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Effects of blur on Humphrey 24-2 results

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Abstract

***Aim*: To determine the effects of defocus on the retinal sensitivity within the central 2° and at 24° of the visual field and to compare the effect on the two areas.**
***Methods*: Twelve normal subjects (aged 18–22 years) undertook three visual field tests on a Humphrey visual field analyser, one with a +3.00 DS lens, one with a +4.00 DS and one with a +5.00 DS. Mean threshold sensitivity was recorded in the central 2° and at 24°. Analysis of variance and paired *t*-tests were used for data analysis.**
***Results*: Two participants were excluded. Analysis of the 10 remaining participants showed that the strength of lens used affected sensitivity ($p < 0.0013$), the difference occurring when the +5.00 DS lens was used. Each lens had a similar effect on the central 2° and at 24° ($p = 0.6706$).**
***Conclusion*: Threshold sensitivity was reduced with induced blur from plus lenses, without cycloplegia.**

Key words: Blur, Ocular refraction, Retinal sensitivity, Visual fields

Introduction

The visual field has been defined by Tate and Lynn[1] as 'all the space that one eye can see at any given instant'. Sensitivity decreases with an increase in eccentricity. The change in sensitivity at different points in the field can be described as the 'hill of vision', the central points being the highest and therefore the most sensitive. The hill of vision can, however, change with the state of visual adaptation. This is why perimetry must be able to keep external factors, such as background illumination, stable.

Studies using both kinetic and static perimetry have been carried out to investigate different aspects of the visual field including the effect of blur. Threshold elevation has been demonstrated in uncorrected presbyopia,[2] or by inducing blur by contact lenses[3] or plus lenses.[4,5]

Henson and Morris[6] looked at the effect of blur on visual fields in two groups of subjects, pre-presbyopes and presbyopes, by comparing differences between corrected and uncorrected results. A Henson CFA 3000 static perimeter, with a stimulus size of 0.5° (30 min of arc), was used to measure threshold sensitivity within the central 25°. With blur a decrease in threshold sensitivity was found, which appeared independent of eccentricity. However, Frankhauser and Enoch[7] showed an apparent central scotoma developed when blur was increased. A Goldmann perimeter with a Goldmann size I target (0.107°) was used to test points at 2.5° intervals up to 30° in two cyclopleged, pre-presbyopic subjects. Contrast threshold increased either side of the fixation target with increasing defocus and apparent central relative scotomas developed for higher degrees of blur.[7] Ogle[8] and Benedetto and Cyrlin[9] also found the effect of defocus to be dependent on eccentricity. Decreased sensitivity has also been shown in peripheral areas of myopes when uncorrected (30° to 50°).[10]

None of the previous reports studied the effect of blur on the results of a static field test using the Humphrey visual field analyser. In a clinical setting cycloplegia is not used during field testing. This study aimed to determine the effects of lens-induced defocus, without cycloplegia, on the central 2° and at 24° of the visual field and to compare the effect on the two areas.

Materials and methods

Twelve participants, aged between 18 and 22 years, were recruited from the student population by means of an advertisement. A repeated measures design was used. The order of field tests was randomised to control order effects by determining all possible orders for the three field tests and selecting an order before each participant arrived. The study complied with the guidelines of the Declaration of Helsinki and informed consent was obtained from all participants.

Criteria for inclusion were: visual acuity (VA) of 6/6 or better in the right eye; emmetropic or myopic wearing contact lenses only, with a prescription no older than 2 years and no greater than −6.00 DS; and no known visual field defect.

Procedure

Participants were informed of the testing procedure. Contact lens wearers performed the procedure wearing their contact lenses. Visual field testing was carried out on a Humphrey autoperimeter using programme 24-2. Three fields were performed using:

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- a +3.00 DS spherical lens to account for the testing distance (perimeter bowl radius 33 cm) and therefore eliminating accommodation;
- a +4.00 DS spherical lens (accommodation eliminated and an extra +1.00 DS spherical lens to induce blur);
- a +5.00 DS spherical lens (accommodation eliminated and an extra +2.00 DS spherical lens to induce blur).

Full aperture lenses were used.[11,12] The lighting in the room was reduced to that routinely used in a clinical setting and the subject was given 5 minutes to adapt to the luminance of the bowl.[11] The left eye was then occluded. Foveal sensitivity was tested by instructing the subject to 'look at the central four lights and press the button each time a light flashes in the middle of these four lights'. Fixation was then tested by instructing the subject to 'look at the centre light for a couple of seconds'.

For visual field testing the participant was given the following instructions: 'Always look straight ahead at the steady fixation light. Other lights will flash one at a time at other positions around the centre light. Some may be bright, and others will be dim. Press the button whenever you see one of these flashes. You are not expected to see all of them.'

After each field test the participant removed their left eye occlusion and had a 5 minute rest to prevent bias due to fatigue. The lighting conditions remained the same for the duration of the test period. Consistency during testing was aided by one examiner carrying out assessments on all participants. Participants with fixation losses greater than 20% were excluded, as in the clinical setting diagnoses would not be made due to unreliable results.[13]

Data analysis

The five innermost points of the visual field, including foveal sensitivity, were summed and the mean calculated. These points extended to 2° from the centre of the visual field. The 20 outermost points (all at 24° from the central field) were summed and the mean calculated. The mean of the five outermost points in each quadrant was also calculated. Analysis of variance and paired t-tests were used to statistically analyse the results. The following aspects were examined:

- whether there was a decrease in threshold sensitivity on the central visual field with an increase in induced blur;
- whether the increase in induced blur would decrease threshold sensitivity in the peripheral field;
- whether there was a smaller decrease in threshold sensitivity in the peripheral field than the central field with increasing blur.

Results

Twelve participants were tested, but 2 were excluded from the study due to inadequate fixation during testing. Data analysis was carried out on the 3 remaining contact lens wearers and 7 emmetropic subjects. The mean age of subjects was 20.3 years (range 19.9–22.1 years).

Table 1 shows the mean threshold sensitivity of all 10 subjects in the central 2° of the field (inner field) and at 24° from the centre of the field (outer field) with the different strength lenses. A two-factor repeated-measures analysis of variance was performed to test whether sensitivity was related to the strength of lens or distance from the central field. The higher sensitivity in the central 2° compared with 24° was statistically significant ($p < 0.0001$). The lens power also had a statistically significant effect on sensitivity at both the central 2° and 24° ($p < 0.0013$). There was, however, no statistical significance between the two areas of field and different strength lenses ($p = 0.6706$). As a lens effect had been shown, paired t-tests where carried out to see where the difference occurred. No significant difference was found between the +3.00 DS spherical lens and +4.00 DS spherical lens on the central 2° ($t = 1.15$, d.f. = 9, $p = 0.2786$). The difference between a +4.00 DS spherical lens and +5.00 DS spherical lens was significant ($t = 2.94$, d.f. = 9, $p < 0.05$). Comparing a +3.00 DS spherical lens and +5.00 DS spherical lens also showed a significant difference ($t = 3.03$, d.f. = 9, $p < 0.05$). The pattern was the same at 24° ($t = 0.76$, d.f. = 9, $p = 0.4649$; $t = 2.71$, d.f. = 9, $p < 0.05$; and $t = 3.29$, d.f. = 9, $p = <0.05$, respectively).

Discussion

As expected, the results showed a difference in sensitivity between the central (inner field) and peripheral field (outer field) that was statistically significant. The sensitivity in the central and peripheral field decreased with increasing blur, showing that increasing plus lenses decreased sensitivity in both areas of the visual field. For both the central and peripheral areas the +5.00 DS lens significantly reduce sensitivity compared with the +4.00 DS or +3.00 DS lens. No statistical difference was found between the sensitivities recorded with the +4.00 DS lens and +3.00 DS lens.

Although the effect of inducing blur decreased sensitivity levels, the interaction between the lens and

Table 1. The mean and standard deviation (SD) sensitivities of all the subjects for each of the lens and field positions

	Lens (dioptre spheres)					
	3		4		5	
	Inner field (2°)	Outer field (24°)	Inner field (2°)	Outer field (24°)	Inner field (2°)	Outer field (24°)
Mean (db)	33.46	28.75	33.02	28.54	32.06	27.72
SD	1.01	1.02	1.26	0.94	1.80	1.61

the inner and outer area of field was not statistically significant, suggesting a similar decrease in the threshold sensitivity in these two areas. However a type 2 error could have occurred here, as the statistical power for calculating the significance of the interaction is low.

Unlike other studies,[4,7] cycloplegia was not used in this study. It was felt that a +3.00 DS spherical lens would be sufficient to minimise the effects of accommodation during testing. However, it is possible that some subjects did not fully relax their accommodation, thus leading to more blur. Rosenfield and Carrel[14] have reported a number of subjects of a similar age (mean 24.2 years) who failed to relax their accommodation to a +2.50 DS spherical lens. Weinreb and Perlman[4] used cycloplegia and static perimetry (Octopus). They compared the mean threshold retinal sensitivity in 10 eyes at the fovea and found that the sensitivity decreased with an additional +1.00 D lens and again with a +2.00 D lens. Due to the dilation of the pupils the authors considered that the effect of inaccurate refractive error might have been overestimated. However, they concluded that even small refractive errors could decrease threshold retinal sensitivity within the central 6° of the visual field. When the area tested was extended to 30° similar changes in sensitivity to those in the central area were found and sensitivity decreased with eccentricity.[5] Although these studies have similar methods to ours, they are not directly comparable, as subtle differences exist between the Humphrey and Octopus machines.

In this study the use of plus lenses induced blur. However, the level of blur may have varied between participants as refraction prior to the procedure was not performed and therefore participants were not corrected to absolute emmetropia. In addition, proximal accommodation, which has been shown to occur at distances nearer than 3 m,[15] may have been induced and whilst the test distance remained constant throughout, this could produce variations in the level of blur and an effect on sensitivity.

Variation in the level of blur may also have resulted from variations in refractive error with eccentricity. Jackson *et al.*[16] have found a general tendency towards myopia in the periphery when testing up to 20° off axis. Variations in the cylinder axes were found and this aspect was particularly unpredictable. Their individual data plots suggest that subjects were low myopes or hypermetropes. Seidemann *et al.*[17] using infrared photorefraction found myopes tended to become less myopic with eccentricity, by a mean of 2.73 D at 45°. In our study three participants were myopic. Anderson *et al.*[18] performed perimetry on 2 subjects, having corrected for variation in refractive error prior to inducing blur with plus lenses and measured threshold to a range of target sizes centrally and at 30°. They reported foveal thresholds to be more affected by blur, particularly with smaller stimuli, and highlighted that whilst their findings may be similar to other studies, peripheral refractive error does have an effect on perimetric performance.

Sloan,[2] Frankhauser and Enoch,[7] Ogle[8] and Benedetto and Cyrlin[9] all reported central targets to be more affected by blur than peripheral targets. These studies all used a small stimulus size (0.6–30.710 min of arc). However, Sloan,[2] Atchinson,[3] Henson and Morris,[6] Weinreb and Perlman[4] and Goldstick and Weinreb[5] used much larger stimuli sizes $\geq$30.710 min of arc and showed that defocus was independent of eccentricity. The results of this study, whilst they must be viewed with caution due to the likely variation in the levels of blur induced, show that for a stimulus size 30.71 min of arc defocus was independent of eccentricity, in agreement with the findings of Goldstick and Weinreb.

The findings of this study suggest that an uncorrected refractive error would be expected to reduce sensitivity across the whole visual field. Conclusions can only be drawn regarding the effect of lens-induced blur in young adults without ocular disease. Further study would be needed to determine the effects of blur produced by uncorrected presbyopic errors in a presbyopic population. Further study would also be needed to determine whether the use of spherical equivalent lenses used in place of low to moderate astigmatism affects threshold sensitivity, as this is commonplace in clinical practice.

Conclusion

Inducing blur by plus lenses decreases the threshold sensitivity within the central 2° and 24° of the visual field in young adults. Variations in the findings of this study compared with previous literature are most likely due to the use of smaller target sizes to plot the visual field and the lack of cycloplegia. Although localised defects would still be detected, this study suggests a subject's refractive correction should be used for a visual field examination to allow clinical judgements on the basis of threshold sensitivity.

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There are no competing interests.

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