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# Is the ring scotoma of a monocular telescope present when viewing binocularly?

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**Abstract.** Telescope magnification causes a ring scotoma (blind area) around the magnified view, which has been suggested as a hazard when bioptic (spectacle-mounted) telescopes are used for driving. Preliminary work in our lab suggests when viewing binocularly on simple plain backgrounds, people can use the fellow (non-bioptic) eye to detect objects in the ring scotoma area (known as bi-ocular multiplexing). This paper presents preliminary findings on visually-complex noise backgrounds. To date 4 normally-sighted and 1 low vision subject have participated in pilot studies. Static perimetry was utilized to evaluate subject's bi-ocular multiplexing ability with and without the bioptic during passive and active fixation tasks. In general, detection performance of the fellow eye was similar without and with the bioptic, and was similar in the passive and active fixation conditions. These results suggest bi-ocular multiplexing is possible in visually-complex conditions and that the ring scotoma of a monocular bioptic is not always present in binocular viewing.

*Keywords:* Bioptic telescope; Central visual field loss; Ring scotoma

## 1. Introduction

Central vision impairment (resulting from diseases such as macular degeneration) is characterized by loss of high-resolution vision (a reduction in visual acuity) and central visual field loss (CFL), which create difficulty in visual tasks such as reading, recognizing faces, watching television, and seeing street signs while driving. Monocular bioptic telescopes, “bioptics”, are small spectacle-mounted telescopes used as low vision aids enabling people with reduced visual acuity to see details of distant objects (Fig. 1a). Driving with a bioptic is permitted in 36 states.[i] Wearers use the bioptic to obtain a magnified view for a brief period (1-2 seconds) for tasks such as reading signs or determining the status of traffic signals.[ii] The magnification causes a ring scotoma (blind area) around the bioptic view (Fig. 1b and 1c), which has been suggested as a hazard when a bioptic is used for driving.[iii,iv] With binocular bioptic telescopes, the ring scotoma will always be present in binocular viewing conditions and could potentially obscure and delay detection of hazards when driving. However, previous work in our lab with **monocular** bioptics suggests that when viewing binocularly, people can use the fellow eye (eye not viewing through the bioptic) to detect stimuli presented in the area of the monocular ring scotoma in simple conditions (e.g., detecting a spot of light on a plain background).[v,vi] This ability is known as bi-ocular multiplexing.[vii] While simple visual conditions are typical of those employed in conventional visual field testing, they are not representative of real life situations. Therefore, the purpose of this study was to evaluate the bi-ocular multiplexing ability of people using monocular bioptics in more visually-complex conditions.

### *1.1 Stage 1: Real image backgrounds*

In the first stage of this study we conducted pilot tests using visually-complex static street scene images as backgrounds against which were presented black-and-white checkerboard stimuli. We selected street images to be representative of the scenes in which bioptics are likely to be used when driving. Both the 5 normally-sighted (NS) and 3 central-field loss (CFL) subjects tested exhibited bi-ocular multiplexing ability on these image backgrounds. When viewing through a monocular bioptic, they were all able to detect suprathreshold stimuli with the fellow eye in the area of the monocular ring scotoma. However, we noted that 2 CFL subjects needed stimulus motion to detect stimuli in some areas of the ring scotoma. This suggests that the stimulus presented to the fellow eye was suppressed under some conditions. The motion of the stimulus may have broken the suppression; alternatively, the stimulus might simply have been moved so that it was presented against a part of

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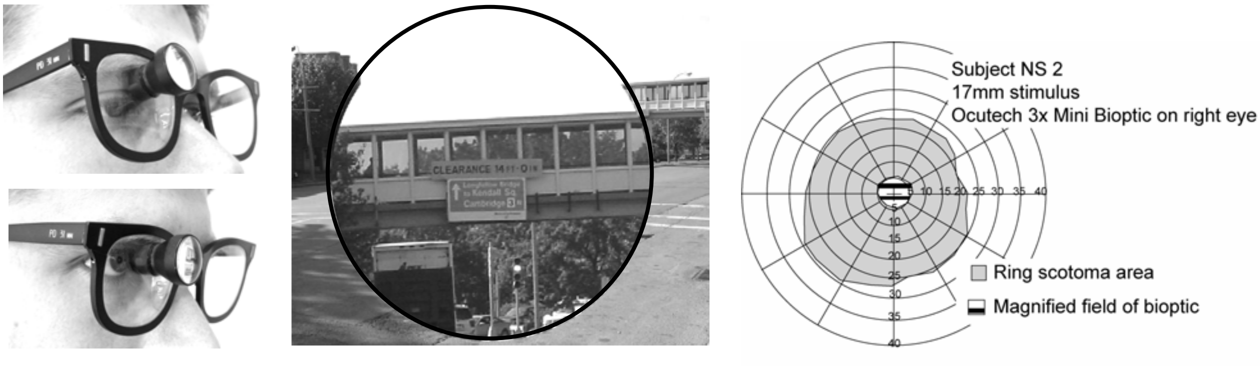
the natural scene background where it was more easily seen. A major drawback of using natural scenes is the large variations in spatial frequency and contrast characteristics across the background, which will affect stimulus visibility. To control for this variability, and to know the specific characteristics of the background image, we used visually-complex “noise” backgrounds in the second stage of the project.




(a) (b) (c)

Fig. 1. (a) A monocular bioptic telescope. The user views below the telescope most of the time (top), looking intermittently through the telescope by a downward tilt of the head (bottom). (b) A simulated view of a road sign as viewed through a 3x bioptic telescope. The magnified view blocks the view of the intersection; this effect can be measured by clinical visual field testing, where the blockage is shown as a ring scotoma (blind area) around the magnified view. (c) A monocular visual field of a normally sighted subject viewing through a 3x bioptic telescope over the right eye (the left eye was covered). The ring scotoma (gray shading) surrounds the magnified view (horizontal hatched area).

*1.2 Stage 2: “Noise” image backgrounds*

We developed a set of “noise” images that can be used to create visually complex backgrounds, which have spatial frequency and contrast characteristics within a specified range and are similar across the whole image (Fig. 2). In this paper we report preliminary results for our evaluations of bi-ocular multiplexing with monocular bioptics on these noise backgrounds.

## 2. Methods

*2.1 Subjects*

To date, 4 NS subjects (VA 20/30 or better) and 1 CFL subject (VA 20/125) have participated. The NS subjects used an Ocutech 3x mini monocular adjustable focus telescope on their dominant eye. Three NS subjects wore the bioptic on their right eye and 1 on the left eye. All were naïve to using bioptics. The CFL subject wore her own bioptic (an Ocutech 3x mini monocular adjustable focus). The bioptic had been supplied for driving about 9 months before the experimental session; however, she reported using it only very occasionally.

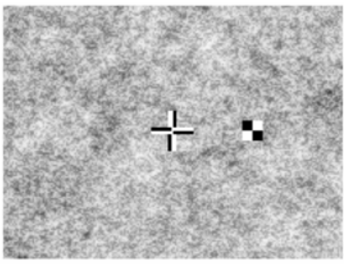


**Fig. 2.** The $1/f^{-0.75}$ noise background used in the study. The passive fixation target and checkerboard stimulus are shown

*2.2 Apparatus*

A computerized perimeter with a novel dichoptic viewing system, developed in our lab, was used to plot central visual fields (out to $40^o$ eccentricity). The dichoptic viewing system with ferro-electric liquid crystal shutter lenses was used to enable independent control of the information presented to each eye. The shutter lenses were suspended from an extension to a lightweight helmet worn by the subjects so that the bioptic could fit behind the shutter lenses. This system allows measurement of visual fields on simple plain and more complex backgrounds. In this study a 17mm, 4 square (black and white) checkerboard stimulus was presented on a noise background which changed after each stimulus presentation (Fig. 2). The noise had a spatial frequency content of $1/f^{-0.75}$ which is similar to that of many natural images.[viii] Mean luminance of the noise images was 38 $cd/m^2$. The stimulus and fixation cross were bipolar (black and white) so that they would be visible on all areas of the background.

*2.3 Procedures*

Subjects sat one meter from a large, rear-projection screen on which the fixation target and stimuli were presented. First the boundary of the visual field (isopter) and any central scotomas were mapped for each eye using kinetic perimetry under binocular conditions (without a bioptic telescope) while subjects viewed through the shutter lenses. The ring scotoma of the telescope was then mapped with the "telescope eye" viewing through the bioptic. Finally static perimetry was utilized under binocular conditions to evaluate the ability of the "fellow eye" (the eye without the telescope) to detect suprathreshold static targets presented in the area of the ring scotoma. Stimuli were presented in a "script" in 7 locations each repeated twice in random order for a total of 14 stimulus presentations. Of the 14 stimuli, 12 were shown to the fellow eye in the area of the ring scotoma (within the field of the fellow-eye shutter-lens and not within a central scotoma area), and 2 stimuli to the telescope eye inside the area of the ring scotoma (to check for false positives) (Fig. 3). Stimuli were presented for 500 ms with a random variable interval of 1000 to 1950 ms between presentations.

*2.4 Experimental conditions*

The static perimetry script was presented in two conditions: "passive" fixation and "active" fixation (dual tasking). Passive fixation involved looking at the central black-and-white fixation cross, as in conventional perimetry. However, this is not representative of the conditions in which a bioptic is normally used, where attention has to be paid to the object that is being viewed (e.g., reading a road sign). Therefore an active fixation task was also included to provide conditions more representative of those in which a bioptic might be used. Instead of the fixation cross, subjects were asked to use the bioptic to read letters which appeared at the fixation location. They were 13 by 17mm (6 by 8 pixels) black on a white 32 mm (16 pixel) square, and changed every 2 seconds. Subjects called out each letter as it changed, while also responding using a button press to the appearance of the checkerboard stimuli. Changes in the fixation letters were not synchronized with the appearance of stimuli. All subjects were given at least one practice session to become familiar with the active fixation task.

The static perimetry script was presented four times: once each for passive fixation, with and without the bioptic, and once each for active fixation, with and without the bioptic. This allowed us to evaluate a) the effect of the bioptic and b) the effect of an active fixation task on detection performance of the fellow eye. We expected that detection performance would be worse in the active fixation condition as attention would be taken from the peripheral detection task and allocated to the fixation task.[ix]

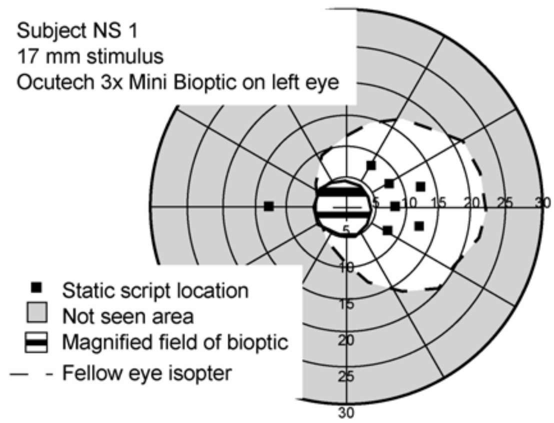



**Fig. 3.** The position of the static stimuli (marked by squares) presented to subject NS 1. 14 total stimuli were presented in 7 locations, with each location repeated twice. The isopter marking the boundary of the area seen by the fellow eye through the shutter lens is marked with a dashed line and the magnified field of view through the bioptic shown with horizontal hatch marks.

## 3. Results

Detection performance for the fellow eye in each of the four conditions is shown in Fig. 4. As only a small number of static stimulus presentations were included in the preliminary testing reported in this paper, statistical analyses have not been conducted.

*3.1 Bi-ocular multiplexing ability*

All four NS subjects and the CFL subject were able to bi-ocularly multiplex (i.e., detect stimuli with the fellow eye in the area of the ring scotoma in the with-bioptic conditions), and in general there was little difference in detection performance between conditions with and without the bioptic (Fig. 4). However, all NS subjects did report occasional fading of the passive fixation cross only while fixating on it through the bioptic.

*3.2 Effect of Active Fixation Task*

All subjects were able to do the active fixation task in combination with the peripheral detection. Accuracy in calling out the letters was high (> 95%), and subjects tended to self-correct when they incorrectly reported letters. Anecdotal reports from subjects revealed that they perceived a greater level of task difficulty when asked to dual-task in the active fixation task; however, contrary to our expectations, the NS group data showed little difference in detection performance between the active and passive tasks. The same trend is also apparent in the data for the CFL subject. Subjects NS 3 and NS 4, who reported that the magnified cross in the passive fixation task faded occasionally during the session, observed that the magnified letters in the active fixation task did not fade.

**4. Discussion**

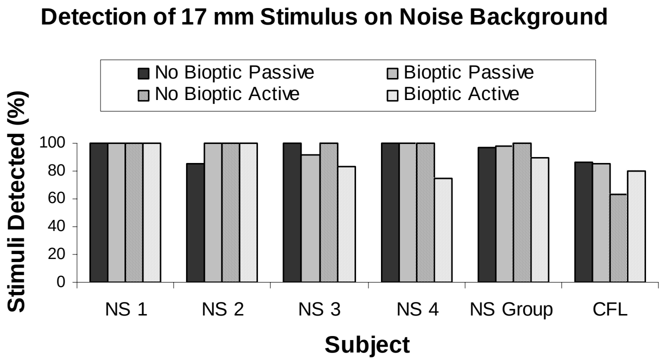



**Fig. 4.** Fellow eye (eye without bioptic) detection performance for static stimuli presented in the area of the ring scotoma in each of the four conditions. Overall there was little difference in detection performance with and without the bioptic in front of the other eye. Also there was little difference in detection performance between passive and active fixation conditions. NS = normal sight; NS Group = Data pooled across the 4 NS subjects; CFL = Central field loss

The conclusions that can be drawn from these results are limited due to the small sample size and small number of stimulus presentations in this preliminary data. Nevertheless, the results suggest that the CFL subject and all NS subjects exhibited bi-ocular multiplexing ability in the presence of a visually-complex background. They were able to detect suprathreshold stimuli presented to the fellow eye in the area of the ring scotoma while fixating through the bioptic in the passive as well as the active fixation conditions. The fact that the detection performance of the fellow eye was similar in the without- and with- bioptic conditions suggests that the detection ability of the fellow eye in the area of the ring scotoma was not adversely affected by the introduction of the bioptic. The fading of the fixation cross in the passive task may suggest binocular rivalry or the Troxler effect. As expected, anecdotal reports from the subjects suggested that the active fixation condition was more difficult than the passive fixation condition; however, subjects appeared to be able to perform the detection task equally well in both conditions. For the NS subjects, the lack of a difference in detection performance with and without the bioptic and between the passive and active fixation conditions might also be due to a ceiling effect. We will use lower contrast, smaller checkerboard stimuli and more stimulus presentations in future pilot work.

These preliminary results are promising, suggesting that bi-ocular multiplexing is possible in visually-complex conditions and that the ring scotoma of a monocular bioptic telescope is not always present in binocular viewing conditions. We will continue to refine our method of testing bi-ocular multiplexing and will explore other more complex visual situations. In the future, we will be conducting a larger study with naïve and experienced CFL bioptic users.

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