund, the Rauno and Anne Puolimatka foundation, the Finnish Ophthalmological Society, the J. R. Danielsson-Kalmari fund, the Paavo Salminen fund, the Combined Research Foundation of the University of Turku, the Intermunicipal Hospital District of Southwest Finland and the TYKS foundation.

Commercial relationships: The authors LK and EV report no conflict of interest. The author MTL is the founder and shareholder of Ocuspecto Oy (**www.ocuspecto.com**) that is responsible for developing the reaction time perimeter. The author MTL also has pending intellectual property of interest in reaction time perimetry.

References

1. Tatham AJ, Boer ER, Rosen PN, Della PM, Meira-Freitas D, et al. (2014) Glaucomatous Retinal Nerve Fiber Layer Thickness Loss Is Associated With Slower Reaction Times Under a Divided Attention Task. Am J Ophthalmol 158: 1008-1017.e2.
2. Richman J, Lorenzana LL, Lankaranian D, Dugar J, Mayer JR, et al. (2010) Relationships in glaucoma patients between standard vision tests, quality of life, and ability to perform daily activities. Ophthalmic Epidemiol 17: 144-151.
3. McKean-Cowdin R, Varma R, Wu J, Hays RD, Azen SP; Los Angeles Latino Eye Study Group (2007) Severity of visual field loss and health-related quality of life. Am J Ophthalmol 143: 1013-1023.
4. Bennett AG, Rudnicka AR, Edgar DF (1994) Improvements on Littmann's method of determining the size of retinal features by fundus photography. Graefe's Archive for Clinical and Experimental Ophthalmology 232: 361–367.
5. Knaapi L, Aarnisalo E, Vesti E, Leinonen MT (2015) Clinical verification of the formula of Bennett et al. (1994) of determining the size of retinal features by fundus photography. Acta Ophthalmol 93: 248-252.
6. Katz J, Sommer A (1988) Reliability indexes of automated perimetric tests. Arch Ophthalmol 106: 1252-1254.
7. Tschopp C, Safran AB, Viviani P, Bullinger A, Reicherts M, et al. (1998) Automated visual field examination in children aged 5-8 years. Part I: Experimental validation of a testing procedure. Vision Res 38: 2203–2210.