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# Binocular Function under Unusual Light Condition: A Cross-Sectional Study

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Original Article


## Abstract

**Introduction:** Glare is an unusual light condition that may alter the visual function. The aim of this study is to evaluate the effect of glare on binocular evaluation tests.

**Materials and Methods:** In this cross sectional study, 44 healthy students of Zahedan University of Medical Sciences, Zahedan, Iran were selected. Binocular evaluation tests were direct tests such as cover test, near point of convergence, and fusional reserves, and the indirect tests included binocular accommodative facility and relative accommodation, which were performed in the standard and glare light conditions. Statistical analysis was performed using the paired sample t-test.

**Results:** The findings showed the negative fusional reserves at blur, break, and recovery point was significantly different in the two light conditions ($P < 0.049$). Moreover, other tests of binocular evaluation had no significant difference under the glare and normal light conditions ($P > 0.050$).

**Conclusion:** Given this study, glare seems to have a negative impact on negative fusional reserves. Therefore, given the limited range of negative fusional reserve, effect of unusual lighting condition should be considered, especially in people with intermittent esotropia or decompensated esophoria.


**Keywords:** Binocular vision; Glare; Accommodation

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## Introduction

Binocular vision is one of the most important visual functions, especially in near vision activities, which increases stereopsis. One of the most common problems reported in clinics is non-strabismic binocular vision problems, which are reported in the form of blurred vision or diplopia with symptoms such as eye fatigue, headache, discomfort, and impaired visual function (1). These symptoms are exacerbated during near long-time activities, especially computer work (2,3). Proper diagnosis of binocular disorders and its causes and appropriate treatment can help improve symptoms in individuals (3,4).

In their daily lives, people are exposed to different lighting conditions, such as driving at night, which can affect their vision performance. Glare is an abnormal light condition that is defined as an unpleasant feeling when a light source is placed close to the line of sight. Glare manifests itself in two forms: disability glare and discomfort caused by glare. In disability glare, visual functions such as visual acuity are reduced in glare conditions. Therefore, the patient complains of decreased vision in the glare conditions, and often the main cause of this phenomenon is the diffusion of intraocular light, which occurs due to opacity in the eye media or when a light source is near the line of sight (5). In discomfort glare, visual functions are normal, but these conditions cause discomfort and early fatigue and occur more often when a strong light source is in the individual's field of vision (6). The light of cars and roadside lights at night

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while driving, especially in the elderly, is one of the most important causes of glare at night, which leads to road accidents (7).

One of the major problems with computer work is the glare problem caused by the monitor screen; especially when the brightness of the environment is less than that of the monitor screen. In addition, the light reflected from the window or ceiling light from the monitor screen can cause glare (5). This problem has been reported with high prevalence in computer users (5,8). Previous studies have shown different results in improving the effects of glare on visual functions using color filters (6,9).

The state of binocular vision and accommodation system in computer users has been investigated in previous studies, with the results suggesting an increase in binocular vision disorders and accommodation problems (10,11). There are many causes for eye problems in computer users, and the glare caused by the monitor screen cannot be the only cause of binocular vision disorders in them. Considering the importance of binocular vision in the visual comfort of individuals, especially in glare conditions, the aim of this study was to investigate the binocular vision functions of healthy individuals in natural light and glare conditions and compare them with each other.

## Materials and Methods

In this cross-sectional study, 44 healthy students (27 men and 17 women) of Zahedan University of Medical Sciences, Zahedan, Iran were selected using the convenience sampling method through the announcement of participation in the research project mounted at the entrance of colleges, in October to March 2017. The present study was in accordance with the Declaration of Helsinki (DoH) and was approved by the ethics committee of Zahedan University of Medical Sciences with the code IR.ZAUMS.REC.1398.450. Informed consent form was obtained from all participants to participate in the study. Using the formula for pairwise comparisons with $\alpha = 0.05$, power = 0.95, and effect size = 0.5 in G*Power software version 3.1 (G*Power 3.1.5 freeware, University of Düsseldorf, Düsseldorf, Germany) (12,13), the sample size was estimated as 45 people (13).

First, the General Health Questionnaire (GHQ) was completed based on the participants' self-declaration. Then, eye health was assessed by the slit-lamp examination (Topcon slit lamp, Topcon Optical Corporation, Japan) and funduscopy with a direct ophthalmoscope (Heine Ophthalmoscope K180, HEINE Optotechnik Company, Germany) by the center optometrist. The subjects were included in the study if they did not have any systemic or ocular diseases. The study exclusion criteria included having systemic disease, eye disease such as glare, heterotropia, amblyopia, and a history of any eye surgery. The inclusion and exclusion criteria were checked by the center optometrist who was unaware of the research project. In the next step, the refractive errors of all individuals were determined with a retinoscope (Heine Beta 200 Retinoscope, HEINE Optotechnik, Germany). Then, subjective refraction was performed for each eye and finally, binocular balance was performed and sharpness was recorded with the best optical correction.

The direct binocular vision assessment tests include amplitude of deviation, near point of convergence (NPC), and fusional reserves, and indirect tests include binocular accommodative facility, positive relative accommodation (PRA), and negative relative accommodation (NRA). To evaluate the amplitude of deviation, the intermittent cover test method with prism bar was used and the esophoria and exophoria deviations were recorded with negative sign and positive sign, respectively. These tests are common tests for assessing binocular vision (14,15) and are used by oculoplasty specialists and optometrists to assess binocular vision.

*A. NPC measurement:* For this purpose, an accommodative target with a near chart letter with a size of 0.8 was used, which slowly approached the eyes from a distance of 40 cm along the person's nasal bridge. The first position the person reported fixed binocular and the examiner saw an outward movement of one of the eyes was recorded as NPC (16).

*B. Recording horizontal fusional reserves:* To do this, a vertical line from the near chart with a size of 0.8 was placed as a fixation target at a distance of 40 cm from the person and first the prism bar was placed in front of one of the eyes as the base. Then, the prism power increased and the person was asked to report when the target was blurred, and then by adding the amount of prism, to report when the target doubled and this binocular was fixed. This point was recorded as a binocular point. Then, after the fusion breakpoint was determined, the prism power was reduced until one image was seen. This point was recorded as the point of return to binocular vision. Positive fusional reserves were performed in the same way with the base-out prism (17).

*C. Binocular accommodative facility:* To check the binocular accommodative facility, a flipper bar with numbers ± 2.00 was used. The subject looked at the 0.8 line of the near chart at a distance of 40 cm. First the +2.00 lenses and then the -2.00 lenses were placed in front of both eyes and the person was asked to report when the image became clear. The lenses were then moved. Each time of rotation of the lenses was considered one cycle and the number of cycles per minute was recorded (18).

*D. Relative accommodation:* In order to evaluate the relative accommodation, the person looked at the same accommodative target at a distance of 40 cm and a positive lens with 0.25 steps was added in front of the two eyes. The person was then asked to see the image clearly and uniquely. The first place where the fixed binocular was created was considered as the NRA. PRA was performed in the same way only with negative lenses (18).

All of the above tests were performed with correction of individuals for a distance of about 40 cm, once in the standard lighting of the examination room and once in glare conditions on two different days. The sequence of light conditions was randomly selected for each individual by removing the envelopes that contained the light conditions. To create a glare, a 60 W Tungsten Filament Incandescent lamp was used at a distance of 18 cm from the eyes of the individuals and 2 cm above their line of sight (angle of 10 degree relative to the line of sight) (6,19). It should be noted that before the tests, the subjects were exposed to the light condition for at least 20 minutes to get used to it (20) and then the binocular vision tests were performed.

To evaluate the normal distribution of data, the Shapiro-Wilk test was used and due to the normality of the data, paired t-test was used to evaluate the effect of glare on binocular vision tests. Descriptive statistics were expressed as mean, standard deviation (SD), mean difference, and 95% confidence interval (CI) of mean difference. Finally, the data was analyzed in SPSS software (SPSS version 15, Chicago, IL, USA). $P < 0.05$ was considered as the significance level.

## Results

A total of 44 patients with a mean age of 22.62 ± 0.87 years participated in the present study. The mean of the tests evaluated in two lighting conditions is presented in table 1.

Table 2 shows the average fusion reserves in two light conditions. The paired t-test results indicated that negative fusion reserves at the blur point [(P = 0.003, 95% CI (0.64-2.69) = 1.66], diplopia (P = 0.049, 95% CI (0.04-2.64) = 1.20), and return to binocular vision (P = 0.023, 95% CI (0.17-2.16) = 1.16) were significantly different in the two light conditions. No significant difference was observed between other binocular vision assessment tests in glare and standard light conditions ($P < 0.050$).

## Discussion

Glare is an over-standard light condition that can lead to eye problems such as discomfort and fatigue. In the present study, the effect of glare on binocular vision functions was evaluated. The findings revealed that glare negatively affected only the fusion reserves and other binocular vision tests were not affected by glare.

**Table 1.** Mean of binocular vision assessment tests in two different lighting conditions

| Lighting conditions | Accommodation facility (cycle per minute) | PRA (diopter) | NRA (diopter) | NPC (cm) | Amplitude of deviation (Prism diopter) |
|---|---|---|---|---|---|
| Standard lighting | 10.45 ± 3.68 | 3.29 ±0.70 | 2.84 ± 0.60 | 7.30 ± 1.02 | 4.91 ± 3.42 |
| Glare lighting conditions | 10.59 ± 1.53 | 3.25 ± 1.20 | 2.50 ± 4.70 | 7.08 ± 1.11 | 4.82 ± 3.33 |
| P | 0.851 | 0.873 | 0.059 | 0.11 | 0.428 |

PRA: Positive relative accommodation; NRA: Negative relative accommodation; NPC: Near point of convergence

**Table 2.** Average fusional reserves in two different light conditions

| Lighting conditions | Negative fusional reserves (prism diopter) | | | Positive fusional reserves (prism diopter) | | |
|---|---|---|---|---|---|---|
| | Opacity point | Binocular | Return to binocular vision | Opacity point | Binocular | Return to binocular vision |
| Standard lighting | 12.58 ± 3.21 | 18.83 ± 2.54 | 15.50 ± 2.37 | 18.66 ± 3.60 | 30.70 ± 6.40 | 24.37 ± 4.34 |
| Glare lighting conditions | 10.91 ± 2.28 | 17.02 ± 3.06 | 14.33 ±2.92 | 17.45 ±3.55 | 30.20 ± 4.53 | 23.62 ±3.76 |
| P | 0.003 | 0.049 | 0.023 | 0.057 | 0.671 | 0.342 |

Evaluation of the fusion reserves is one of the most important clinical tests for binocular vision. When the prism is placed in front of the eyes, due to the retinal disparity caused by the prism, the vergence system is excited and the motor fusion eliminate the disparity and establish the binocular single vision (BSV). The physiological and neurological features of the convergence and divergence vergence systems differ. Moreover, negative fusion reserves are more limited than positive fusion reserves, and stress in the visual system, such as illness and fatigue, has a greater effect on negative fusion reserves (21). Therefore, the effect of glare on negative fusion reserves compared to other binocular vision assessment tests, may be due to the greater sensitivity of the divergence vergence system to changes in the visual system and the stress caused by the glare on the visual system. Fixation disparity is a condition in which the eye axes are not parallel, but this ampltude of deviation is so small that binocular images are located in the Panum's fusional area and people have a BSV, but with ocular symptoms (22). In fact, fixation disparity is an accurate assessment of the binocular vision vergence system and plays an important role in eye fatigue. In a study of 16 normal subjects, glare was examined in two modes of direct and indirect light emission, which changed the fixation disparity to the esophoric state, and this condition was more severe in the direct light mode (13). In other words, glare caused by direct light to the eyes can damage the binocular vision and increase fixation disparity. The results of the present study showed that accurate visual evaluation tests may affect the glare. Therefore, abnormal light conditions such as glare in individuals such as decompensated esophoria with negative fusion amplitude can contribute to worsening of their symptoms.

One of the reasons for the lack of effect of glare on NPC tests, accommodation facility, relative accommodation, and positive fusional amplitude in the present study, may be the age of the participants, all of whom were young in the study. Therefore, the amount of glare created due to the transparency of the ocular media was equal in both eyes; however, age-related opacity and physiological changes in the two eyes differed in previous studies, and this asymmetry impaired binocular vision and stereopsis in the elderly due to glare (23-25). The results of a study by Rajaram and Lakshminarayanan indicated that glare had no effect on binocular vision and stereopsis in young people; however, it increased the noise compared to the no-glare mode. They believed that the effect of glare on stereopsis was more severe in the elderly due to opacity in the eye media (24).

## Limitations

One of the limitations of the present study was the lack of assessment of binocular vision in abnormal light conditions in the elderly. Additionally, the samples were all medical students, which limits the generalization of results to young people to some extent.

## Recommendations

Since opacity in ocular media such as cataract is age-dependent and also the difference between the two eyes in the degree of media opacity may affect the occurrence of ocular symptoms in abnormal light conditions, it is suggested that in future studies, the role of glare be compared in two age groups of youth and the elderly. Due to the low light conditions in everyday life, it is recommended that in future investigations, the effect of reducing light conditions such as mesopic light conditions in binocular vision state be examined.

## Conclusion

The results of the present study suggested that glare light conditions have a negative effect on fusional reserves. Due to the limited amplitude of negative fusional reserves, non-standard workplace lighting can cause symptoms of binocular vision impairment.

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## Authors' Contribution

Monireh Mahjoob: study design and ideation, attracting financial resources for the study, study support, executive, and scientific services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized manuscript evaluation in terms of scientific concepts, approval of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Batool Haghighi: data collection, manuscript preparation, approval of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments.

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## Conflict of Interest

The authors declare no conflict of interest. Dr. Monireh Mahjoob attracted funding for basic studies from Zahedan University of Medical Sciences and has been working as a faculty member of department of optometry at this university since 2006. Batool Haghighi has been working as a faculty member at the School of Rehabilitation Sciences, Zahedan University of Medical Sciences since 2013.

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