Ferris State University
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EFFECT OF REDUCED VISUAL ABILITY ON THE IDENTIFICATION OF OCULAR DISEASE

by

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and
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This paper is submitted in partial fulfillment of the requirements for the degree of

Doctor of Optometry

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Has been approved

April, 2012

APPROVED: , Faculty Advisor

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ABSTRACT

Background: This study investigated the effects that reduced visual acuity and contrast sensitivity have on the ability to discriminate subtle and distinct diseases of the eye, namely retinal diseases. By understanding the limitations of visual impairment in the optometric community, we hope our findings can be applied to the determination of a base criterion for entrance into optometric programs, which is either non-existent or arbitrary at present.

Methods: The healthy vision of optometry students, who have the educational knowledge to discriminate the subtleties of the retina, was uniformly blurred to uncover limitations in their abilities to detect retinal disease at varying levels of visual impairment.

Results: There was little difference between the subjects ability to discriminate without blur and with blurring goggles #1 (least reduced acuity), but borderline significance with goggles #3 (most reduced acuity) and a significant difference found with goggles #2.

Conclusions: This demonstrates that drastically reduced acuity and contrast has an impact on detecting abnormal posterior segment images from normal posterior segment photos, this was most apparent in the more mild disease processes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Is it possible for a student to enter and succeed in the optometric field with reduced visual abilities? Since there are no known quantitative studies, this research team wanted to investigate the effects, challenges, and potential limitations that various levels of reduced vision might pose on an optometric student or doctor of optometry. In examining this question, we acknowledge that many political, educational and individual biases exist as to the potential competence of doctors of optometry or ophthalmology with reduced visual function. An example of one such stereotype is that a student with amblyopia or strabismus who cannot discriminate depth will struggle to learn retinal examination, in which the appreciation of depth is viewed as an important but not essential skill. The balance between the potential for motivated students with visual impairment to become proficient despite vision loss and the fiduciary need to protect the public is a difficult one not currently supported by research.

The entrance standards adopted by all the optometry colleges and schools for visual ability are based on the ASCO functional guidelines. These are a specific set of criteria that all students applying to these institutions agree they are able to achieve, however they are not quantitative in nature, only qualtitive. This makes questionable cases difficult to judge, forcing admission committees to decide if the student, meeting all other requirements, is capable of success in their program. Most of the optometry schools follow only these guidelines and must use their discretion on admission of these students. With more quantitative research from studies like this one, the approach toward the decision making process could be much more methodical and fair. Increased depth of research is required before an overhaul of these guidelines can or should occur.

The world health organization estimates that approximately 11 million are visually impaired worldwide, defined as those with acuity of 20/70 or less in the better eye.1,2 Since 1999, Vision 2020-the Right to Sight has been working to reduce the number of people with avoidable vision loss, with cataracts and uncorrected refractive error topping the list of causes.1,3 Among disease processes, glaucoma, age-related macular degeneration (ARMD), trachoma, and diabetes are major causes of vision loss.3 ARMD is the leading cause of severe and irreversible loss in the world and US.4,5 The prevalence of vision impairment in the US, Cuba and Canada is ~0.4% of people over 50 years old, but the rate is much higher in Latin and South America varying from 1.3% to 2.6% for the same group.1,2 Although this data is pertinent on a global scale, it is not representative of the population that applies to optometry or medical school.

At present, there have been limited studies that quantify the effects of visual impairment on image quality (both VA and contrast reduction),4,6,7 and none to our knowledge as it relates to the ability to practice optometry or ophthalmology, although there are limited studies that actively mimic visual impairment in young and healthy subjects.8 Many more studies focus on utilizing patients that are visually impaired from diseases like Diabetic Retinopathy, ARMD and hereditary diseases; since each individual has a slightly different manifestation of vision loss, these studies are not ideal for direct comparison, but are the best we have currently.9

The major causes of visual impairment in children, and therefore the young adults that are applying to graduate school, are hereditary retinal conditions, nystagmus, and maculopathies, more specifically with Stargardts disease and ocular albinism accounting for the largest percentages globally.9 Of the 270 children in one study, nearly 85% were able to see 20/60 or better at distance and 1 M or better at near with the help of low vision devices.9 There are four areas of challenge to this group: communication, mobility, daily living activities, and sustained near vision tasks.9 In another study, daily challenges include facial recognition, reading, and space perception.10 Students who enter optometry school with less than optimal BVA would need to acquire adaptive ways to learn the material.10 When so much of optometrists' diagnostic skills rely on sight, low vision aids could be used to assist in this process but the extent of help from the visual aides may be restricted by the limitations or mechanics of certain optometric or ophthalmic procedures. For instance, fundus photos could be taken and a computer screen could offer increased magnification to view the photo, but the larger size may be offset by the lack of stereovision and reduced contrast suffered by the student or doctor.

Additional factors to consider when determining the visual criteria for admitting a student are the psychological and stress-related aspects that come with any graduate level work. ARMD is probably the best known ocular disease to demonstrate a reduced quality of life from visual impairment, but others surely reduce quality of life as well.4 Post cataract surgery, patients have also shown increased psychological anxiety and depression after lens extraction, especially if expectations of the outcome were unrealistic.[11] A study about anxiety and depression relating to retinal detachments before and after surgery, demonstrated that a high number of patients (59%) remain anxious even 12 months after surgery was performed, even when their acuity returned to near normal levels in the affected eye.[11] Their anxiety stemmed from fear of the same event occurring in the fellow eye. However, their levels of depression were shown to decrease during the same time frame.[11] Moreover, it has been shown through studying age-related vision losses, that the person's level of adaptation modifies the relationship between physical VA loss and level of impairment. Greater perceived functional loss may lead to increased impairment compared to someone with the same level of acuity and better perceived functioning.[12] Although this is not typically the population pursuing advanced degrees, it does offer some insight. In the highly visual environment of ocular examination, a student may perceive greater vision loss and therefore manifest greater functional visual impairment than their acuity would suggest.

BACKGROUND

Two important measurements of reduced visual function that may relate to quality of life are binocular visual acuity and binocular contrast sensitivity. Both were utilized in this study.[13] When testing our subjects, we performed these two tests on each subject simulating different levels of acuity to help us understand their limitations as well as ascertain data to kick start contemporary research. Contrast was measured because it best correlates to activities of daily living and we believed it would be a big factor in the retinal diagnostic performance of optometric students.[4]

In amblyopic vision loss, it has been shown that the magnocellular pathways are affected along with the parvocellular pathways in the eye with the reduced VA. These deficits are manifested in contrast sensitivity reduction. 14

METHODS

Subjects, having signed a consent form and assigned a number, had the ability to discontinue the study at anytime. Visual acuity was recorded with the subjects wearing their best refractive correction (spectacles or contact lenses) using a logMAR chart at 3m. Contrast sensitivity, also measured at 3m with a Vistech contrast chart, provided data for 5 spatial frequencies and was recorded on the subject's data collection form (see Appendix B for sample).

The subject was given a pre-test before wearing the binocular blurring spectacles consisting of a series of 10 photographs, shown one at a time in a well lit room, and asked to identify whether the posterior segment photograph represented a healthy posterior segment or had ocular disease present. Naming the disease was prohibited. There were four sets of ten photos, each containing five healthy and five diseased photos, including but not limited to moderate to severe diabetic retinopathy, age-related macular degeneration, retinal hole or tear, Stargardt disease, epiretinal membrane, etc. (See Appendix A for a few sample photographs). The five diseased photos in each set varied approximately equally as to how ostensible the disease was, with all sets containing both subtle and more readily observed defects.

The subject then wore the blurring spectacles marked # 1, which uniformly reduced contrast sensitivity and visual acuity throughout their visual field. Visual acuity was again measured with a logMAR chart and contrast sensitivity with a Vistech chart. This was completed to correlate our findings to various levels of visual impairment. The spectacles were worn over the subject's optimal refractive correction. The subject was again shown a different series of 10 retinal photographs and asked whether they believed the image displayed a diseased or healthy posterior segment image.

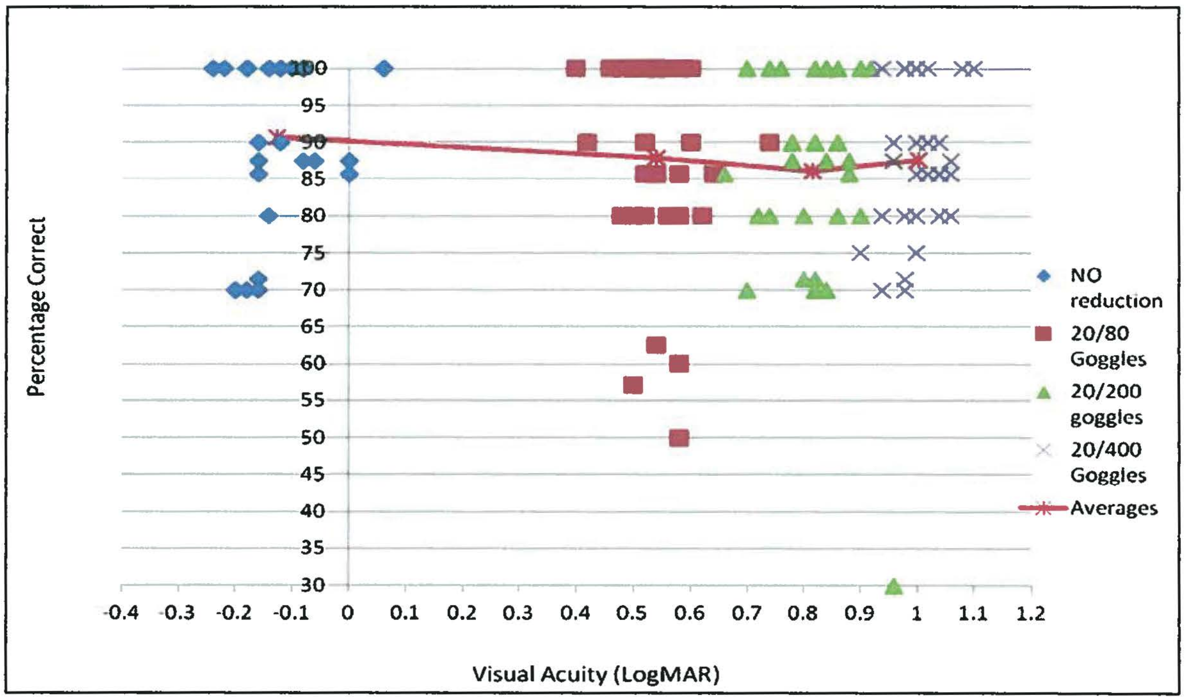
Blurring spectacles #1 were removed and the above process was repeated 2 more times with blurring spectacles #2 and #3, each time utilizing a new set of ten photographs. Each set of photographs was rotated in order (First subject saw set A without blur, set B with #1 goggles, set C with #2 goggles and Set D with #3 goggles and the next subject saw B first, then C, then D, then A, and so on) to reduce the effect of data skew from photos believed to be more ambiguous. The blurring goggles 1, 2, and 3 were manufactured to have a uniform reduced visual acuity of 20/80, 20/200 and 20/400 respectively. There is no published data on the level of contrast the each pair of goggles represent. The data was analyzed using Microsoft Excel and Open Office software.

RESULTS

Of the 34 data sets, 32 provided useful information. Five pictures out of 40 were not included with the analyzed data because artifacts in the printed images made them too ambiguous, causing our subjects to answer only slightly better than chance would predict. The remaining images were correctly answered no less than 71% of the time. The average percentage correct without blurring glasses was

90.71%, with the #1 blurring goggles 87.89% accuracy was achieved, 86.15% with the #2 goggles, and 87.66% with the #3 goggles. A z-value of 0.08474 between the #1 and no blur set shows that the decrease in accuracy is likely due to the change in VA, but not within accepted statistical limits to rule out variation as cause of this decrease. A z-value of 0.06839 between the #3 and no blur set shows a borderline statistical significance, and a z value of 0.01318 between the #2 set and no blur set shows a significant loss in accuracy to a 95% confidence level.

Figure 1. Correlation between visual acuity and percentage correctly identified



The scatter plot in Figure 1 shows the slight positive correlation between the achievable visual acuity and the percent correct. However, many of those with high amounts of blur still scored very well.

Figure 2. Measured contrast sensitivity of goggles

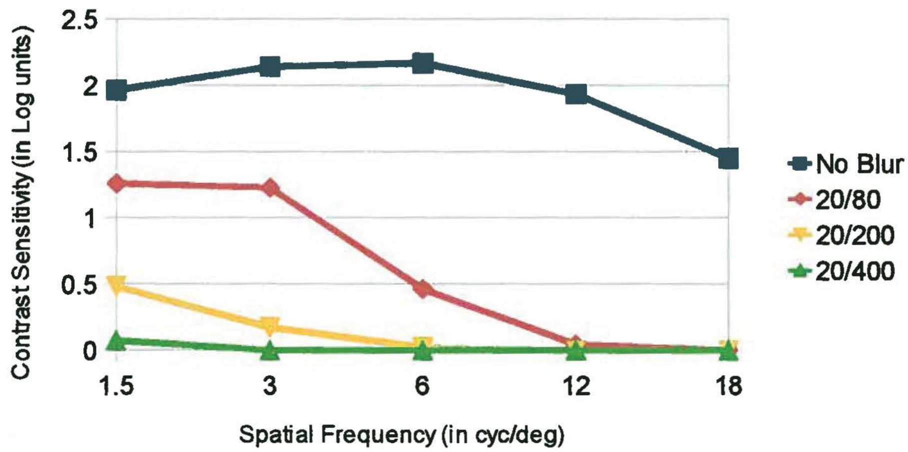


Figure 2 demonstrates the drop in contrast sensitivity with increased blur. Our best corrected set closely mimics that of other sources for normal contrast abilities in a healthy population. While wearing the #1 blurring spectacles (labeled as "20/80" in the graph), the characteristic drop in high spatial frequencies compared to low spatial frequencies is demonstrated as we predicted, but we did not anticipate the #2 or #3 goggles (labeled "20/200" and "20/400" respectively) to have such a pronounced reduction of contrast sensitivity even at the lower spatial frequencies. Each with 3 values being zero, the exact amount contrast reduction for #2 and #3 was outside the measureable range of the Vistech chart since the chart is designed to test contrast threshold and not drastically reduced sensitivity. It is likely the subjects have some contrast ability, but with the upper limit of chart was too low to detect what little sensitivity remained.

The goggles we used were labeled with VA reduction estimates by their manufacturer. It is interesting to note that our average VA levels for the goggles did not confirm the estimated level of acuity reduction. The measured Snellen equivalents of our four categories (no blur, goggles 1, goggles 2, and goggles 3) are 20/15, 20/69, 20/130, and 20/200 respectively. The labeled acuities were 20/80, 20/200, and 20/400.

Table 1. Measured values with goggles with standard deviation

	Average Contrast sensitivity (@ 6 cycles per degree) (Log 10)	Average Visual acuity (LogMAR)	Average % correct
No blur	2.17 +-0.14	-0.12 +-0.077	90.71 +-13.82
Goggles 1	0.46 +-0.43	0.54 +-0.066	87.89 +-13.94
Goggles 2	0.20 +-0.12	0.82 +-0.069	86.15 +-14.49
Goggles 3	0.00 +-0.00	1.00 +-0.043	87.66 +-9.83

DISCUSSION

Potential ways to improve the study include using dilated patients instead of retinal photographs, or the use of stereoscopic images. Since the subjects were looking at a 2-dimensional retina, limitations exist on how students judge various pathologies. This was problematic with our healthy eye photos, since the internal limiting membrane sheen often looked like a retinal pseudo-hole with surrounding epiretinal membrane. Incorporating the examination of dilated patients would provide further study results on the difficulties students may encounter in performing optometric procedures with visual impairments. The order by which subjects started with the blurring glasses or with best corrected vision may have affected the results due to a learning effect in examining the photographs.

Although we intended to measure an acuity drop of over 1.3 LogMAR, the experimental range of the results was actually only 1.12 LogMAR. The 20/400 and 20/200 labeled goggles only reduced acuity to approximately half of what was expected. Our data, therefore, may have been less conclusive due to the reduced experimental range of acuities.

As far as the judging the gross posterior segment pathology, the subjects performed very well regardless of their level of blur. This may be in part due to the recognition of unusual colors in the fundus. Since our subjects likely had normal or near normal color vision, they do not suffer from the characteristic reduction in ability to discriminate colors as seen with actual visually impaired patients, aside from the reduction from contrast sensitivity loss. In future studies, color vision data could also be collected. Images with more subtle retinal changes gave the subjects difficulty even without the blurring glasses and were missed more often with the blurring glasses, but not as much as anticipated. Overall the subjects performed well even with greatly impaired acuity and contrast sensitivity. The downward trend of visual acuity and contrast sensitivity as it correlated to accurately identifying pathology was not as great as was originally expected.

The results of our study do not show a definitive level of contrast or acuity that makes it significantly more difficult to recognize retinal disease. A larger subject pool with greater variance in levels of blur may provide improved results and possibly a point that shows significant and sustained decrease in interpretation of the photographs.

CONCLUSION

With increased occupationally-related visual demands, identifying limitations is the first step to overcoming them. We hope this study will help guide admission committees who currently rely on personal biases to determine what they feel a student can do or qualitative guidelines that are difficult to interpret in borderline cases, rather than what can be actually be achieved. We also do not believe this study should be the sole deciding factor in a student's acceptance or denial of acceptance into an optometric program, since it appears that acuity and contrast sensitivity are not exclusive contributors to successful identification of ocular pathology.

Although identifying ocular pathology is one of the most visually demanding activities an optometrist performs, other visual challenges must also be considered. Optometrists must be able to meet a variety of potentially challenging visual tasks from measuring pupils to the half millimeter and inserting tiny punctal plugs, to utilizing measuring devices such as lensometers, radiuscopes, and keratometers and reading textbooks, ebooks or notes. Various adaptive solutions may require utilization in order to be successful as an optometrist while suffering from vision reduction. Additional studies are certainly needed to determine an empirical admissions criterion, in addition to consideration of the adaptations and motivation of the candidate.

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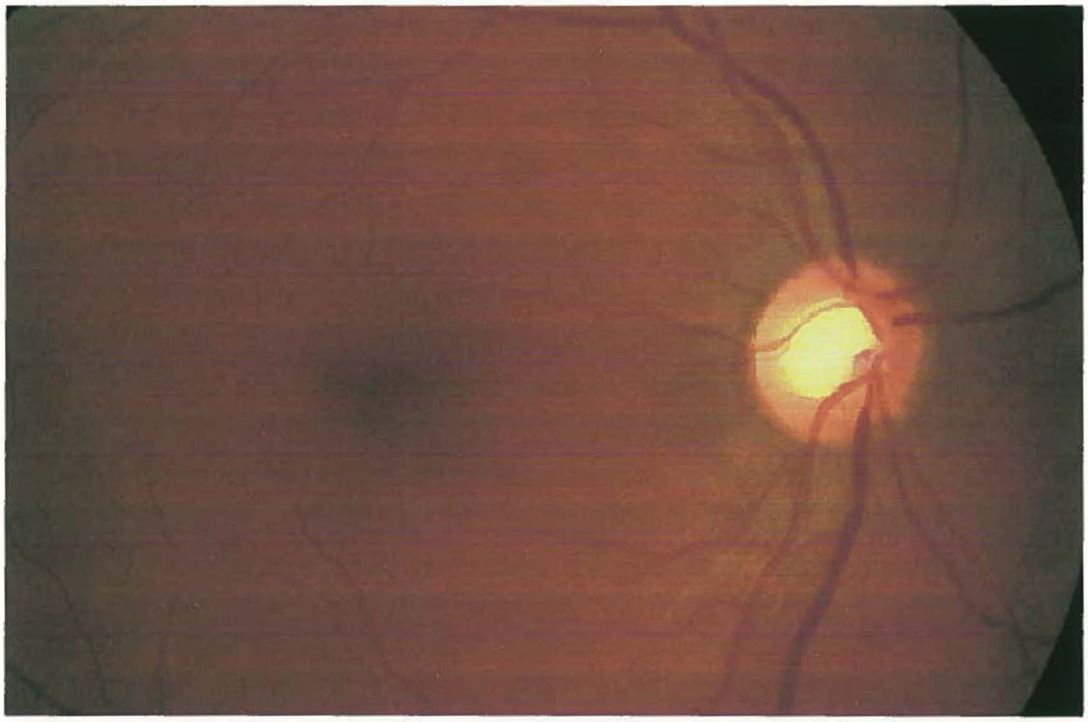
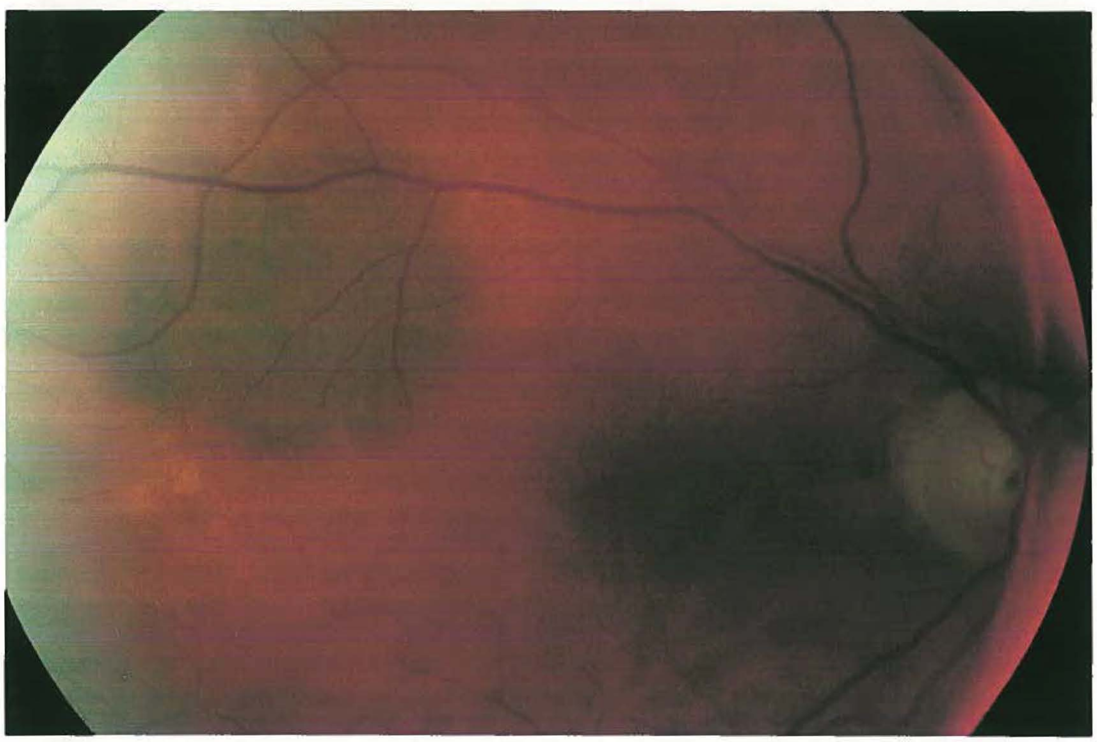
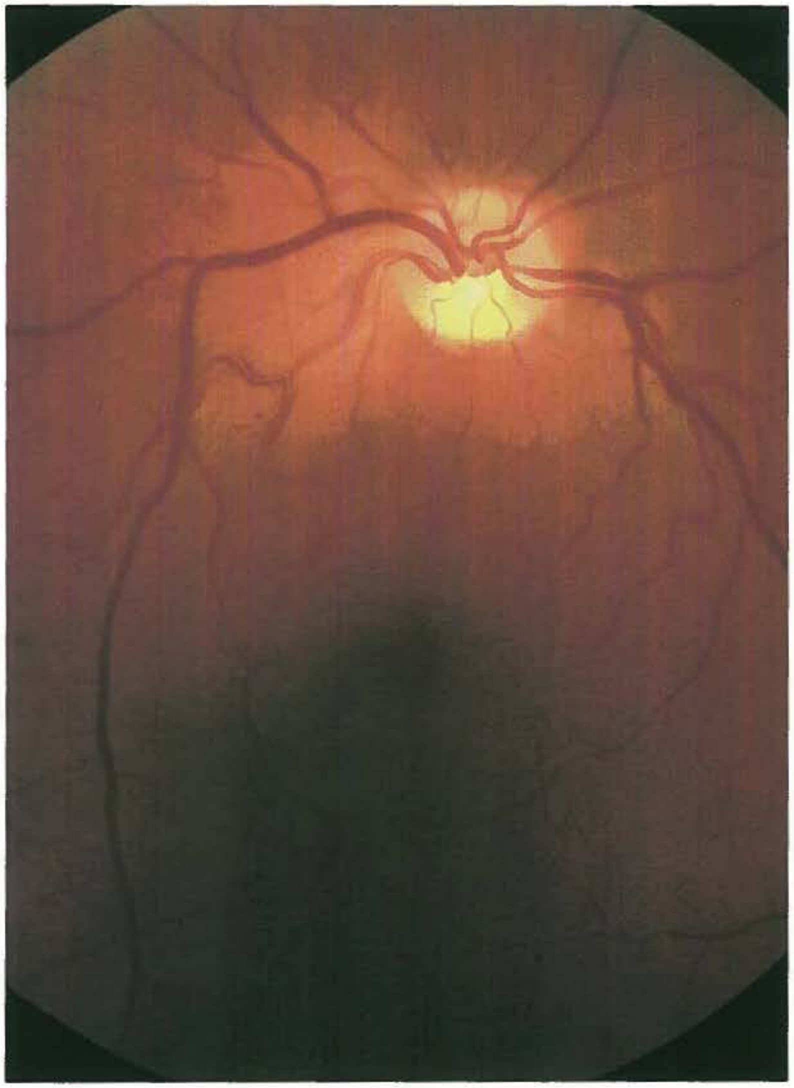
APPENDIX A

Sample Photographs







APPENDIX B

Data Collection Form

Subject number: ______

Write "D" if the image contains a diseased posterior segment and "H" if it is healthy posterior segment.

Pre-Test VA OU: ____ Contrast Sensitivity: A _____ B_____ C_____ D_____ E _____

Photo 1: ________ Photo 2: ________ Photo 3: ________ Photo 4: ________

Photo 5: ________ Photo 6: ________ Photo 7: ________ Photo 8: ________

Photo 9: ________ Photo 10: ________

Blurred Glasses #1

VA OU: ______ Contrast Sensitivity: A _____ B_____ C_____ D_____ E _____

Photo 1: ________ Photo 2: ________ Photo 3: ________ Photo 4: ________

Photo 5: ________ Photo 6: ________ Photo 7: ________ Photo 8: ________

Photo 9: ________ Photo 10: ________

Blurred Glasses #2

VA OU: ______ Contrast Sensitivity: A _____ B_____ C_____ D_____ E _____

Photo 1: ________ Photo 2: ________ Photo 3: ________ Photo 4: ________

Photo 5: ________ Photo 6: ________ Photo 7: ________ Photo 8: ________

Photo 9: ________ Photo 10: ________

Blurred Glasses #3

VA OU: ______ Contrast Sensitivity: A _____ B_____ C_____ D_____ E _____

Photo 1: ________ Photo 2: ________ Photo 3: ________ Photo 4: ________

Photo 5: ________ Photo 6: ________ Photo 7: ________ Photo 8: ________

Photo 9: ________ Photo 10: ________