Testing the Effects of Multifocal Lenses on Contrast Sensitivity using a Visual Choice Paradigm

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Abstract

Objective: To create a reliable and valid measure of distant edge contrast sensitivity, which can discriminate between participants wearing single and multifocal lens glasses.

Design: This study used a within- subjects repeated measures design to examine the mean differences between 4 lens conditions.

Participants: Four UWM students volunteered to participate in this study. All participants met inclusion criteria and passed visual and balance screening tests.

Methods: A computerized Contrast sensitivity experiment paradigm based on the Melbourne Edge Test was used. This paradigm uses a timed visual choice paradigm in which the participants have to determine which figure is different from the others. Four contrast levels were used to measure visual sensitivity when wearing different lens types.

Main Outcome Measures: Correct versus incorrect responses and response time to select an answer.

Background

Recent research has shown that wearing multifocal lenses increases the risk rate for falling in older adults by affecting the gait performance and comfort level of the wearer. Individuals who wear multifocal lens glasses have decreased distant edge-contrast sensitivity and depth perception (Lord, S. W., Dayhew, J., Howland, A. 2002). It has been shown that multifocal lens glasses (lined bifocal, trifocal, and unlined progressives) cause distortions and/or blurred vision in the bottom portion of the glasses, thus affecting contrast edge sensitivity (Smith, Tomashek, Stalberger, & Rust, 2012). Contrast edge sensitivity is affected by the use of multifocal lens glasses and is one of the strongest risk factors for multiple falls (Lord, R. S., & Dayhew J., 2001). When walking people typically look approximately two steps ahead of them, this is the "critical distance" for detecting environmental hazards (Patla & Vickers, 1997).

References

Lord, S. R., & Dayhew, J. (2001). Visual risk factors for falls in older people. *Journal of American Geriatric Society 49(5),* 508-515.

Lord, S. R., J. Dayhew, & Howland, A. (2002). Multifocal glasses impair edge-contrast sensitivity and depth perception and increase the risk of falls in older people. *Journal of the American Geriatrics Society 50(11),* 1760-1766.

Patla, A.E., & Vickers, J.N. (1997). Where and when do we look as we approach and step over an obstacle in travel path? *Neuroreport*, *97(8),* 3661-3665.

Smith, R. O., Tomashek, D., Stalberger, K., & Rust, K. (2012). Submitted for publication in the *Journal of the American Geriatrics Society*

Methods

All procedures used in this study were approved by the University of Wisconsin-Milwaukee Institutional Review Board.

In the first phase of this study four participants, all UWM students, completed the testing procedure. Each session began with tests of visual acuity, depth perception, ability to see color, and standing balance to determine inclusion eligibility. The test paradigm was projected onto a large screen. Participants stood approximately four feet from the screen with their head stabilized in an apparatus to prevent any extraneous head movements.

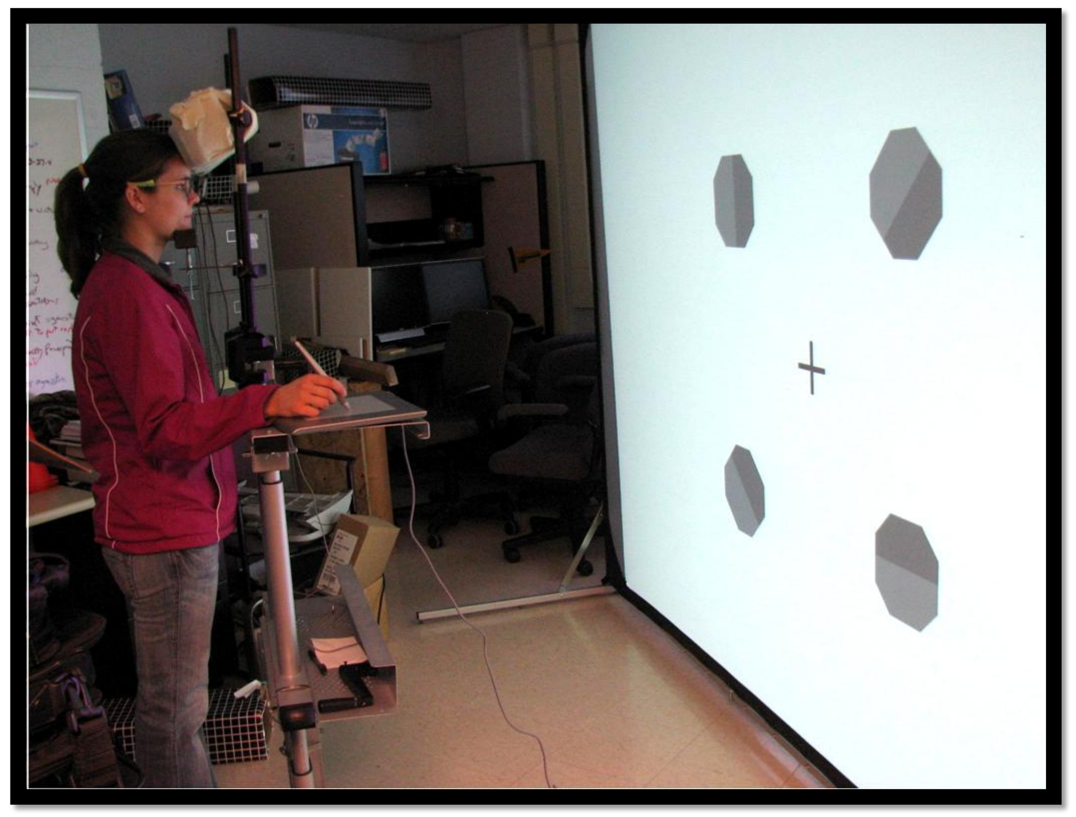

Figure 1: Participant using contrast sensitivity program

The test paradigm is based on the Melbourne Edge Test (MET), which consists of octagonal shapes that have two shades of gray equally dividing the shape; the difference in the two shades is the contrast. The original MET is held in the hand, and test contrast at near distances.

Each slide of the program displayed four octagons, one of which of which is divided in a different orientation. This acted as the target stimulus. Four levels of contrast were used, and were classified from very high to very low.

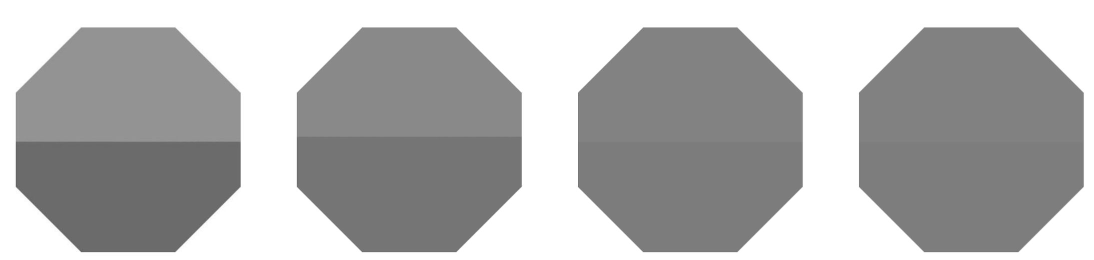

Figure 2: Contrast levels 1-4, from highest to lowest

A stylus with a clicker was used to move the cursor on the screen in conjunction with an electronic mouse pad. The participants were allotted four seconds to make a decision on each slide. If no selection was made their answer was counted as incorrect. Some slides did not have a differing direction of the contrast dividing line; the correct response was an "x" in the middle of the four figures on the screen for this condition.

Four blocks of timed trials were completed with four lens conditions. These conditions included: no glasses, clear lenses, bifocal lenses (+2.75), and progressive lenses (+2.75). A brief break was given to participants between blocks.

Results

Preliminary analyses found a significant difference in the ability to differentiate contrast edge between participants when wearing bifocal lens glasses and the other lens conditions (p<.05).

For further analysis bifocal and progressive lens conditions were grouped together as multifocal lenses and clear and no lens condition were grouped together as non-multifocal lenses. This was done based on performance outcomes and the theoretical premise of the two groups of lens conditions. Additionally, initial analysis found that the 4 contrast conditions grouped into 2 groups, high and low, which were used during analysis. Significant differences (.000) were found between the multifocal and non-multifocal lens groups in response time. There was also a significant difference (.000) between the grouping of the two highest contrast levels and the two lowest contrast levels. The interaction of the two lens type groups and the two contrast level groups approached significance (.056).

Condition	F-Statistic	Significance
Multifocal vs. non-multifocal lenses	19.005	.000*
High vs. low contrast	225.896	.000*
Interaction between lens and contrast	3.668	.056

*=significant at .05

Table 1: Levels of significance for contrast levels

The number of incorrect responses was greatest among the bifocal lens condition. The mean of incorrect responses across lens conditions was .14.

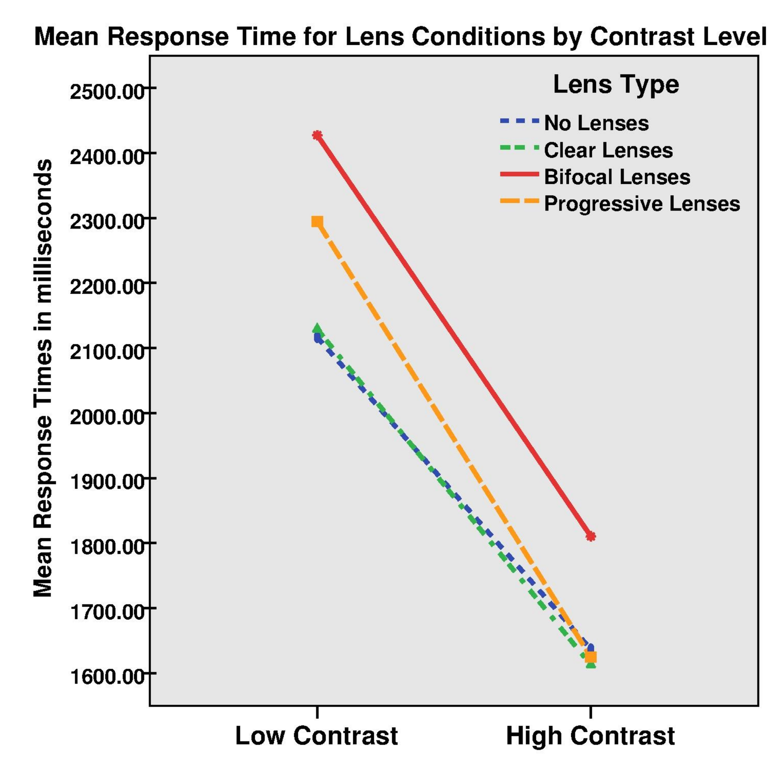

Figure 3: Mean response time for lens conditions by contrast level

	High Contrast (Standard Deviation)	Low Contrast (Standard Deviation)
Multifocal Lenses	1717.65 (432.36)	2361.14 (446.90)
Non-Multifocal Lenses	1624.83 (428.37)	2122.86 (510.40)
Total	1671.24 (432.13)	2242.00 (493.51)

Table 2: Response times by contrast levels and lens types

Response time was greatest when the participants wore multifocal lens glasses in the low contrast condition and was shortest when wearing non-multifocal lenses in the high contrast condition.

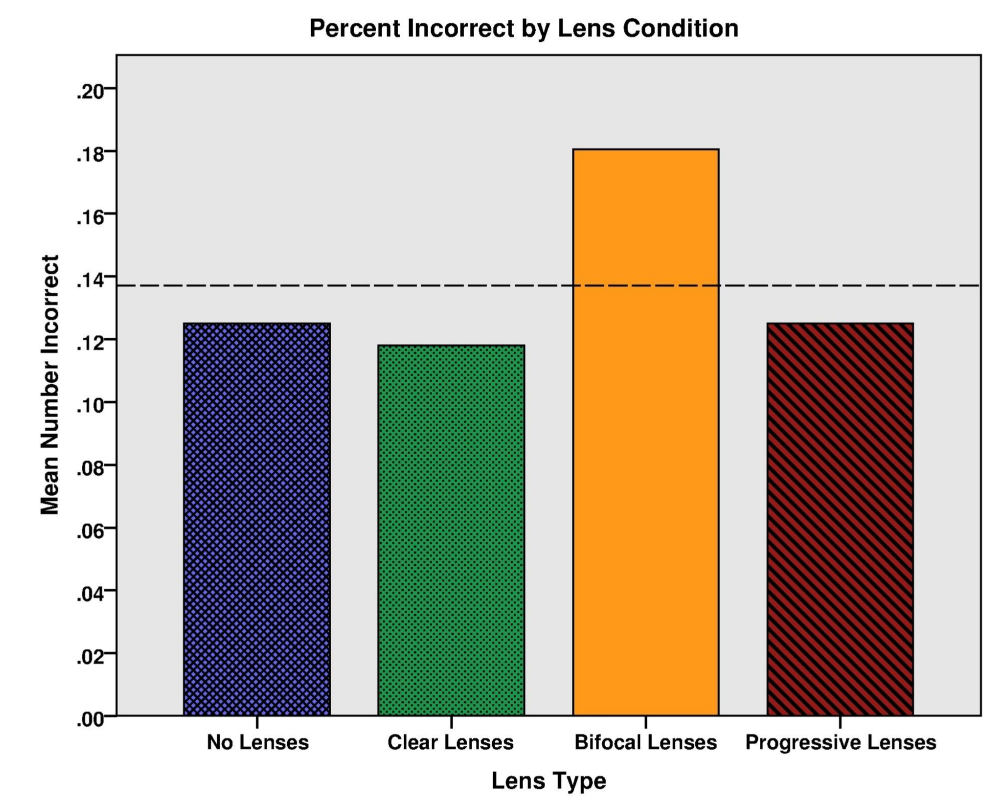

Figure 4: Percent incorrect by lens condition

The number of incorrect responses (70) was also greatest when the lower level contrasts was viewed.

Variable	Low Contrast	High Contrast	Total
Number of Incorrect Responses (Percent)	70 (24.3%)	9 (3.1%)	79 (13.7%)
Number of Correct Responses (Percent)	218 (75.7%)	279 (96.9%)	497 (86.3%)
Total	288	288	576

Table 3: Number of incorrect responses by contrast level

Discussion

The findings of this study revealed that there was a significant difference between multifocal and non-multifocal lens wearers. When participants wore multifocal lenses, response times were greater compared to non-multifocal lenses. This is consistent with previous research that found that multifocal users have decreased edge-contrast sensitivity. Lower contrast figures were more difficult to see as noted by the increased time needed to identify the correct target and the higher error rate.

This study warrants further research to determine if cutpoints can be identified for different lens strengths on the perception of distant edge contrast sensitivity.

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