EVALUATION OF HETEROPHORIA AFTER SUSTAINED NEAR WORK UNDER VARYING ILLUMINANCES

by

Mark Wayne Lantz
Danica Maleine Tea

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Has been approved

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Doctor of Optometry Paper
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ABSTRACT

Background: Since reading and studying are major activities in the life of an optometry student, it would be relevant to explore the mechanism through which reading under different levels of illumination causes fatigue. Heterophoria is the latent deviation of the eyes from the orthovergence, straight-ahead, position. Determining the level of illumination that causes a dissociated heterophoria to increase the least may mean that that specific level of illumination is best to use for reading and decreasing symptoms of asthenopia after prolonged near work. *Methods*: This controlled experiment examined whether eye fatigue after completion of a near task under different levels of illumination caused different increases in the magnitude of a patient's dissociated heterophoria. The amount of heterophoria present in the 30 patients, aged 22 - 35 years, was measured with the modified Thorington phoria test. *Results*: The study demonstrated no consistent or predictable change in a subject's heterophoric posture when reading under varying illuminance levels. *Conclusion*: With the tested subject population, change in heterophoria does not seem to be the mechanism by which asthenopia occurs.

TABLE OF CONTENTS

LIST OF FIGURES

Introduction

It has been demonstrated that poor contrast and quality of a viewed image are associated with increased asthenopia[1,2]. Since low illumination decreases the contrast of printed material, the conventional wisdom that reading in low light levels causes eyestrain has, in a way, proved true. Many of the most common causes of asthenopia during reading are related to binocular vision conditions[3], commonly being associated with certain heterophoric postures of the eyes[4,5]. Heterophoria has been defined as the locus of intersection of the lines of sight, measured with respect to the object of regard, in the absence of a fusional vergence response.[6] While it has been shown that both low illumination levels and heterophoric posture are associated with eye strain, no study to date has demonstrated that change in heterophoria is the mechanism through which low lighting conditions cause asthenopia. Therefore, it is reasonable to evaluate the effect of reading under varying illuminances on heterophoric posture in order to confirm or rule out this as a possible mechanism.

In order to maximize the effects of lighting conditions on heterophoric posture, it was necessary to first define the levels of illumination that will mimic standard, bright and dim lighting conditions for near work. According to Garzia, an appropriate level of illumination for near work tasks is 50 foot-candles.[7] Bright illumination, comparable to the level of illumination needed in a dental work area, at 400 foot-candles was used.[7] Five foot-candles illuminance was set as a dim lighting condition because it imitates darker reading environments such as restaurant dining areas and inactive library stacks.[7]

Measurement of heterophoria in the clinical setting is commonly performed with the modified Thorington test. In our study we have chosen the modified Thorington test because several previous studies[8-12] have demonstrated that it gives the best test-retest results. Howarth and Heron[13] have suggested that the reliability of the modified Thorington test is due to the requirement that the numbered scale must be clearly resolved by the patient, providing a stable accommodative stimulus. Since the experiment involved repeated measurement of the patients' heterophoric postures, a method with the best test-retest results was imperative.

This controlled experiment examined whether completion of a near task under different levels of illumination will cause different increases in the magnitude of a patient's dissociated heterophoria. Since reading and studying are major activities in the lives of optometry students, it is relevant to explore the effect of sustained near work under different levels of illumination and determine if heterophoric posture is a mechanism for eye strain. Determining the level of illumination that causes a dissociated heterophoria to deviate the least may mean that that specific level of illumination is best to use for reading and decreasing symptoms of asthenopia from prolonged near work.

Methods

The experimental study was submitted to the Ferris State University Institutional Review Board's Human Subjects Research Committee and received approval (Appendix A). The patient population for this study was 30 young optometry students who spent a lot of time doing near work and studying. Consent forms were signed by each participant (Appendix B). This age group was selected for their convenient availability and the importance of near work tasks in their activities of daily living. The ages of the students ranged from 22 to 35 years old; the average age being 24.7 years with a standard deviation of +/- 2.66 years. Neither gender was actively sought for this study;

however, 23 of 30 subjects who volunteered were female. Exclusion criteria of the subject pool were the presence of a heterotropia, presbyopia, or amblyopia. The subjects wore their habitual prescription and were corrected with a visual acuity of no worse than 20/40 O.U. and no more than two lines difference between the eyes on the equivalent Snellen acuity chart at near.

The controlled experiment was done in the evening with reading areas that were standardized so that the near work distance and near task was the same for each different level of illumination. For pre-test controls, the patients' heterophorias were measured along with their accommodative lag, vergence ranges and fixation disparity posture. All of the data was collected and recorded by two primary researchers, who also monitored the subjects for adherence to instructions during testing.

There were three different levels of illumination that the subjects performed near work under: 5, 50, and 400 foot-candles. Each of the three trials the subject performed included one of the three levels of illumination determined randomly. The sustained near work was constant for ten minutes and then the heterophoria was measured immediately afterward with the modified Thorington test which required a Saladin card (Bernell, USA), transillluminator, and a Maddox rod. The instructions to the patient were, "please spend the next ten minutes concentrating on this task. Since the level of light is critical in this experiment, do not shade the page. Keep going until we call time, and then you will have a five minute break to rest your eyes before starting the next trial. Try your best at finishing, but how well you do is not a factor in this study, it is just necessary for you to concentrate on the task."

Subjects were allowed to choose between bringing their own reading material or completing word searches. Requirements for both tasks were black text on white paper of font no larger than 12 point. During the five minute rest, the subject simply sat still with his or her eyes closed. After the rest, the starting heterophoria was rechecked immediately before the next trial. At the conclusion of the three trials, the subject was asked whether they felt any of these asthenopic symptoms: strain, pulling, fatigue, blur, headache, burning, pain, heaviness, dryness, double vision, tearing, itching, foreign body sensation, lid spasming, photophobia, or different color sensations.

Results

All 30 subjects completed the entire study. The range of the subjects' ages was from 22 to 35 years old, with a mean age of 24.7 years (σ = +/- 2.66 years). Twenty-three of the thirty subjects were female. The refractive errors of the subjects ranged from -11.25 diopters to +5.75 diopters with a median refractive error of -2.75 diopters. The results from the three stations were compared for the effects of each illumination level on the subjects' heterophoria measurements. Post-trial heterophoria measurements were referenced to initial measurements and evaluated statistically using the JMP 5.0 statistical software program by SAS. The range of initial near phoria measurements was 15 prism-diopters esophoria to 18 prism-diopters exophoria with a mean of 2.23 prism-diopters exophoria (S.E.M. = +/- 0.974). Figures 1 through 4 illustrate the distribution of initial phoria measurements, and change in phoric posture after each station.

The range of changes in prism-diopters after exposure to 5 foot-candles was from 4 prism-diopters more exophoric to 6 prism-diopters more esophoric, and the mean change was 0.537 prism-diopters ($p>t=0.354$ and $p<t=0.646$). At the

Figure 1. Distribution of Initial Phorias

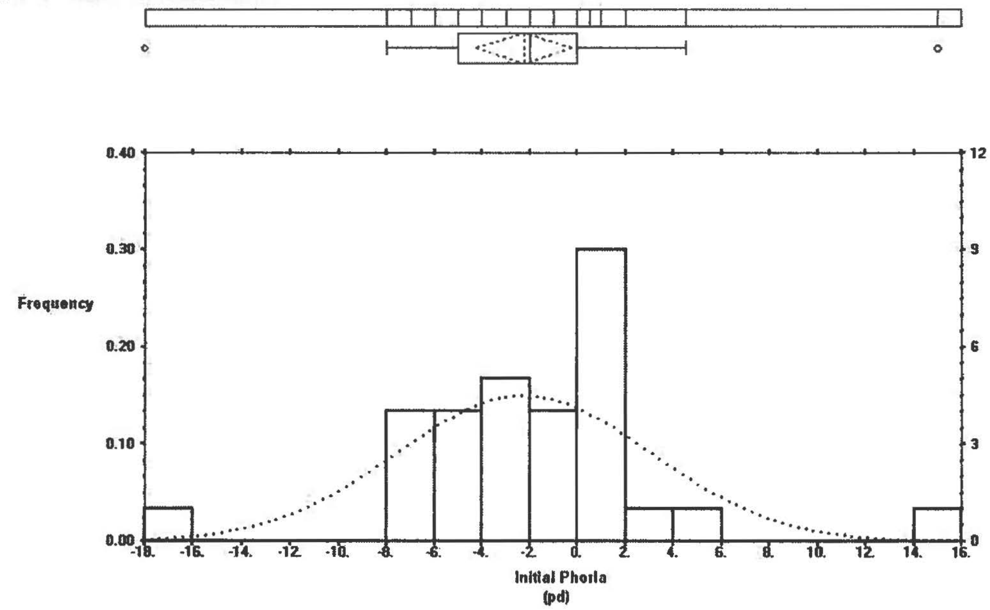


Figure 2. Distribution of the Change in Phoria After 5 foot-candles Illumination

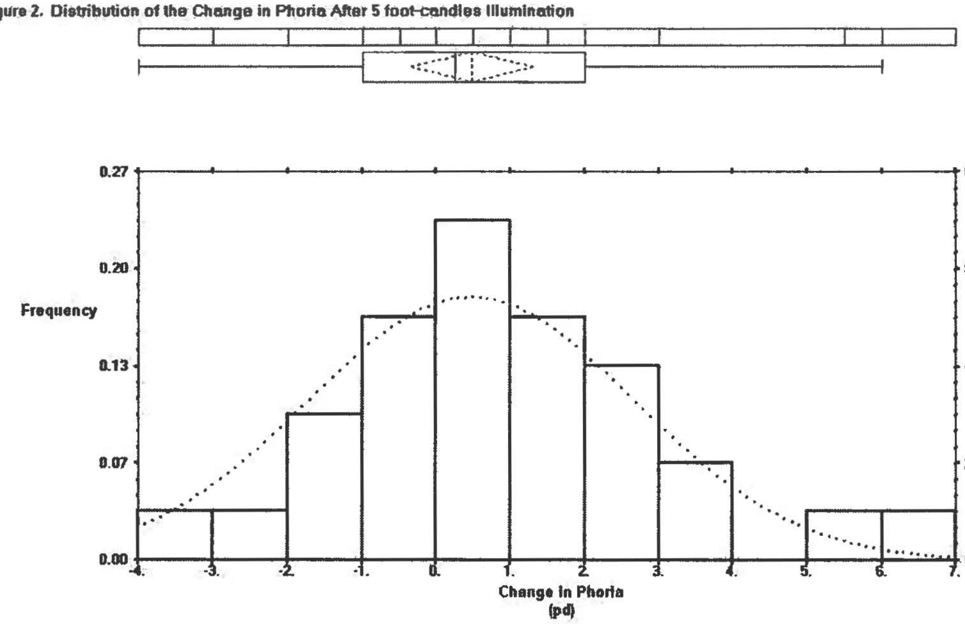


Figure 3. Distribution of the Change in Phoria After 50 foot-candles Illumination

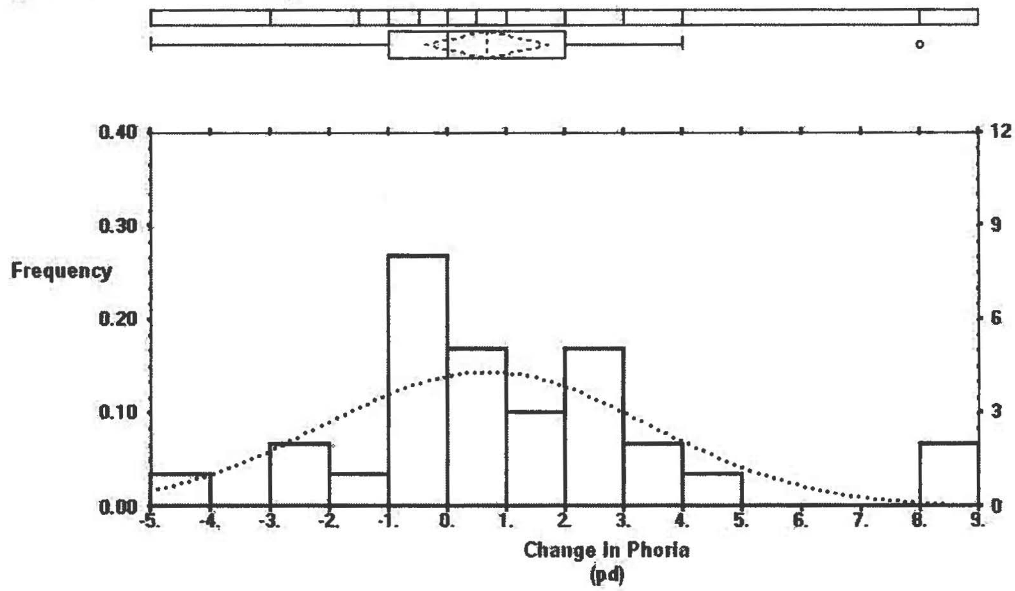
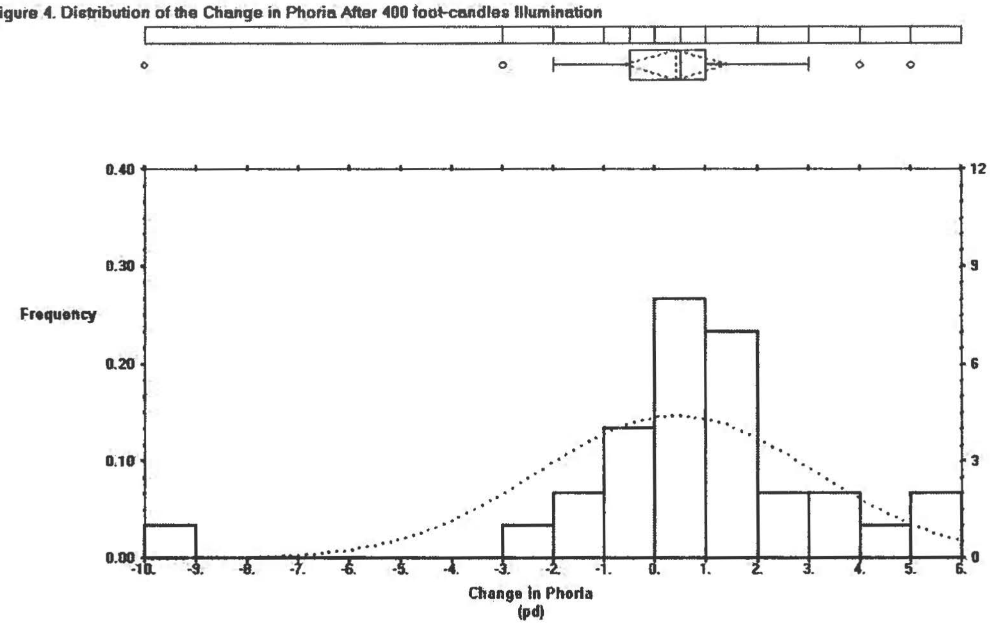


Figure 4. Distribution of the Change in Phoria After 400 foot-candles Illumination



station with 50 foot-candles, the range of changes was 5 prism-diopters more exophoric to 8 prism-diopters more esophoric, and the mean change was 0.733 prism-diopters ($p>t=0.270$ and $p<t=0.730$). At the 400 foot-candle station, the range was 10 prism-diopters more exophoric to 5 prism-diopters more esophoric, with a mean change of 0.489 prism-diopters ($p>t=0.069$ and $p<t=0.931$).

The changes in subjects' heterophoria measurements after stations with illuminances of 5, 50, and 400 foot-candles with respect to initial measurements are displayed in figures 5, 6, and 7, respectively. For the station with an illuminance of 5 foot-candles, the standard error was 0.485 and the mean difference (MD) was 0.183 prism-diopters esophoria. Secondly, the comparison done at the station with 50 foot-candles illuminance resulted in a standard error of 0.485 and a mean difference of 0.300 prism-diopters esophoria. Finally, the station with an illuminance of 400 foot-candles produced a standard error of 0.448 and a mean difference of 0.683 prism-diopters esophoria.

Discussion

Statistical analysis of the data collected clearly shows that no significant relationship was demonstrated

Figure 5. Average of Change in Phoria after 5 foot-candles Illumination vs. Change in Phoria

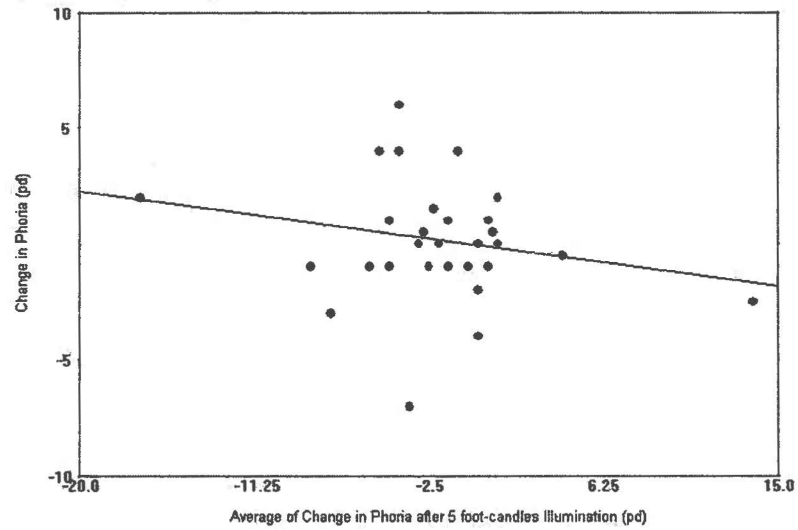


Figure 6. Average of Change in Phoria after 50 foot-candles Illumination vs. Change in Phoria

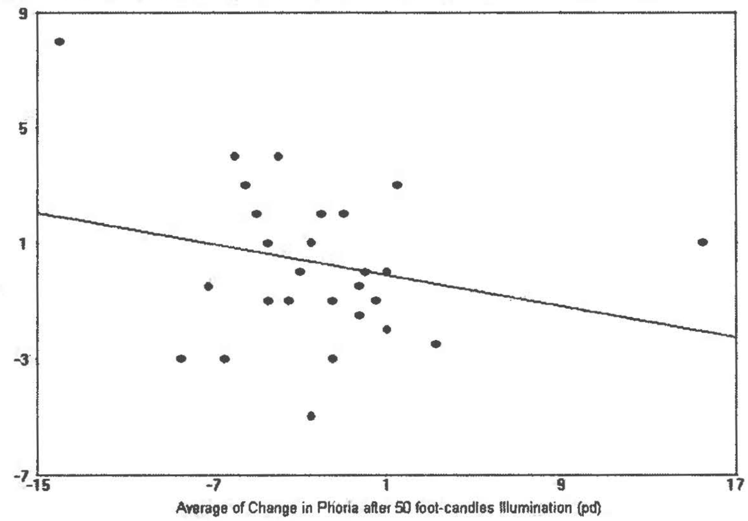
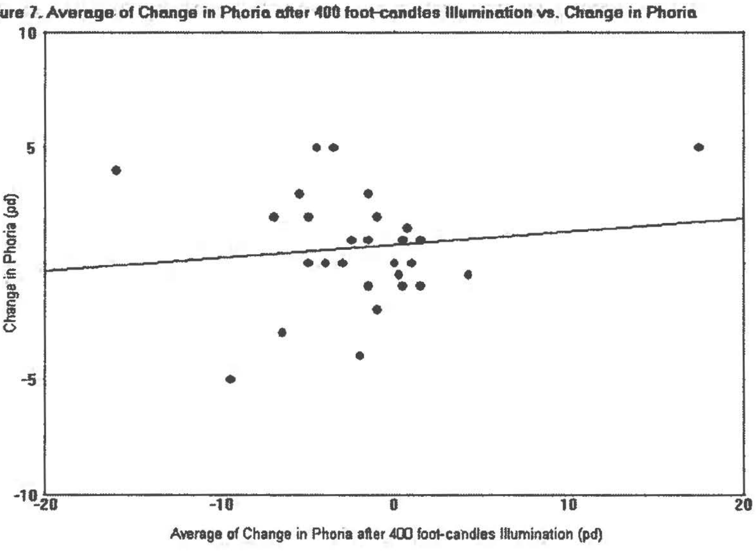


Figure 7. Average of Change in Phoria after 400 foot-candles Illumination vs. Change in Phoria



between illumination and change in heterophoria after sustained near work. While each station produced a mean change in phoric posture in the eso direction, the magnitude of all three mean deviations was so small as to be considered clinically insignificant and within the measurement error limit of the Modified Thorington test.

While the mean change in heterophoria for each station was negligible, 4 of the 30 subjects tested displayed significant changes in posture during testing. While no trend in direction of these four subjects' heterophoria measurements was displayed, the magnitudes of changes in posture during testing for these four were much greater than for the other twenty-six subjects. Interestingly, the common characteristic these four subjects shared was having the four greatest magnitudes of entering exophoric postures at 18, 8, 7 and 7 prism-diopters. It is notable that the most exophoric subjects showed postures that were more greatly affected by environmental stresses, and it could be hypothesized that highly exophoric binocular vision systems are somehow more susceptible to fluctuations. This finding may warrant investigation with further studies.

Factors that may have influenced the validity of the results of the experiment included relying on full subject cooperation. The subjects needed to concentrate completely on the near work task, with little ability to monitor attention. The experimental data also relied on patient feedback for measurement of phoric posture during the modified Thorington test. Other variables such as subject fatigue and variable lighting were controlled for with randomization of stations and standardized station setup.

Several possible deductions could be drawn from the results of this experiment. Based on the results reported, it is likely that performing near work under varying illuminances results in no predictable changes in heterophoric postures. Therefore, changes in heterophoric posture would not likely be the mechanism by which reading under specific lighting conditions causes asthenopia. Another deduction that may be taken from the results is that the group studied in this experiment was not representative of the general population, therefore this experiment's results cannot be extrapolated to people with other characteristics. The group that participated in this study was composed predominantly of young, myopic females, so the results are more accurate for this select population. A more balanced population may be called for in subsequent studies.

Conclusion

With the tested subject population, change in heterophoria does not seem to be the mechanism by which asthenopia occurs under dim lighting conditions. These results are most accurate for a population dominated by females that are young and myopic, such as the subjects tested in this study; therefore, the findings may not be accurate when applied to other more diverse population groups with varying refractive errors, age ranges and gender makeups. For patients with known difficulties related to heterophoria and near work, clinicians will not be able to make recommendations for optimal lighting conditions based on the results of this study because no significant relationship was found between illuminance levels and heterophoric posture. Clinicians may continue to recommend adequate lighting conditions to the general patient population, based on previous research associating poor illuminance levels with asthenopia.

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APPENDIX A

HUMAN SUBJECTS RESEARCH COMMITTEE APPROVAL

FERRIS

Connie Meinholdt, Ph.D.
Psychology Program
820 Campus Drive
Ferris State University
Big Rapids. MI 49307
(231) 591-2759

To: Dr. Michael Cron, Mr. Mark Lantz & Ms. Danica Tea
From: C. Meinholdt, HSRC Chair
Re: HSRC Applications #070208 (Title: Evaluation of heterophoria after sustained near work under varying illuminances)
Date: February 28th, 2007

The Ferris State University Human Subjects Research Committee (HSRC) has reviewed your application for using human subjects in the study, "Evaluation of heterophoria after sustained near work under varying illuminances" (#070208) and approved it under the category of *expedited - 2D*.

Your application has been assigned a project number (#070208) which you may wish to refer to in future applications involving the same research procedure. Project approvals receive an expiration date one year from the date of approval. As such, you may collect data according to procedures in your applications until March 1st, 2008; you must apply for a renewal if data collection continues beyond this date. Finally, it is your obligation to inform the HSRC committee of any changes in your research protocol that would substantially alter the methods and procedures reviewed and approved by the HSRC in this application.

Best wishes for a successful research endeavor and please let me know if I can be of future assistance.

APPENDIX B

SUBJECT CONSENT FORM

Ferris State University: Michigan College of Optometry
1310 Cramer Circle, Big Rapids, MI 49307-2394

March 2007

Dear Prospective Participant:

We are interns at the Michigan College of Optometry at Ferris State University and are conducting a research project. This letter is designed to inform you of the experiment we are undertaking and the procedures involved in your participation.

The goal of this study is to investigate any possible effects of various lighting conditions on the posture of the eyes after concentrating on near work. Your participation in this experiment will take approximately 55 minutes. The procedure used to measure the posture of the eyes, along with the pre-testing procedures we wish to utilize, is non-invasive and routinely performed in optometric examinations. Your privacy will be protected to the maximum extent allowable by law. We will issue you a random number during the tests to identify the results. No association between your name and number will be made because no names will be mentioned in the final report.

The purpose of this research is to determine which lighting condition results in the smallest amount of change in the posture of the eyes. This would inform individuals of the type of light to use that fatigues the eyes the least. We hope that the results of this experiment would benefit optometry because a great amount of reading and other near work is done in the general population, and even more so in the college student population. This information would allow people to perform near work without much eye strain so that they could read longer and more comfortably.

Please sign below if you wish to participate in this study. Your participation is completely voluntary and you may discontinue at any point during this study. Any questions or concerns about this project may be directed to Dr. Michael Cron at 231-591-2171.

Thank you for your time and consideration.

Sincerely,

Mark Lantz	Danica Tea	Michael T. Cron, O.D.
Optometry Intern	Optometry Intern	Faculty Advisor

I, ______________________________, wish to participate in this vision research project.
(print name)

Signature: ______________________________ Date: ____________________

Concerns about the conduct of this research may be directed to the Chair of FSU's Human Subjects Review Committee, Dr. Connie Meinholdt, at 231-591-2759.