5-1995

A comparison of monocular and binocular refractive results in prepresbyopes

Brenda Stephens Offerdahl
Pacific University

Kimberly Rosenthal Tinge
Pacific University

A comparison of monocular and binocular refractive results in prepresbyopes

Abstract

There have been several reports in the literature documenting various methods of binocular refractions and how they compare to traditional refractive methods. However, no studies have been published in which the subjects were allowed to compare the two prescriptions subjectively. A total of eighty-one subjects was assessed. Each was given two refractions: a traditional one and a binocular one utilizing the AO Vectographic Slide. Forty-nine of these subjects had significant differences in the prescriptions and of these, fifteen chose to participate in a wearing trial using both of the prescriptions. The percentage of eyes showing more than a 0.25D change was 20% in spherical power, 22% in cylindrical power, and 27% in equivalent spherical power. Nine percent of eyes showed an axis shift equivalent to a 0.25D induced change in power. Eight percent of subjects had a change in anisometropia based on the equivalent sphere and 19% of subjects required a vertical prism on the binocular refraction. In the clinical trial, 42% preferred the binocular prescription, 28% preferred the traditional prescription, and 28% liked both prescriptions equally.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Hannu Laukkanen

Keywords

refraction, binocular, vectographic slide, autorefractor

Subject Categories

Optometry

A COMPARISON OF MONOCULAR AND BINOCULAR REFRACTIVE RESULTS IN PREPRESBYOPES

By

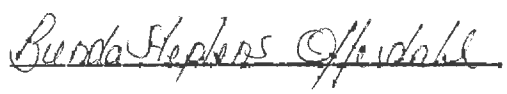
BRENDA STEPHENS OFFERDAHL
KIMBERLY ROSENTHAL TINGE

A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May, 1995

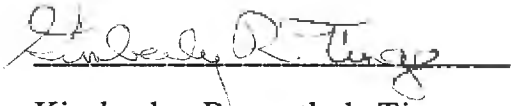
Advisors:

Hannu Laukkanen, OD, MEd
Richard D. Septon, OD, MS

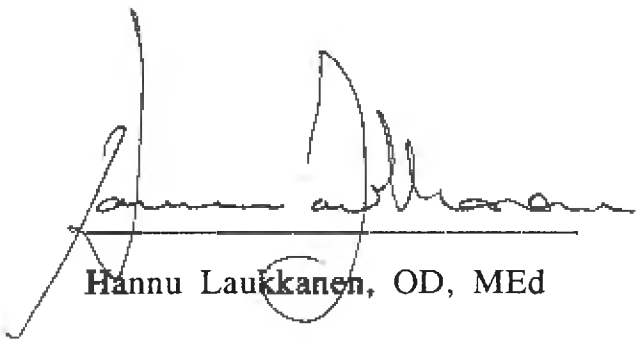
SIGNATURES



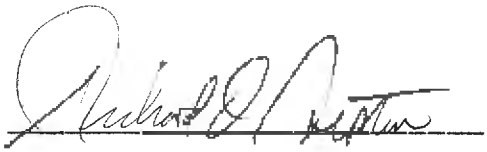
Brenda Stephens Offerdahl



Kimberly Rosenthal Tinge



Hannu Laukkanen, OD, MEd



Richard D. Septon, OD, MS

BIOGRAPHICAL SKETCHES

Brenda Stephens Offerdahl grew up on a ranch in Paradise, Montana. She graduated with honors from Montana State University at Bozeman with a bachelor's degree in Biomedical Sciences. While at MSU she received the Rittenour Medical Clinic Scholarship, the MSU Honors Scholarship, and was involved in the Pre-Med Honors Society. Other activities included marching band, the MSU Ski Club, and an exchange program to France. Her interests in optometry include vision therapy and low vision. Following graduation from Pacific University College of Optometry, she plans to return to Montana to pursue a career in private practice optometry. Brenda and her husband Gary's interests include camping, music, traveling, and enjoying their new baby, Madison Leigh.

Kimberly Rosenthal Tinge grew up in and around her family's private optometric practice in Highland, Illinois. Upon graduation with high honors from Highland High School, she attended Southern Illinois University at Edwardsville on a Presidential Scholarship. After three years of studies focusing in biology, chemistry, and music, she entered Pacific University College of Optometry and was awarded a Bachelor's in Visual Science degree in 1993. A member of Beta Sigma Kappa and the Optometric Extension Program, Kimberly's main interests lie in the areas of pediatrics, vision therapy, and low vision. Following graduation she plans to join her family's practice. In their free time, Kimberly and her husband Philip enjoy camping, hiking, fishing, and making music together.

ABSTRACT

There have been several reports in the literature documenting various methods of binocular refractions and how they compare to traditional refractive methods. However, no studies have been published in which the subjects were allowed to compare the two prescriptions subjectively.

A total of eighty-one subjects was assessed. Each was given two refractions: a traditional one and a binocular one utilizing the AO Vectographic Slide. Forty-nine of these subjects had significant differences in the prescriptions and of these, fifteen chose to participate in a wearing trial using both of the prescriptions.

The percentage of eyes showing more than a 0.25D change was 20% in spherical power, 22% in cylindrical power, and 27% in equivalent spherical power. Nine percent of eyes showed an axis shift equivalent to a 0.25D induced change in power. Eight percent of subjects had a change in anisometropia based on the equivalent sphere and 19% of subjects required a vertical prism on the binocular refraction. In the clinical trial, 42% preferred the binocular prescription, 28% preferred the traditional prescription, and 28% liked both prescriptions equally.

Key words: refraction, binocular, vectographic slide, autorefractor.

ACKNOWLEDGMENTS

We would like to express our sincere appreciation to Opti-Craft and Columbian Bifocal for the donation of frames and lenses for our subjects, to Bernel for the donation of two vectographic slides, and to Beta Sigma Kappa for funding. Special thanks also to Dr. Karl Citek and Dr. Robert Yolton for their advice, and to LeAnn Sundhagen for assisting in the glasses trial.

INTRODUCTION

Optometrists realize that most people have binocular vision. We discuss ACA ratios and vergence ranges and all of those important aspects of binocular vision. We consider extensive vision therapy or a carefully derived prism prescription when a patient has unstable binocularity. Yet when we assess a patient's refractive error, we perform most of the tests (indeed, all of the tests for astigmatism) with an occluder totally blocking one eye. The complex relationships between vergence and accommodation mean very little when the patient is monocular.

STATEMENT OF THE PROBLEM

It comes as no surprise, then, that many meticulous refractionists have attempted to test patients' refractive errors while they are in a binocular state. This raises the obvious problem of determining one eye's refractive status while the other eye is fixating as well. The perfect test would show some of the target to one eye, some to the other, and enough to both to provide a strong fusional lock, while at the same time providing the good contrast and stability one would expect from a standard refraction chart. Ignoring for the moment the logistics involved in achieving such a test, what improvements would this make over a traditional refraction? The easiest answer is that the exam would more closely mimic real world

vision. To elaborate further, the potential benefits of this fall in four main areas (1, 2, 3).

1. A more perfect balance could be achieved between the two eyes. This is of great importance, as it has been shown that as little as 0.25D difference in accommodative demand between the two eyes is too much to be compensated by the accommodative system (4). Equalizing visual acuities is not valid if accommodation is not controlled, requiring a blur; precise patient response is also needed. Separating left and right eye images with prisms provides a good comparison, but this break in fusion allows the patient to slip to their phoric posture, thus allowing accommodation the possibility of changing as well. If this effect is strong enough, it could lead to underminusing the exophore and overminusing the esophore in a traditional refraction (5). Furthermore, if the potential acuities differ, neither one of these techniques is valid. A binocular balance, with the patient's normal accommodative and vergence postures in effect, would obviously be preferred.

2. Cyclophorias are not often considered. Yet they do occur in some individuals, and would be manifested when the patient is under monocular conditions. If the patient's astigmatism were measured in this state, the axis would be measured based on the patient's cyclophoric posture. When the patient returned to binocularity, the eyes would turn back to their normal, fused alignment, and the measured axis would no longer be correct.

3. In a traditional refraction, even in those tests which assume binocularity, there is no way to determine if suppression is present. A chart which monitored both eyes individually would be a potent

suppression control. The patient's binocularity could be continually assessed throughout the refraction, and the prism or lens balance which reduced suppression could be determined.

4. A binocular chart would provide an ideal way to measure fixation disparity. With this chart, binocular fusion would be maintained because each eye would see part of a target and the off-center target could be aligned with prisms. In cases of a symptomatic vertical disparity, the resultant prism is viewed by many clinicians as a prescribable amount.

Fixation disparity measurements have assumed a greater role in assessing binocular vision performance. Yet the importance of a binocular balance, axis alignment without the possibility of a cyclophoric shift, and monitoring suppression throughout the refraction should not be ignored. With the emphasis of fixation disparity the usefulness of other factors of the vectographic slide are often overshadowed.

The discovery of polarization helped to attain the above criteria with the vectographic slide. Little research has been done in this area, however, since the earlier methods of cyclodamia (6), the Turville Infinity Binocular Balance (7, 8) and other septum methods (9), and Humphriss' method of Immediate Contrast (10, 11, 12). We have been unable to find published studies in which the patients were allowed to compare monocularly and binocularly derived prescriptions.

The present study sought to compare refractions using the vectographic slide to those using a standard projected slide, to determine the percentage of patients yielding different results by

the two techniques. We aimed to carry this further by allowing patients with a difference in their refractive results to compare them in an extended glasses trial.

REVIEW OF THE LITERATURE

Turville presented the first septum technique in 1936. Later modified by himself and by Morgan, the Turville Infinity Balance (TIB) became the standard for binocular refractions. The chart consisted of left and right fields of letters separated by 60mm and positioned behind the patient's head. The chart was viewed in a mirror positioned 3m in front of the patient, for a total 6m testing distance. The mirror was bisected by a 3cm wide strip of ground glass. When this arrangement was aligned precisely, the patient could see the letters on one side with the right eye and on the other side with the left eye. The septum, outer border of the chart, and periphery of the room could be seen by both eyes, creating a fusional lock (13).

With the TIB the eyes could be tested separately without ever occluding an eye. Gross fixation disparities were detected and measured based on subjective alignment of the letters, though researchers agreed that this worked much better for vertical than for lateral fixation disparities. The major difficulty was aligning the patient correctly. Keeping the patient in that exact location throughout testing was not difficult once the phoropter was in place.

Morgan developed an American Optical Project-o-chart slide to perform the TIB with standard exam room equipment. With the slide projected at 6m, a 25-35cm wide septum the same color as the projection screen was positioned 3m from the patient so that each eye could see just half of the chart (14).

Morgan reported on 215 patients refracted in his office using both the TIB and a traditional refraction. In spherical power, he found a difference of 0.25D in 20% and a difference of 0.50D or more in 2%. He found no difference in cylinder power in anyone, but a difference in axis of 10° or more in 2%. As these were not the same patients who had the 0.50D difference in spherical power, he considered that a total of 4% showed a significant difference in refractive prescription. He also prescribed the full amount of the associated vertical phoria found in 32 patients. Only two individuals could not adapt to this. Both were over the age of 50 and only had binocular vision with the prism in place. Morgan assumed this change was too much to adapt to at their age (4).

Morgan also noted the benefits of a TIB exam on six patients who suppressed. Binocular vision was restored to five of these patients using prism or a different lens balance. The sixth patient required vision therapy (4). Though the numbers in the above paragraph may seem insignificant, it should be noted that these small changes in a few people often meant the difference between monocularity and binocularity.

With the application of polarization methods, a new type of binocular refraction became possible (15, 16, 17, 18). In the 1950's various researchers (19, 20) used charts with crossed polarized

overlays such that one eye would see part of the chart and the other eye would see the rest. A fusional lock was provided by the periphery and sometimes by an outdoor scene projected behind the chart to provide a feeling of real-world depth. With the entire chart covered by overlays and the polarized filters in front of the eyes, however, the testing conditions were darkened and contrast was reduced. Also, the area in which an eye did not see letters was black, which often led to rivalry and suppression.

Norman compared binocular balances using polarized overlays to monocular balances and found a difference of at least 0.25D in 35% of his 350 subjects (21). He suggested that clinical acceptance of the two balances be studied next.

In 1966 Gentsch and Goodwin compared several methods of monocular and binocular balance. They used haploscopic measurements with the Nagle optometer system as their standard for comparision. With just 27 subjects, they found that the TIB had the smallest mean deviation from the haploscopic measurement. In order of decreasing accuracy, the other tests compared were: monocular comparison of visual acuities, acuities under prism dissociation, static retinoscopy, and the bichrome technique under prism dissociation. Polarization was not used. On looking at the data for individual subjects, they found agreement between the tests for most subjects, with significant disagreement for a few subjects (22).

The following year, Grolman developed a sophisticated technique whereby high resolution letters could be individually polarized on a film of dicroic crystals. This resulted in a letter being shown to one eye while the other eye saw the same area to be

uniform with the film. Ghost images did not appear until a rotation of 20°. Grolman found that the properly aligned vectographic slide was equally effective in bright or dim illumination (23). Grolman suggested normal room illumination for most testing because reduced illumination decreased the peripheral fusional lock. The American Optical Vectographic Slide was developed based on this approach.

In 1972 Rabbetts compared astigmatic prescriptions determined binocularly using a neutral density filter to fog one eye to those determined monocularly. The Jackson Crossed Cylinder test was used in both cases. In 50 subjects, he found a difference of 0.25D in 10% and 0.50D or more in 3%. There was a difference in axis in 25%, though most were less than 7°, which he considered "rarely significant" (24).

We were only able to find one study that incorporated the vectographic slide, one by West and Somers in 1984. They considered the vectographic slide to be the standard to which all other methods of balancing the spherical power were compared. They compared equal acuity through low plus blur, red-green equalization, the distance crossed cylinder test, and equal loss of acuity through plus blur. With just 25 subjects, they found each test to have a mean standard deviation of less than 0.25D (25).

Stage one of our study was based on Morgan's classic study (4), using the more current vectographic slide. We modified his criteria for significance only for the difference in axis, which we related to cylindrical power. Stage two, the spectacle trial for clinical

acceptance, had been suggested by Norman (21) in 1953, but we could find no record of it ever having been conducted.

METHODS

A total of eighty-one subjects was seen at the Forest Grove Family Vision Center in a five week period. Subjects were recruited from the Pacific University student body, and included mainly optometry students and their spouses. There were 37 male subjects and 43 female subjects, with an age range from 18 to 37 years. Subjects volunteering for this study were required to be binocular prepresbyopes with a near point of accommodation within at least 15 centimeters and a minimum stereoacuity of 60 arcseconds. These test criteria were assessed by the binocular push-up to blur using a .67M paragraph and the circle portion of the Bernell Stereo Fly Test, respectively.

The study excluded strabismics as determined by the stereoacuity test, amblyopes, and subjects with any systemic conditions or medications that could influence refractive error. Upon completing the examinations, the data of six subjects was discarded: four because of worse than 20/20 visual acuity with the binocular refraction and two because they were currently undergoing orthokeratology treatment. This resulted in a total of 75 subjects who were examined using both methods who qualified for inclusion in the study.

Stage one of the study began by measuring the subjects' monocular refractive errors with the Canon R1 Autorefractor, first with both eyes open and then with each eye alternately occluded. The Canon R1 was chosen as it utilizes free space viewing while measurements are taken. This method was seen as a possible screening test to identify those patients who would have a significant difference between their traditional and binocular refractions. A minimum of three readings were obtained on each eye. In some instances more measurements were necessary to obtain three consistant readings, which were then averaged.

Subjects were then given two refractions: a traditional subjective refraction and a binocular one utilizing the AO Vectographic Slide. The refractions were performed by two different researchers without access to the other's findings, to avoid bias. To minimize problems with differences in techniques, each researcher randomly conducted half of the refractions of each type. Two subjects were scheduled every forty-five minutes. Each researcher began with one subject, then the subjects switched rooms to do the second refraction with the second researcher. A strict exam protocol was followed to help ensure consistency (see Appendices A and B). For example, if there was a situation in which the subject was unable to decide between two choices on a balance test, the researcher always recorded the lens which resulted in the lesser amount of anisometropia.

The second stage of the study involved only the subjects whose two refraction results showed differences in findings which were judged to be clinically significant in the following parameters:

spherical power, cylindrical power, cylinder axis, equivalent spherical power, and anisometropia. A difference greater than 0.25D in any one parameter was considered significant. A difference in axis that would induce a 0.25D equivalent difference in cylinder power was considered significant (see Appendix C), as was any amount of vertical fixation disparity detected on the vectographic slide. Forty-nine subjects showed such differences and were offered the opportunity to compare spectacles derived from both refractive methods. These subjects all demonstrated visual acuity of 20/20 or better with both prescriptions, as determined on the slide used for each refraction. Prescriptions were written directly from the binocular subjective to best visual acuity for each refraction. Any vertical prism required to neutralize a fixation disparity on the vectographic slide was prescribed in full, split equally between the two eyes when greater than 1^. Though we realize that prescriptions are often modified based on clinical wisdom, this was not encorporated in order to avoid confounding the results. As binocular refractive methods are often used for detecting and prescribing for vertical disparities, but traditional vertical phorias are not, we elected to prescribe vertical prism from the binocular refraction only.

Fifteen subjects chose to participate in the second stage. They were required to purchase one pair of glasses, while a second, identical pair, differing only in prescription, was supplied by the researchers. To avoid bias from either the subjects or the researchers, an independent assistant marked each pair of frames to distinguish the prescriptions. After the glasses were received from the lab, the researchers verified both pairs using a standard

lensometer. The assistant was then given the glasses and the order forms with the prescriptions. One temple of each pair of glasses was tagged with a colored sticker and was recorded on a master list which was not revealed to the researchers until all of the glasses had been dispensed and the trials completed. Subjects were given one prescription to wear for one week and the other one for the next week. Half wore the traditional prescription first, half the binocular prescription. The third week, the subjects were instructed to wear each prescription for at least an hour, and to wear whichever they preferred for the remaining hours of the day. At the time of each dispensing, subjects were given a survey form, which included recording hours of each prescription worn, ranking ocular symptoms, and a preference scale for comparing the two prescriptions (see Appendix D). Subjects returned the survey form to the researchers following the three week trial period.

RESULTS

The subjects meeting the criteria for inclusion in the stage one of the study totaled 75, or an equivalent of 150 eyes. Results are included in detail in Appendix E and summarized in Table 1. Autorefractor results, though highly reliable, were not valid as compared to either of the subjective refractions. Comparing the two subjective refractions, the percentage of eyes showing more than a 0.25D difference was 20% in spherical power, 22% in cylindrical power, and 27% in equivalent spherical power. Most of these differences were in the 0.50D range. The percentage of eyes showing

Table 1. Percentage of Eyes with a Significant Difference between Traditional and to Binocular Refraction Results

Autorefractor results

Change (D)	Sph	Cyl	ES
0.37 - 0.50	9	9	10
0.62 - 0.75	0	3	0
0.87 - 1.00	1	1	2
> 1.00	1	1	0
Totals	11%	14%	12%

Significant axis difference 21%
Anisometropia 11% of subjects

Difference in any parameter:
35% of eyes
28% of subjects

Subjective refractions

Change (D)	Sph	Cyl	ES
0.37 - 0.50	11	17	13
0.62 - 0.75	4	3	8
0.87 - 1.00	4	1	5
1.12 - 1.25	1	1	1
Totals	20%	22%	27%

Significant axis difference 9%
Anisometropia 8% of subjects
Vertical prism 19% of subjects

Difference in any parameter:
46% of eyes
65% of subjects

Percent showing a difference in any parameter in both autorefractions and subjective refractions:
17% of eyes
16% of subjects

---

a significant axis shift (equivalent to a 0.25D induced difference in power) was 9%. Only 8% of subjects had a difference in anisometropia based on the difference in equivalent spherical power, indicating that even when a prescription varied, the balance between the two eyes more often remained consistant. Nineteen percent of subjects required a vertical prism on the binocular refraction. Only 29% of these subjects also showed a vertical phoria on the traditional refraction. Many subjects showed a difference in more than one of the parameters. Overall, a total of 45% of eyes and 65% of subjects showed a significant difference in one or more of the parameters, as

defined previously. Only 16% of subjects showed a significant difference on both the autorefractions and the subjective refractions.

In stage two, 14 of the 15 subjects returned their questionnaires. Purely descriptive statistics were used on this small group. Following each week of wear, subjects ranked various asthenopic factors through each prescription. A scale of zero to seven was used with zero indicating total intolerance and seven indicating complete satisfaction. See Appendix F for a summary of the results. The mean satisfaction rate of all fourteen subjects on the traditional prescription was 5.8 with a range from 2.9 to 7.0.. This compares to the binocular prescription mean satisfaction rate of 5.3 with a range from 2.1 to 7.0. This comparison suggests that the traditional prescription resulted in a slightly greater satisfaction rate than the binocular prescription following the first two weeks of the study. This difference may not be clinically significant.

Comparing individual asthenopic factors with regard to each prescription provided a more detailed perspective as to which prescription resulted in the most adverse symptoms following the first two weeks of the study. With the traditional prescription, "comfort" recieved the worst rating overall, while "diplopia" and "burning" sensations recieved the least complaints. The binocular prescription recieved more varied complaints, including "tension," "headaches," "unnaturalness," "pulling sensation," "eyestrain," and "tired eyes." The average of all factors was 5.8 for the traditional prescription and 5.4 for the binocular prescription.

Therefore, comparing overall satisfaction with each of the two prescriptions and ranking of individual asthenopic factors, the

prescription derived from the traditional refraction provided slightly increased satisfaction in the first two weeks of wear. However, after the third week of trial wear, when the subjects were asked to make an overall judgement as to which of the two prescriptions they preferred, 42% preferred the binocular, 28% preferred the traditional, and 28% liked both prescriptions equally. This direct comparison indicated an overall preference for the binocular prescription.

Appendix G lists the complete data on each subject in the spectacle trial. Interesting antecdotes drawn from their comments are described below.

Three subjects initially reported less satisfaction and more asthenopic complaints with the binocular prescription, but by the end of the study preferred this prescription. This corresponds with the statements of several subjects that the binocular prescription required a longer adaptation time. Two of these subjects had vertical prism in the binocular prescription. Subject #71 was initially dizzy and lightheaded with the binocular prescription, and also stated that reading material seemed to slant. This subject did not have a significant change in axis, but did have 2^ of prism in the binocular refraction. However, both complaints resolved within five days of wearing, and she preferred the binocular prescription by the end of the study.

Seven of the fourteen subjects wore vertical prism in the binocular prescription. During the third week of wear, when they could choose which to wear the most, many noticed difficulty

switching back and forth. But in the end, five of the seven preferred the binocular prescription, the one with the prism.

A few subjects had extenuating circumstances which complicated their wearing time. Subject #47 reported itching with both prescriptions, but noted that this was secondary to allergies. Another subject with decreased wearing time with both prescriptions, #36, was nearly emmetropic and had never before worn correction.

Three subjects stated that they absolutely could not wear one of the prescriptions. Subject #57 complained about the binocular prescription, commenting that she got headaches and dizziness instantly and did not trust herself to drive while wearing the glasses. Subject #2, who had 0.5^ BD OS, also was extremely uncomfortable with the binocular prescription. However, neither of these subjects wore the binocular prescription for more than two hours per day and perhaps did not allow enough adaptation time. Subject #76, on the other hand, never adapted to the traditional refraction. He found one eye to be blurrier than the other, and stated that he never got over a "warped" sensation when wearing them.

DISCUSSION

We found what we defined as a significant difference between refractions in 65% of subjects, higher than what had previously been assumed based on refractions using other methods. The autorefractor proved to be a poor method of identifying the patients

who would exhibit this difference. And a very small percentage of people (four individuals in this study) had insufficient binocularity to obtain a reasonable prescription using the vectographic slide. These people were easily identified by their inconsistent responses at the beginning of the binocular refraction.

Though we unfortunately had too few subjects to draw any strong scientific conclusions, the clinical trial of the two prescriptions resulted in many interesting and thought-provoking anecdotes. From speaking with our subjects, it is evident that a few of them gained comfort with the binocular prescription which had not been attained before through traditional refractive methods. This study is being continued in the hope that more subjects in the clinical trial will provide enough data for a more formal analysis.

For the researchers involved in this project for the past year, however, the benefits of a binocular refraction to a select group of individuals has been evident. Certainly it is a clinically relevant method for prescribing vertical prism. Suppression can be easily monitored and a binocular balance attained that will best reduce or eliminate the suppression. And for patients who have rejected traditional prescriptions in the past, a binocular refraction might be the solution. Clinical judgment must be used in identifying the patients who might benefit from a binocular refraction.

REFERENCES

1. Amos, JF. Binocular refraction: When is it clinically advantageous? Clin Eye Vision Care 1990; 2(2): 79-80.

2. Eskridge JB. Rationale for binocular refraction. New England J Optom 1971; 22(6): 160-165.

3. Wick B, London R. Analysis of binocular function using tests made under binocular condition. Am J Optom Arch Am Acad Optom 1987; 64(4): 227-240.

4. Morgan MW. The Turville Infinity Binocular Balance test. Am J Optom Arch Am Acad Optom 1949; 26(6): 231-239.

5. Bannon RE. Binocular refraction -- a survey of various techniques. Optom Wkly 1965; 56(31): 25-30.

6. Miles PW. Binocular refraction. Am J Ophthalmol 1948; 31(121): 1460-1466.

7. Elvin FT. The results of prescribing vertical prisms from the Turville test. Am J Optom Arch Am Acad Optom 1954; 31(5): 308-313.

8. Morgan MW. The Turville Infinity Binocular Balance test. J Am Optom Assoc 1960; 31(6): 447-450.

9. Butler N, Roth N. A non-polarized alternative to polarized nearpoint test cards. J Am Optom Assoc 1982; 53(2): 141-143.

10. Humphriss D. Binocular vision technique -- the psychological septum. Optical J Review Optom 1962; 99(11): 19-21.

11. Humphriss D, Woodruff EW. Refraction by immediate contrast. Optom Wkly 1962; 53(44): 2171-2175.

12. Llewellyn R. Binocular refractive procedures. Optician 1989; 197(5187): 16-22.

13. Borish IM. Clinical refraction, 3rd ed. Chicago: Professional Press, Inc, 1970.

14. Morgan MW. Instructions: AO Morgan Project-o-chart slide for monocular subjective testing under vinocular conditions. Buffalo: American Optical Company, 1951.

15. Abraham FA. A device for testing malingering and binocular refraction. Am J Ophthalmol 1986; 101(5): 613-614.

16. Cowen L. Binocular refraction -- a simplified clinical routine. Br J Physiol Optics 1955; 16: 60-82.

17. Goodlaw E. A new test for binocular refraction at the near-point working distance. Am J Optom Arch Am Acad Optom 1961; 38(8): 420-432.

18. Haase H. Binocular testing and distance correction with the Berlin Polatest. J Am Optom Assoc 1962; 34(2): 115-125.

19. Amigo G. Binocular balancing techniques. Am J Optom Arch Am Acad Optom 1968; 45(7): 511-521.

20. Eskridge JB. A binocular refraction procedure. Am J Optom Arch Am Acad Optom 1973; 50(5): 499-505.

21. Norman SL. Plus acceptance in binocular refraction. Optom Wkly 1953; 44(2): 45-46.

22. Gentsch L, Goodwin H. A comparison of methods for the determination of binocular refractive balance. Am J Arch Am Acad Optom 1966; 43(8): 658-663.

23. Grolman B. Binocular refraction -- a new system. New England J Optom 1966; 17(5): 118-128.

24. Rabbetts RB. A comparison of astigmatism and cyclophoria in distance and near vision. Br J Physiol Optics 1972; 27(3): 161-190.

25. West D, Somers WW. Binocular balance validity: a comparison of five common subjective techniques. Ophthal Physiol Opt 1984; 4(2): 155-159.

APPENDIX A: EXAM PROTOCOL

I. Confirmation of Eligibility: record each of the following
   A. History
      1. Age.
      2. Systemic conditions, including diabetes and pregnancy.
      3. Medications.
   B. Stereoacuity: using the Bernell Stereofly.
   C. Donder's Amplitude of Accommodation.

II. Autorefraction
   A. Instrument: Canon R1 Autorefractor.
   B. Monocular readings: measure each eye with the other eye occluded and record.
   C. Binocular readings: measure each eye with the other eye unoccluded and record.

III. Monocular Refraction
   A. Lighting: 40 lux.
   B. Monocular Sphere to Best Visual Acuity (MSBVA)
      1. Lens preset: 20/40 fog obtained monocularly from the binocular autorefraction.
      2. Target: Snellen chart with the 20/40 to 20/15 lines exposed.
      3. Procedure for each eye seperately
         a. Add minus in 0.25D increments, asking the patient to call out the lowest line of letters seen with each change.
         b. Continue until the patient sees at least two-thirds of the 20/20 line.
         c. Forced choice, showing the more plus choice first.
         d. Bracket the most preferred lens OR stop if the patient reaches 0.75D more minus than the endpoint in step b.
   C. Jackson Cross Cylinder (JCC)
      1. Lens preset: results of step B.
      2. Target: isolated 20/40 line.
      3. Procedure for each eye seperately
         a. Refine power, ending at the higher amount if equality is never reached.

b. Refine axis.
c. Refine power, ending at the lower amount if equality is never reached.

D. MSBVA
1. Repeat if there is a change in cylinder from the JCC.
2. Record results.

E. Distance Equalization
1. Lens preset: 20/30 fog obtained monocularly from the results of step D.
2. Target: isolated 20/30 line.
3. Prism: 3 BD OD, 3 BU OS.
4. Procedure
a. Add plus to the clearer line.
b. Add minus to the blurrier line.
c. Continue alternating plus and minus until a midpoint of equality is bracketed.
d. If equality is never reached, ask the patient which set of lines match the best.
e. If the patient can't decide, end at the least anisometropic difference.

F. Binocular Maximum Plus to 20/20 (OEP #7)
1. Lens preset: results of step E.
2. Target: isolated 20/20 line.
3. If the 20/20 line is readable, add plus binocularly until it is not.
4. Reduce plus binocularly until the patient can read at least two-thirds of the 20/20 line.
5. Record results.

G. Binocular Maximum Plus to Best Visual Acuity (OEP #7A)
1. Lens preset: results of step F.
2. Target: isolated 20/20 line.
3. Forced choice, showing the more plus choice first.
4. Bracket the most preferred choice OR stop if the patient reaches 0.75D more minus than the endpoint in step F.
5. Confirm that none of the changes make the letters become smaller or darker.
6. Take visual acuities: OD, OS, and OU.
7. Record results and acuities.

F. Lateral Phoria
1. Lens preset: results of step G.
2. Prism: 12 BI OD, 6 BU OS.

3. Target: isolated 20/30 "O".
4. Increase BI prism if the top letter is not to the right of the bottom letter.
5. Reduce BI prism until one letter passes directly above the other, then retest from the BO side.
6. Record results.

G. Vertical Phoria

1-3. As in step F.
4. Reduce BU prism until one letter is seen directly across from the other, then retest from the BD side.
5. Record results.

IV. Binocular Refraction (See Vectographic Slide, Appendix B)

A. Lighting: 40 lux.

B. MSBVA

1. Lens preset: 20/40 fog obtained monocularly from the binocular autorefraction.
2. Target: appropriate monocular chart with the 20/40 to 20/15 lines exposed.
3. Procedure for each eye separately
   a. Add minus in 0.25D increments, asking the patient to call out the lowest line of letters seen with each change.
   b. Continue until the patient sees at least two-thirds of the 20/20 line.
   c. Forced choice, showing the more plus choice first.
   d. Bracket the most preferred lens OR stop if the patient reaches 0.75D more minus than the endpoint in step b.

C. JCC

1. Lens preset: results of step B.
2. Target: isolated 20/40 line on the appropriate monocular chart.
3. Procedure for each eye separately
   a. Refine power, ending at the higher amount if equality is never reached.
   b. Refine axis.
   c. Refine power, ending at the lower amount if equality is never reached.

D. MSBVA

1. Repeat if there is a change in cylinder from the JCC.
2. Record results.

E. Distance Equalization
   1. Lens preset: 20/30 fog obtained from the results of step D.
   2. Target: isolated 20/30 line on the split chart.
   3. Procedure
      a. Add plus to the clearer side.
      b. Add minus to the blurrier side.
      c. Continue alternating plus and minus until a midpoint of equality is bracketed.
      d. If equality is never reached, ask the patient which set of lines match the best.
      e. If the patient can't decide, end at the least anisometropic difference.

F. OEP #7
   1. Lens preset: results of step E.
   2. Target: isolated binocular 20/20 line.
   3. If the 20/20 line is readable, add plus binocularly until it is not.
   4. Reduce plus binocularly until the patient can read at least two-thirds of the 20/20 line.
   5. Record results.

G. OEP #7A
   1. Lens preset: results of step F.
   2. Target: isolated binocular 20/20 line.
   3. Forced choice, showing the more plus choice first.
   4. Bracket the most preferred choice OR stop if the patient reaches 0.75D more minus than the endpoint in step F.
   5. Confirm that none of the changes make the letters become smaller or darker.
   6. Take visual acuities: OD, OS, and OU.
   7. Record results and acuities.

H. Anisometropia Check
   1. Lens preset: results of step E.
   2. Target: the alternating letters chart.
   3. Ask if any of the letters appear dimmer or less stable than the others.
      a. If the patient responds negatively or identifies all of the monocular letters as being less stable, proceed to step I.
      b. If the patient identifies the letters seen by one eye or the other as being less stable, add 0.25D more minus to that side.

c. Continue changing the aniso in 0.25D steps until the patient reports the most uniformity between the letters.

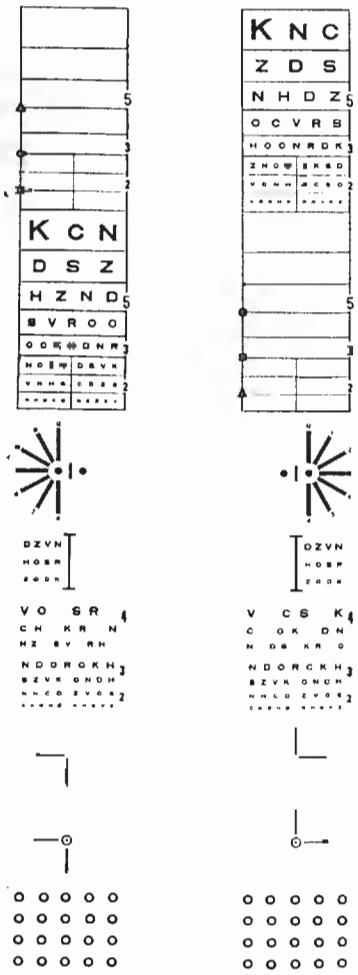
4. Repeat steps F and G with this new aniso.

I. Lateral Phoria

1. Lens preset: results of step H.
2. Prism: 12 BI OD, 6 BU OS.
3. Target: isolated binocular 20/30 "O".
4. Increase BI prism if the top letter is not to the right of the bottom letter.
5. Reduce BI prism until one letter passes directly above the other, then retest from the BO side.
6. Record results.

J. Vertical Fixation Disparity

1. Lens preset: results of step H.
2. Target: fixation disparity target with central fixation lock.
3. Ask the patient if one of the horizontal lines is higher than the other.
4. If so, neutralize with prism.
5. Record the prism needed to neutralize.



Right eye monocular chart

Left eye monocular chart

Radial line target

Split chart

Alternating letters chart

Binocular chart

Fixation disparity targets

Stereoacuity target

Appendix B

Appendix C

For each cylinder power, the amount of axis difference that would induce a 0.25D difference was calculated. Results were as follows.

Cylinder Power	Significant Axis Difference
0.25D	30°
0.50	15
0.75	10
1.00	8
1.25	6
1.50	5
1.75-2.00	4
2.25-2.75	3
>3.00	2

Appendix D: Subject Questionaire

Name:

Week #1: Wear Rx #1 (red tag) full time for seven days. Answer these questions upon completion of your first week of trial wear.

Please rate your level of satisfaction, 7 indicating complete satisfaction and 0 indicating total intolerance to lens wear.

1. Acuity - level of visual clarity

0 1 2 3 4 5 6 7

2. Visual comfort (not the fit of the frame). Rate each of the following on the same 0 - 7 scale, 7 indicating no problem and 0 indicating a severe problem.

tension 0 1 2 3 4 5 6 7 sensitivity to light 0 1 2 3 4 5 6 7

headaches 0 1 2 3 4 5 6 7 glare 0 1 2 3 4 5 6 7

unnaturalness 0 1 2 3 4 5 6 7 dizziness 0 1 2 3 4 5 6 7

"pulling" sensation 0 1 2 3 4 5 6 7 eye strain 0 1 2 3 4 5 6 7

diplopia 0 1 2 3 4 5 6 7 tired eyes 0 1 2 3 4 5 6 7

burning 0 1 2 3 4 5 6 7 itching 0 1 2 3 4 5 6 7

Rate comfort in general:

0 1 2 3 4 5 6 7

3. Approximately how many hours per day did you wear this prescription?

If not full time, indicate your reasons.

Week #2: Wear Rx #2 (blue tag) full time for seven days. Answer these questions upon completion of your first week of trial wear.

Please rate your level of satisfaction, 7 indicating complete satisfaction and 0 indicating total intolerance to lens wear.

1. Acuity - level of visual clarity

0 1 2 3 4 5 6 7

2. Visual comfort (not the fit of the frame). Rate each of the following on the same 0 - 7 scale, 7 indicating no problem and 0 indicating a severe problem.

tension 0 1 2 3 4 5 6 7 sensitivity to light 0 1 2 3 4 5 6 7

headaches 0 1 2 3 4 5 6 7 glare 0 1 2 3 4 5 6 7

unnaturalness 0 1 2 3 4 5 6 7 dizziness 0 1 2 3 4 5 6 7

"pulling" sensation 0 1 2 3 4 5 6 7 eye strain 0 1 2 3 4 5 6 7

diplopia 0 1 2 3 4 5 6 7 tired eyes 0 1 2 3 4 5 6 7

burning 0 1 2 3 4 5 6 7 itching 0 1 2 3 4 5 6 7

Rate comfort in general:

0 1 2 3 4 5 6 7

3. Approximately how many hours per day did you wear this prescription?

If not full time, indicate your reasons.

Week #3: Wear each prescription at least one hour each day. Wear whichever you prefer for the rest of the day. Record the number of hours you wear each prescription.

Day	Rx #1	Rx #2
1		
2		
3		
4		
5		
6		
7		

How strongly did you prefer one prescription over the other?

0 Didn't like either Rx

1 Strongly preferred Rx #1

2 Moderately preferred Rx #1

3 Slightly preferred Rx #1

4 Liked both prescriptions equally

5 Slightly preferred Rx #2

6 Moderately preferred Rx #2

7 Strongly preferred Rx #2

Thank you so much for your assistance in our thesis!

APPENDIX E

SUBJECT		AUTOREFRACTION								SUBJECTIVE REFRACTION										
NUMBER	AGE	MONOCULAR				BINOCULAR				MONOCULAR (RX 1)				#8	#12	BINOCULAR (RX 2)				#8	VERT FD
1	20	0.00	-0.37	X	15	0.12	-0.37	X	14	0.50				2 ESO	0	0.25	-0.25	X	163	2 ESO	0
		0.12	-0.62	X	143	0.25	-0.75	X	136	0.50	-0.25	X	180			0.25	-0.25	X	175		
2	25	-0.75	-1.50	X	2	-1.00	-1.50	X	179	-0.25	-2.25	X	178	1 EXO	0	-0.75	-2.50	X	175	0	
		-1.25	-2.37	X	167	-1.00	-2.50	X	171	-0.75	-2.00	X	4			-1.00	-3.00	X	180		.5 BD
3	23	-0.37	-0.62	X	114	-0.37	-0.75	X	112	0.00				0	0	-0.25				1 EXO	0
		-0.25	-0.50	X	73	0.00	-0.50	X	103	0.75	-1.00	X	90			0.00	-0.50	X	90		
4	26	-1.50	-0.62	X	109	-1.87	-0.25	X	141	-1.00	-0.50	X	136	0	0	-1.00	-0.50	X	130	0	0
		-1.75	-0.25	X	70	-1.62	-0.50	X	68	-1.00	-0.25	X	58			-1.00	-0.25	X	68		
5	29	-3.50	-0.87	X	170	-3.37	-0.37	X	170	-3.00	-0.75	X	165	2 EXO	0	-3.00	-1.00	X	170	3 EXO	0
		-3.12	-1.12	X	157	-3.25	-0.75	X	150	-3.00						-3.25	-0.75	X	167		
6	25	0.00	-0.25	X	97	0.00	-0.25	X	89	0.00	-0.25	X	90	0	0	0.00	-0.50	X	85	0	0
		-0.12	-0.62	X	90	0.00	-0.87	X	90	0.25	-0.75	X	76			0.25	-0.75	X	80		
7	25	-2.87	-0.75	X	168	-2.87	-0.62	X	155	-2.75				1 ESO		-3.00				0	0
		-2.75	-0.62	X	48	-3.00	-0.50	X	50	-3.25	-0.25	X	96		.5 BD	-3.50					
8	23	-1.62	-1.50	X	99	-1.50	-1.75	X	100	-1.00	-2.00	X	95	2 ESO	0	-1.00	-2.00	X	94	3 ESO	0
		-1.75	-1.37	X	98	-1.75	-1.37	X	97	-1.25	-1.25	X	92			-1.25	-1.25	X	95		
9	18	0.50	-0.75	X	14	0.37	-0.75	X	13	0.50	-0.50	X	15	2 EXO	0	0.25	-0.25	X	15	2 EXO	0
		0.25	-0.75	X	164	0.12	-0.62	X	169	0.50	-0.25	X	176			0.25	-0.75	X	175		
10	24	-6.75	-0.25	X	159	-6.75	-0.50	X	162	-6.50				1 EXO	0	-6.50				2 EXO	
		-5.75	-0.37	X	39	-5.62	-0.37	X	43	-6.50						-6.50	-0.25	X	178		.5 BU
11	23	-2.37	-1.12	X	6	-2.25	-1.00	X	5	-2.25	-1.00	X	5	1 ESO	0	-2.75				2 ESO	0
		-2.50				-2.37				-2.50						-2.50	-0.25	X	165		
12	25	-2.12	-1.00	X	161	-2.12	-1.00	X	154	-2.00				2 EXO	0	-2.75				1 EXO	0
		-2.00	-0.62	X	135	-2.25	-0.37	X	129	-2.00						-2.50	-0.25	X	165		
13	26	0.37	-1.00	X	124	0.37	-1.12	X	132	0.25	-0.25	X	130	1 ESO	0	0.00				2 EXO	0
		0.50	-0.50	X	28	0.25	-0.50	X	27	0.25	-0.50	X	25			0.25	-0.50	X	25		
14	27	-0.87	-0.87	X	175	-0.62	-0.62	X	124	-0.25				2 EXO	0	0.00				3 EXO	0
		-0.75	-0.37	X	102	-0.87	-0.37	X	140	-0.50						-0.50					
15	25	-1.62	-0.37	X	18	-1.50	-0.25	X	11	-1.25	-0.50	X	10	1 ESO	0	-1.25	-0.25	X	5	1 ESO	0
		-1.75	-1.00	X	131	-1.75	-0.75	X	125	-1.50	-0.25	X	117			-1.50	-0.50	X	130		
16	24	-6.12	-0.37	X	6	-5.87	-0.37	X	171	-4.75				4 EXO	0	-5.75				0	
		-5.50	-0.62	X	149	-5.50	-0.87	X	173	-4.50						-5.25	-0.50	X	142		1 BU
17	24	-1.37	-1.12	X	175	-1.37	-1.37	X	172	-1.00	-0.75	X	180	1 ESO	0	-1.00	-1.00	X	178	0	0
		-1.87	-1.00	X	4	-2.00	-0.75	X	11	-1.75	-0.75	X	10			-1.50	-1.00	X	5		
18	24	-6.25	-1.25	X	170	-6.62	-1.00	X	164	-6.00	-0.50	X	180	6 ESO	0	-6.50	-0.50	X	5	2 ESO	0

		-8.12	-0.37	X	154	-7.62	-0.75	X	165	-7.50	-0.25	X	171			-7.75					
19	21	-0.12	-0.87	X	83	0.00	-0.87	X	83	0.50	-0.50	X	162	2 EXO		0.50	-1.00	X	73	1 EXO	0
		0.12	-1.50	X	114	0.25	-1.50	X	117	0.50	-1.00	X	113		.5 BD	1.00	-1.00	X	110		
20	26	-8.62	-0.50	X	66	-8.50	-0.50	X	70	-8.50	-0.50	X	70	3 ESO	0	-8.50	-0.50	X	75	3 ESO	0
		-8.50	-0.62	X	124	-8.37	-0.50	X	134	-8.75						-8.50	-0.50	X	75		
21	22	-6.62	-1.62	X	15	-6.87	-1.50	X	15	-6.50	-1.75	X	12	2 EXO	0	-6.50	-1.25	X	15	2 EXO	0
		-6.75	-1.50	X	162	-6.87	-1.75	X	164	-6.50	-1.25	X	172			-6.50	-0.75	X	166		
22	25	-1.00	-0.37	X	176	-1.00	-0.37	X	4	-1.00	-0.50	X	175	0	0	-1.00	-0.25	X	168	1 EXO	0
		-1.00	-0.25	X	178	-1.12	-0.25	X	169	-1.00	-0.50	X	23			-1.00	-0.25	X	22		
23	21	2.62	-2.25	X	99	2.25	-2.00	X	99	3.75	-1.25	X	93	2 ESO	0	3.75	-1.25	X	96	2 EXO	0
		1.25	-0.87	X	95	2.50	-1.37	X	94	3.25	-1.25	X	81			3.00	-0.75	X	89		
24	24	-6.50	-0.62	X	15	-6.75	-0.37	X	1	-6.75				0	0	-6.50				0	0
		-6.00	-0.62	X	170	-6.00	-0.87	X	170	-6.00	-0.25	X	9			-5.75					
25	21	-1.12	-0.75	X	126	-1.25	-0.62	X	122	-1.25	-0.25	X	120	1 EXO	0	-1.50				1 EXO	
		-1.50	-0.62	X	90	-1.37	-0.62	X	94	-1.25	-0.50	X	49			-1.50					1 BD
26	24	-1.50	-0.62	X	102	-1.12	-0.62	X	114	-0.75	-0.25	X	92	1 ESO	0	-0.75	-0.25	X	86	2 EXO	0
		-1.37	-0.37	X	124	-1.37	-0.50	X	102	-0.50	-0.25	X	52			-0.75					
27	21	0.12				0.12				0.25				0	0	-0.25	-0.25	X	65	0	0
		0.25	-0.50	X	116	0.50	-0.62	X	112	0.25	-0.25	X	120			0.25	-1.00	X	133		
28	27	-3.37	-0.25	X	143	-3.12	-0.25	X	164	-2.75				5 ESO	0	-2.50	-0.25	X	20	5 ESO	
		-2.87	-0.25	X	134	-2.75	-0.25	X	143	-2.75						-2.75					1 BD
29	25	-0.12	-1.12	X	109	0.12	-1.62	X	111	-0.50				1 ESO	0	-0.50	-0.50	X	99	2 ESO	
		-0.37	-1.12	X	79	-0.37	-1.12	X	81	-0.25	-1.00	X	73			-0.75	-0.50	X	70		.5 BU
30	25	1.75	-1.87	X	17	1.75	-2.00	X	15	0.25	-0.75	X	5	1 EXO	0	0.50	-0.75	X	5	1 EXO	0
		0.87	-1.37	X	170	1.75	-1.25	X	163	1.25	-1.00	X	5			1.00	-0.50	X	8		
31	20	-6.75	-0.50	X	148	-6.75	-0.62	X	154	-7.00				1 EXO	0	-6.75				0	0
		-6.25				-6.25				-6.25						-5.75	-0.25	X	100		
32	23	-0.87	-0.37	X	46	-0.87	-0.37	X	31	-1.00				7 EXO	0	-1.25				7 EXO	0
		-0.25	-1.00	X	145	-0.37	-0.75	X	143	0.00						-0.25					
33	26	-6.25	-1.00	X	121	-5.87	-1.12	X	146	-6.25	-1.25	X	118	0		-6.25	-1.00	X	116	1 ESO	0
		-7.00	-0.50	X	83	-7.00	-0.62	X	79	-7.00	-1.25	X	67		1.5 BD	-7.00	-1.25	X	71		
34	25	-3.62	-0.75	X	163	-3.50	-0.50	X	165	-3.00	-0.25	X	170	1 ESO		-3.00	-0.25	X	180	1 ESO	0
		-3.50	-1.12	X	158	-3.25	-1.00	X	158	-3.00	-0.50	X	9		1 BD	-3.00	-0.25	X	165		
35	30	-0.25				0.12	-0.37	X	23	0.25				1 ESO	0	0.00	-0.25	X	65	3 ESO	
		-0.62	-0.50	X	137	-0.75	-0.25	X	127	-0.25						-0.50	-0.25	X	8		1 BD
36	27	-0.12	-0.62	X	119	0.00	-0.87	X	119	0.25				0	0	0.00	-0.50	X	105	2 ESO	0
		0.12	-0.50	X	115	0.25	-0.62	X	109	0.50						0.00	0.25	X	92		

37	24	0.25	-0.37	X	126	0.12	-0.37	X	124	1.00	-0.25	X	175	0		0.75				1 EXO	0
		0.12	-0.37	X	161	0.00	-0.25	X	123	0.75					.5 BD	0.75	-0.25	X	5		
38	34	-3.75	-1.62	X	22	-3.75	-1.50	X	22	-5.00	-0.75	X	10	2 ESO		-5.00	-1.00	X	12	1 ESO	0
		-4.62	-1.12	X	161	-4.25	-1.25	X	163	-4.75	-0.75	X	172		.5 BU	-4.75	-0.75	X	180		
39	22	-3.00				-2.75	-0.25	X	75	-2.50				7 ESO		-2.75	-0.25	X	40	3 ESO	0
		-3.12	-0.75	X	137	-3.25	-0.62	X	136	-2.75					1 BD	-3.00	-0.50	X	180		
40	22	0.12	-0.25	X	112	0.12	-0.25	X	113	0.25				0	0	0.25				0	0
		0.25	-0.37	X	153	0.00	-0.25	X	138	0.25						0.00	-0.25	X	165		
41	21	-3.50	-0.87	X	128	-3.37	-1.00	X	122	-4.00				0	0	-4.00				0	
		-3.87	-0.50	X	102	-4.12	-0.50	X	80	-3.75	-0.50	X	62			-4.00	-0.25	X	65		.5 BD
42	30	0.00	-0.37	X	89	0.00	-0.62	X	103	0.00				1 EXO	0	0.00				0	0
		0.00	-0.37	X	75	0.00	-0.37	X	70	0.25	-0.25	X	100			0.00	-0.25	X	106		
43	29	0.00	-1.00	X	113	-0.25	-0.75	X	116	-0.25	-0.50	X	105	2 EXO	0	0.00	-0.75	X	115	2 EXO	
		0.25	-0.75	X	91	0.00	-0.75	X	76	-0.25	-0.25	X	60			-0.25	-0.50	X	75		1 BD
44	25	-0.50	-1.37	X	104	-0.37	-1.25	X	103	-0.25	-1.00	X	100	2 EXO	0	-0.25	-1.00	X	100	2 ESO	0
		-1.00	-0.25	X	112	-1.00	-0.37	X	106	-0.75						-0.75	-0.25	X	80		
45	19	-3.25	-1.00	X	150	-3.12	-1.12	X	155	-3.50	-0.75	X	169	2 EXO	0	-2.75	-0.75	X	180	3 EXO	
		-1.87	-0.87	X	156	-2.00	-0.62	X	155	-1.50	-0.50	X	5			-1.50	-0.25	X	170		1 BD
46	25	-6.12	-2.62	X	19	-6.25	-2.75	X	18	-6.25	-3.50	X	21	8 ESO	0	-7.25	-3.25	X	16	9 ESO	0
		-6.50	-3.75	X	158	-6.75	-3.75	X	158	-7.00	-4.50	X	161			-7.25	-4.50	X	160		
47	23	-3.37	-1.25	X	16	-3.37	-1.00	X	15	-4.25				3 EXO		-4.25	-0.25	X	57	3 EXO	
		-5.37	-0.75	X	136	-5.50	-0.75	X	158	-5.50					1 BU	-5.75					2 BU
48	27	-1.75	-0.87	X	169	-1.75	-0.87	X	163	-2.25	-0.75	X	2	0	0	-1.75	-0.50	X	10	1 EXO	0
		-2.37	-0.50	X	169	-2.37	-0.50	X	171	-2.50	-0.75	X	15			-2.25	-0.50	X	15		
49	28	-1.75	-1.00	X	81	-1.87	-0.87	X	77	-1.50	-0.75	X	87	1 EXO	0	-1.75	-0.75	X	85	1 EXO	0
		-1.75	-1.50	X	86	-2.00	-1.37	X	80	-1.75	-1.25	X	70			-1.75	-1.50	X	69		
50	30	-3.00	0.87	X	2	-3.12	-0.75	X	178	-3.00	-0.50	X	162	2 EXO		-3.50				1 EXO	0
		-3.62	-0.62	X	68	-3.50	-0.75	X	69	-3.00	-0.75	X	35		1 BU	-3.25	-0.75	X	36		
51	33	-3.00	-1.62	X	4	-2.87	-1.62	X	5	-2.50	-1.50	X	5	2 EXO		-2.75	-1.75	X	4	7 EXO	0
		-3.62	-0.62	X	140	-3.62	-0.62	X	148	-3.25	-0.25	X	172		2 BD	-3.25	-0.25	X	160		
52	26	-1.25	-1.87	X	101	-1.12	-2.25	X	103	-1.00	-1.50	X	97	0		-0.75	-1.75	X	95	2 ESO	0
		-1.12	-2.00	X	85	-1.00	-2.00	X	83	-0.50	-1.75	X	74		1 BD	-0.75	-1.25	X	75		
53	24	-1.37	-0.25	X	136	-1.12	-0.87	X	120	-1.50				1 EXO	0	-1.25				1 EXO	0
		-0.87	-0.75	X	144	-0.87	-0.50	X	169	-0.50	-0.50	X	180			-0.25	-0.75	X	2		
54	22	-1.62	-0.87	X	167	-1.62	-0.62	X	154	-1.75	-0.25	X	70	1 EXO	0	-1.75	-0.25	X	170	2 EXO	0
		-2.37	-0.25	X	124	-2.25	-0.37	X	116	-1.50	-0.25	X	30			-1.75					
55	23	-1.00	-0.37	X	134	-0.87	-0.37	X	135	-0.75				1 EXO	0	-0.75				0	0

		-0.87	-0.25	X	121	-0.75	-0.25	X	120	-0.75						-0.75					
56	26	-5.12	-2.12	X	5	-5.12	-2.12	X	6	-6.50	-1.50	X	180	1 EXO	0	-7.25	-1.00	X	5	1 EXO	0
		-4.50	-1.50	X	164	-4.50	-2.12	X	173	-4.75	-1.75	X	90			-5.75	-0.50	X	5		
57	22	-2.37	-1.00	X	21	-2.37	-0.62	X	26	-2.50				0	0	-2.75	-0.50	X	167	4 ESO	0
		-3.00	-0.75	X	157	-2.87	-0.75	X	152	-2.00	-0.75	X	178			-2.50	-1.25	X	180		
58	22	0.37	-0.25	X	5	0.00				0.00				4 ESO	0	-0.25				5 ESO	0
		0.37	-0.25	X	132	0.25	-0.75	X	136	0.25						0.25					
59	24	-3.75				-3.62				-3.75				1 ESO	0	-4.00				1 ESO	0
		-3.12	-1.00	X	131	-3.12	-0.87	X	137	-3.25	-0.25	X	142			-3.25	-0.50	X	140		
60	23	-3.75				-3.75				-3.50	-0.25	X	180	0		-3.25	-0.25	X	20	2 EXO	0
		-4.12	-0.37	X	152	-4.12	-0.50	X	158	-4.50					.5 BD	-4.00	-0.50	X	70		
61	25	-0.50	-1.50	X	12	-0.37	-1.62	X	14	-2.00	-0.25	X	170	3 ESO	0	-2.25				0	0
		-3.87	-1.37	X	170	-3.37	-1.62	X	167	-4.25	-0.50	X	20			-4.50					
62	25	-4.62				-4.37	-0.50	X	124	-4.50	-0.25	X	124	3 EXO	0	-4.75	-0.25	X	100	1 EXO	0
		-4.25	-0.25	X	124	-4.25				-4.50						-4.50					
63	30	0.00	-0.62	X	133	0.12	-0.62	X	132	-0.50	-0.25	X	124	0	0	-0.25	-0.25	X	135	0	0
		0.00	-0.50	X	161	0.00	-0.50	X	162	-0.25	-0.50	X	1			-0.50					
64	22	1.25	-1.37	X	8	0.87	-1.25	X	25	0.50	-1.50	X	14	3 EXO	0	0.75	-2.00	X	11	2 EXO	0
		0.75	-1.12	X	177	0.62	-0.87	X	177	0.50	-1.00	X	6			0.50	-1.25	X	180		
65	29	-2.37	-1.12	X	162	-2.62	-0.75	X	1	-1.75				1 ESO	0	-1.75	-0.25	X	95	0	0
		-1.75	-1.00	X	10	-1.87	-0.37	X	175	-2.00						-2.00					
66	24	-1.62	-1.37	X	89	-1.37	-1.50	X	86	-0.50	-1.75	X	84	2 EXO	0	-1.75	-1.50	X	83	1 ESO	0
		-2.25	-1.12	X	91	-2.25	-1.25	X	84	-1.00	-1.00	X	95			-1.75	-1.25	X	70		
67	27	-0.62	-0.87	X	132	-0.37	-1.75	X	123	0.00	-0.50	X	110	3 EXO		-0.50	-1.00	X	105	3 EXO	0
		-0.37	-1.12	X	89	-0.25	-1.12	X	94	0.00					1 BD	-0.50	-0.75	X	77		
68	21	-0.50	-0.37	X	117	-0.50	-0.50	X	151	-0.50				2 ESO	0	-0.50				1 ESO	0
		-0.12	-0.50	X	140	-0.37	-0.37	X	136	-0.50						-0.25					
69	25	-2.12	-0.50	X	110	-2.25	-0.25	X	84	-1.50	-0.50	X	110	1 ESO		-2.00	-0.75	X	105	2 ESO	
		-2.25	-0.75	X	91	-2.00	-0.87	X	1	-1.50	-0.25	X	75		1 BU	-2.00	-0.50	X	83		1 BU
70	21	-0.12	-1.50	X	38	-0.25	-1.50	X	32	-1.25	-0.50	X	38	7 EXO	0	-1.50	-0.25	X	15	9 EXO	0
		-1.12	-1.62	X	39	-1.37	-1.12	X	40	-1.25	-0.25	X	40			-1.25	-0.50	X	150		
71	37	-4.25	-0.25	X	154	-4.12	-0.87	X	167	-3.75				1 EXO		-4.75				3 ESO	
		-4.25	-0.75	X	143	-4.12	-1.00	X	144	-3.50	-0.50	X	138		2 BU	-4.50	-0.50	X	144		2 BU
72	25	-1.12	-2.00	X	28	-1.25	-1.87	X	26	-2.50	-0.75	X	55	9 ESO		-2.25	-1.00	X	65	7 ESO	0
		0.12	-1.25	X	128	0.62	-1.37	X	38	0.75	-0.75	X	101		2 BU	1.00	-1.00	X	100		
73	34	-0.62	-0.25	X	65	-0.12	-0.25	X	104	-0.50				3 EXO	0	-0.50				1 EXO	0
		-0.62	-1.00	X	168	-0.62	-1.25	X	173	-0.50	-0.75	X	173			-0.50	-1.00	X	172		

74	23	-0.37	-0.75	X	179	-0.37	-0.75	X	173	-0.25	-0.75	X	165	1 EXO	0	-0.25	-1.00	X	173	1 EXO	0
		0.50	-1.37	X	163	0.50	-1.37	X	165	0.50	-0.75	X	172			0.50	-0.75	X	175		
75	27	-9.25	-2.00	X	137	-9.50	-2.12	X	135	-9.75	-0.75	X	30	4 ESO		-9.50	-1.25	X	27	4 ESO	
		-7.12	-2.12	X	6	-7.50	-2.00	X	69	-9.50	-1.25	X	45		1 BU	-9.25	-2.00	X	47		1 BU

SUBJECT	AUTOREFRACTOR COMPARISONS							SUBJECTIVE REFRACTION COMPARISONS						
NUMBER	MONOC ES	BINOC ES	^SPHERE	^CYLINDER	^AXIS	^ES	^ANISO	RX 1 ES	RX 2 ES	^SPHERE	^CYLINDER	^AXIS	^ES	^ANISO
1	-0.19	-0.07	-0.12	0.00	1	-0.12	-0.06	0.50	0.13	0.25	0.25	0	0.38	0.13
	-0.19	-0.13	-0.13	0.13	7	-0.07		0.38	0.13	0.25	0.00	5	0.25	
2	-1.50	-1.75	0.25	0.00	3	0.25	0.44	-1.38	-2.00	0.50	0.25	3	0.63	-0.13
	-2.44	-2.25	-0.25	0.13	-4	-0.19		-1.75	-2.50	0.25	1.00	4	0.75	
3	-0.68	-0.75	0.00	0.13	2	0.07	0.32	0.00	-0.25	0.25	0.00	0	0.25	-0.25
	-0.50	-0.25	-0.25	0.00	-30	-0.25		0.25	-0.25	0.75	-0.50	0	0.50	
4	-1.81	-2.00	0.37	-0.37	-32	0.19	0.19	-1.25	-1.25	0.00	0.00	6	0.00	0.00
	-1.88	-1.87	-0.13	0.25	2	0.00		-1.13	-1.13	0.00	0.00	-10	0.00	
5	-3.94	-3.56	-0.13	-0.50	0	-0.38	-0.33	-3.38	-3.50	0.00	0.25	-5	0.13	-0.50
	-3.68	-3.63	0.13	-0.37	7	-0.06		-3.00	-3.63	0.25	0.75	0	0.63	
6	-0.13	-0.13	0.00	0.00	8	0.00	-0.01	-0.13	-0.25	0.00	0.25	5	0.13	0.13
	-0.43	-0.44	-0.12	0.25	0	0.01		-0.13	-0.13	0.00	0.00	-4	0.00	
7	-3.25	-3.18	0.00	-0.13	13	-0.06	-0.26	-2.75	-3.00	0.25	0.00	0	0.25	0.13
	-3.06	-3.25	0.25	-0.12	-2	0.19		-3.38	-3.50	0.25	-0.25	0	0.13	
8	-2.37	-2.38	-0.12	0.25	-1	0.00	0.00	-2.00	-2.00	0.00	0.00	1	0.00	0.00
	-2.44	-2.44	0.00	0.00	1	0.00		-1.88	-1.88	0.00	0.00	-3	0.00	
9	0.13	-0.01	0.13	0.00	1	0.13	0.18	0.25	0.13	0.25	-0.25	0	0.13	0.13
	-0.13	-0.19	0.13	-0.13	-5	0.07		0.38	-0.13	0.25	0.50	1	0.50	
10	-6.88	-7.00	0.00	0.25	-3	0.13	0.26	-6.50	-6.50	0.00	0.00	0	0.00	-0.13
	-5.94	-5.81	-0.13	0.00	-4	-0.13		-6.50	-6.63	0.00	0.25	0	0.13	
11	-2.93	-2.75	-0.12	-0.12	1	-0.18	-0.05	-2.75	-2.75	0.50	-1.00	0	0.00	-0.13
	-2.50	-2.37	-0.13	0.00	0	-0.13		-2.50	-2.63	0.00	0.25	0	0.13	
12	-2.62	-2.62	0.00	0.00	7	0.00	-0.13	-2.00	-2.75	0.75	0.00	0	0.75	0.13
	-2.31	-2.44	0.25	-0.25	6	0.13		-2.00	-2.63	0.50	0.25	0	0.63	
13	-0.13	-0.19	0.00	0.12	-8	0.06	0.07	0.13	0.00	0.25	-0.25	0	0.13	0.13
	0.25	0.00	0.25	0.00	1	0.25		0.00	0.00	0.00	0.00	0	0.00	
14	-1.31	-0.93	-0.25	-0.25	51	-0.38	-0.50	-0.25	0.00	-0.25	0.00	0	-0.25	-0.25
	-0.94	-1.06	0.12	0.00	-38	0.12		-0.50	-0.50	0.00	0.00	0	0.00	
15	-1.81	-1.63	-0.12	-0.12	7	-0.18	-0.06	-1.50	-1.38	0.00	-0.25	5	-0.13	-0.25
	-2.25	-2.13	0.00	-0.25	6	-0.13		-1.63	-1.75	0.00	0.25	-13	0.13	
16	-6.31	-6.06	-0.25	0.00	15	-0.25	-0.38	-4.75	-5.75	1.00	0.00	0	1.00	0.00
	-5.81	-5.94	0.00	0.25	-24	0.13		-4.50	-5.50	0.75	0.50	0	1.00	
17	-1.93	-2.06	0.00	0.25	3	0.13	0.12	-1.38	-1.50	0.00	0.25	2	0.13	0.25
	-2.37	-2.38	0.13	-0.25	-7	0.00		-2.13	-2.00	-0.25	0.25	5	-0.13	
18	-6.88	-7.12	0.37	-0.25	6	0.25	0.56	-6.25	-6.75	0.50	0.00	5	0.50	0.38

	-8.31	-8.00	-0.50	0.38	-11	-0.31		-7.63	-7.75	0.25	-0.25	0	0.13	
19	-0.56	-0.44	-0.12	0.00	0	-0.12	0.01	0.25	0.00	0.00	0.50	89	0.25	0.25
	-0.63	-0.50	-0.13	0.00	-3	-0.13		0.00	0.50	-0.50	0.00	3	-0.50	
20	-8.87	-8.75	-0.12	0.00	-4	-0.12	0.07	-8.75	-8.75	0.00	0.00	-5	0.00	0.00
	-8.81	-8.62	-0.13	-0.12	-10	-0.19		-8.75	-8.75	-0.25	0.50	0	0.00	
21	-7.43	-7.62	0.25	-0.12	0	0.19	-0.05	-7.38	-7.13	0.00	-0.50	-3	-0.25	0.00
	-7.50	-7.75	0.12	0.25	-2	0.25		-7.13	-6.88	0.00	-0.50	6	-0.25	
22	-1.19	-1.19	0.00	0.00	8	0.00	-0.12	-1.25	-1.13	0.00	-0.25	7	-0.13	0.00
	-1.13	-1.25	0.12	0.00	9	0.12		-1.25	-1.13	0.00	-0.25	1	-0.13	
23	1.50	1.25	0.37	-0.25	0	0.25	0.11	3.13	3.13	0.00	0.00	-3	0.00	0.00
	0.82	1.82	-1.25	0.50	1	-1.00		2.63	2.63	0.25	-0.50	-8	0.00	
24	-6.81	-6.94	0.25	-0.25	14	0.13	0.00	-6.75	-6.50	-0.25	0.00	0	-0.25	0.13
	-6.31	-6.44	0.00	0.25	0	0.13		-6.13	-5.75	-0.25	-0.25	0	-0.38	
25	-1.50	-1.56	0.13	-0.13	4	0.06	0.20	-1.38	-1.50	0.25	-0.25	0	0.13	0.13
	-1.81	-1.68	-0.13	0.00	-4	-0.13		-1.50	-1.50	0.25	-0.50	0	0.00	
26	-1.81	-1.43	-0.38	0.00	-12	-0.38	-0.45	-0.88	-0.88	0.00	0.00	6	0.00	-0.13
	-1.56	-1.62	0.00	0.13	22	0.06		-0.63	-0.75	0.25	-0.25	0	0.13	
27	0.12	0.12	0.00	0.00	0	0.00	0.05	0.25	-0.38	0.50	0.25	0	0.63	0.01
	0.00	0.19	-0.25	0.12	4	-0.19		0.13	-0.25	0.00	0.75	-13	0.38	
28	-3.50	-3.25	-0.25	0.00	-21	-0.25	-0.13	-2.75	-2.63	-0.25	0.25	0	-0.13	-0.13
	-3.00	-2.88	-0.12	0.00	-9	-0.12		-2.75	-2.75	0.00	0.00	0	0.00	
29	-0.68	-0.69	-0.24	0.50	-2	0.01	0.01	-0.50	-0.75	0.00	0.50	0	0.25	0.00
	-0.93	-0.93	0.00	0.00	-2	0.00		-0.75	-1.00	0.50	-0.50	3	0.25	
30	0.82	0.75	0.00	0.13	2	0.06	0.25	-0.13	0.13	-0.25	0.00	0	-0.25	0.00
	0.19	1.13	-0.88	-0.12	7	-0.94		0.75	0.75	0.25	-0.50	-3	0.00	
31	-7.00	-7.06	0.00	0.12	-6	0.06	0.06	-7.00	-6.75	-0.25	0.00	0	-0.25	0.13
	-6.25	-6.25	0.00	0.00	0	0.00		-6.25	-5.88	-0.50	0.25	0	-0.38	
32	-1.06	-1.06	0.00	0.00	15	0.00	0.01	-1.00	-1.25	0.25	0.00	0	0.25	0.00
	-0.75	-0.75	0.12	-0.25	2	-0.01		0.00	-0.25	0.25	0.00	0	0.25	
33	-6.75	-6.43	-0.38	0.12	-25	-0.32	-0.38	-6.88	-6.75	0.00	-0.25	2	-0.13	-0.13
	-7.25	-7.31	0.00	0.12	4	0.06		-7.63	-7.63	0.00	0.00	-4	0.00	
34	-4.00	-3.75	-0.12	-0.25	-2	-0.25	0.07	-3.13	-3.13	0.00	0.00	-10	0.00	0.13
	-4.06	-3.75	-0.25	-0.12	0	-0.31		-3.25	-3.13	0.00	-0.25	24	-0.13	
35	-0.25	-0.07	-0.37	0.37	0	-0.19	-0.19	0.25	-0.13	0.25	0.25	0	0.38	0.50
	-0.87	-0.88	0.13	-0.25	10	0.01		-0.25	-0.63	0.25	0.25	0	0.38	
36	-0.43	-0.44	-0.12	0.25	0	0.01	0.08	0.25	-0.25	0.25	0.50	0	0.50	0.13
	-0.13	-0.06	-0.13	0.12	6	-0.07		0.50	0.13	0.50	-0.25	0	0.38	

37	0.07	-0.07	0.13	0.00	2	0.13	0.06	0.88	0.75	0.25	0.25	0	0.13	0.00
	-0.07	-0.13	0.12	-0.12	38	0.06		0.75	0.63	0.00	0.25	0	0.13	
38	-4.56	-4.50	0.00	-0.12	0	-0.06	0.24	-5.38	-5.50	0.00	0.25	-2	0.13	0.13
	-5.18	-4.88	-0.37	0.13	-2	-0.31		-5.13	-5.13	0.00	0.00	-8	0.00	
39	-3.00	-2.88	-0.25	0.25	0	-0.13	-0.19	-2.50	-2.88	0.25	0.25	0	0.38	-0.13
	-3.50	-3.56	0.13	-0.13	1	0.06		-2.75	-3.26	0.25	0.50	0	0.50	
40	-0.01	-0.01	0.00	0.00	-1	0.00	0.06	0.25	0.25	0.00	0.00	0	0.00	0.12
	0.07	-0.13	0.25	-0.12	15	0.19		0.25	-0.13	0.25	0.25	0	0.38	
41	-3.94	-3.87	-0.13	0.13	6	-0.06	-0.32	-4.00	-4.00	0.00	0.00	0	0.00	-0.13
	-4.12	-4.37	0.25	0.00	22	0.25		-4.00	-4.13	0.25	-0.25	-3	0.13	
42	-0.19	-0.31	0.00	0.25	-14	0.13	0.13	0.00	0.00	0.00	0.00	0	0.00	0.00
	-0.19	-0.19	0.00	0.00	5	0.00		0.13	-0.13	0.25	0.00	-6	0.25	
43	-0.50	-0.63	0.25	-0.25	-3	0.13	-0.13	-0.50	-0.38	-0.25	0.25	-10	-0.13	-0.25
	-0.13	-0.38	0.25	0.00	15	0.25		-0.38	-0.50	0.00	0.25	-15	0.13	
44	-1.19	-1.00	-0.13	-0.12	1	-0.19	-0.25	-0.75	-0.75	0.00	0.00	0	0.00	-0.13
	-1.13	-1.19	0.00	0.12	6	0.06		-0.75	-0.88	0.00	0.25	0	0.13	
45	-3.75	-3.68	-0.13	0.12	-5	-0.07	-0.07	-3.88	-3.13	-0.75	0.00	-11	-0.75	-0.63
	-2.31	-2.31	0.13	-0.25	1	0.00		-1.75	-1.63	0.00	-0.25	15	-0.13	
46	-7.43	-7.63	0.13	0.13	1	0.20	-0.05	-8.00	-8.88	1.00	-0.25	5	0.88	0.63
	-8.38	-8.63	0.25	0.00	0	0.25		-9.25	-9.50	0.25	0.00	1	0.25	
47	-4.00	-3.87	0.00	0.25	1	-0.13	-0.26	-4.25	-4.38	0.00	0.25	0	0.13	-0.13
	-5.75	-5.88	0.13	0.00	-22	0.13		-5.50	-5.75	0.25	0.00	0	0.25	
48	-2.19	-2.19	0.00	0.00	6	0.00	0.00	-2.63	-2.00	-0.50	-0.25	-8	-0.63	-0.25
	-2.62	-2.62	0.00	0.00	-2	0.00		-2.88	-2.50	-0.25	-0.25	0	-0.38	
49	-2.25	-2.31	0.12	-0.13	4	0.06	-0.13	-1.88	-2.13	0.25	0.00	2	0.25	0.13
	-2.50	-2.69	0.25	-0.13	6	0.19		-2.38	-2.50	0.00	0.25	1	0.13	
50	-2.57	-3.50	0.12	1.62	4	0.93	0.99	-3.25	-3.50	0.50	-0.50	0	0.25	0.00
	-3.93	-3.88	-0.12	0.13	-1	-0.06		-3.38	-3.63	0.25	0.00	-1	0.25	
51	-3.81	-3.68	-0.13	0.00	-1	-0.13	-0.13	-3.25	-3.63	0.25	0.25	1	0.38	0.38
	-3.93	-3.93	0.00	0.00	-8	0.00		-3.38	-3.38	0.00	0.00	12	0.00	
52	-2.19	-2.25	-0.13	0.38	-2	0.06	0.18	-1.75	-1.63	-0.25	0.25	2	-0.13	-0.13
	-2.12	-2.00	-0.12	0.00	2	-0.12		-1.38	-1.38	0.25	-0.50	-1	0.00	
53	-1.50	-1.56	-0.25	0.62	16	0.06	0.19	-1.50	-1.25	-0.25	0.00	0	-0.25	-0.13
	-1.25	-1.12	0.00	-0.25	-25	-0.13		-0.75	-0.63	-0.25	0.25	2	-0.13	
54	-2.06	-1.93	0.00	-0.25	13	-0.13	-0.06	-1.88	-1.88	0.00	0.00	79	0.00	-0.13
	-2.50	-2.44	-0.12	0.12	8	-0.06		-1.63	-1.75	0.25	0.25	0	0.13	
55	-1.19	-1.06	-0.13	0.00	-1	-0.13	-0.01	-0.75	-0.75	0.00	0.00	0	0.00	0.00

	-1.00	-0.88	-0.12	0.00	1	-0.12		-0.75	-0.75	0.00	0.00	0	0.00	
56	-6.18	-6.18	0.00	0.00	-1	0.00	-0.31	-7.25	-7.75	0.75	-0.50	5	0.50	0.13
	-5.25	-5.56	0.00	0.62	-9	0.31		-5.63	-6.00	1.00	-1.25	85	0.38	
57	-2.87	-2.68	0.00	-0.38	-5	-0.19	-0.06	-2.50	-3.00	0.25	0.50	0	0.50	-0.25
	-3.38	-3.25	-0.13	0.00	5	-0.13		-2.38	-3.13	0.50	0.50	-2	0.75	
58	0.25	0.00	0.37	-0.25	0	0.25	-0.13	0.00	-0.25	0.25	0.00	0	0.25	0.25
	0.25	-0.13	0.12	0.50	-4	0.37		0.25	0.25	0.00	0.00	0	0.00	
59	-3.75	-3.62	-0.13	0.00	0	-0.13	-0.06	-3.75	-4.00	0.25	0.00	0	0.25	0.13
	-3.62	-3.56	0.00	-0.13	-6	-0.06		-3.38	-3.50	0.00	0.25	2	0.13	
60	-3.75	-3.75	0.00	0.00	0	0.00	-0.07	-3.63	-3.38	-0.25	0.00	20	-0.25	0.00
	-4.31	-4.37	0.00	0.13	-6	0.07		-4.50	-4.25	-0.50	0.50	0	-0.25	
61	-1.25	-1.18	-0.13	0.12	-2	-0.07	0.31	-2.13	-2.25	0.25	-0.25	0	0.13	0.13
	-4.56	-4.18	-0.50	0.25	3	-0.38		-4.50	-4.50	0.25	-0.50	0	0.00	
62	-4.62	-4.62	-0.25	0.50	0	0.00	0.13	-4.63	-4.88	0.25	0.00	24	0.25	0.25
	-4.38	-4.25	0.00	-0.25	0	-0.13		-4.50	-4.50	0.00	0.00	0	0.00	
63	-0.31	-0.19	-0.12	0.00	1	-0.12	-0.12	-0.63	-0.38	-0.25	0.00	-11	-0.25	-0.25
	-0.25	-0.25	0.00	0.00	-1	0.00		-0.50	-0.50	0.25	-0.50	0	0.00	
64	0.57	0.25	0.38	-0.12	-17	0.32	0.32	-0.25	-0.25	-0.25	0.50	3	0.00	-0.13
	0.19	0.19	0.13	-0.25	0	0.00		0.00	-0.13	0.00	0.25	6	0.13	
65	-2.93	-3.00	0.25	-0.37	19	0.06	0.26	-1.75	-1.88	0.00	0.25	0	0.13	0.13
	-2.25	-2.06	0.12	-0.63	15	-0.20		-2.00	-2.00	0.00	0.00	0	0.00	
66	-2.31	-2.12	-0.25	0.13	3	-0.19	-0.25	-1.38	-2.50	1.25	-0.25	1	1.13	0.25
	-2.81	-2.88	0.00	0.13	7	0.06		-1.50	-2.38	0.75	0.25	25	0.88	
67	-1.06	-1.25	-0.25	0.88	9	0.19	0.31	-0.25	-1.00	0.50	0.50	5	0.75	-0.13
	-0.93	-0.81	-0.12	0.00	-5	-0.12		0.00	-0.88	0.50	0.75	0	0.88	
68	-0.69	-0.75	0.00	0.13	-34	0.06	-0.12	-0.50	-0.50	0.00	0.00	0	0.00	0.25
	-0.37	-0.56	0.25	-0.13	4	0.19		-0.50	-0.25	-0.25	0.00	0	-0.25	
69	-2.37	-2.38	0.13	-0.25	26	0.00	0.20	-1.75	-2.38	0.50	0.25	5	0.63	0.00
	-2.63	-2.44	-0.25	0.12	90	-0.19		-1.63	-2.25	0.50	0.25	-8	0.63	
70	-0.87	-1.00	0.13	0.00	6	0.13	0.13	-1.50	-1.63	0.25	-0.25	23	0.13	0.00
	-1.93	-1.93	0.25	-0.50	-1	0.00		-1.38	-1.50	0.00	0.25	70	0.13	
71	-4.38	-4.56	-0.13	0.62	-13	0.18	0.19	-3.75	-4.75	1.00	0.00	0	1.00	0.00
	-4.63	-4.62	-0.13	0.25	-1	0.00		-3.75	-4.75	1.00	0.00	-6	1.00	
72	-2.12	-2.19	0.13	-0.13	2	0.06	0.51	-2.88	-2.75	-0.25	0.25	-10	-0.13	0.25
	-0.51	-0.07	-0.50	0.12	90	-0.44		0.38	0.50	-0.25	0.25	1	-0.13	
73	-0.75	-0.25	-0.50	0.00	-39	-0.50	-0.63	-0.50	-0.50	0.00	0.00	0	0.00	-0.13
	-1.12	-1.25	0.00	0.25	-5	0.13		-0.88	-1.00	0.00	0.25	1	0.13	

74	-0.75	-0.75	0.00	0.00	6	0.00	0.00	-0.63	-0.75	0.00	0.25	-8	0.13	0.13
	-0.19	-0.19	0.00	0.00	-2	0.00		0.13	0.13	0.00	0.00	-3	0.00	
75	-10.25	-10.56	0.25	0.12	2	0.31	-0.01	-10.13	-10.13	-0.25	0.50	3	0.00	-0.13
	-8.18	-8.50	0.38	-0.12	-63	0.32		-10.13	-10.25	-0.25	0.75	-2	0.13	

Appendix F

Traditional															
Subject #	50	52	47	36	64	45	25	2	39	23	57	75	71	26	Avg.
Acuity	7	6	7	6	7	4	7	6	4	7	3	4	6	7	5.80
Tension	7	5	7	6	5	7	7	5	7	7	3	0	7	2	5.40
Headaches	7	7	7	6	7	7	7	7	7	7	4	1	7	3	6.00
Unnaturalness	7	5	7	4	6	7	7	6	7	7	4	1	7	2	5.50
Pulling	7	4	7	7	7	7	7	7	7	7	3	1	7	2	5.70
Diplopia	7	7	7	7	7	7	7	7	2	7	7	5	7	7	6.50
Burning	7	7	7	6	7	7	7	7	7	7	7	7	7	7	6.90
Sens. to light	7	7	7	6	3	7	7	3	7	7	6	4	7	4	5.90
Glare	7	7	7	4	2	7	7	7	7	7	7	3	7	7	6.10
Dizziness	7	5	7	3	7	7	7	7	7	7	3	2	7	3	5.60
Eye strain	7	5	6	6	5	2	7	6	7	7	2	1	7	2	5.00
Tired eyes	7	5	6	6	6	3	7	6	7	7	2	2	7	2	5.20
Itching	7	7	3	6	7	7	7	7	7	7	7	7	7	7	6.60
Comfort	7	5	7	6	5	4	7	6	3	7	3	2	7	3	5.10
Average	7.00	5.90	6.60	5.60	5.80	6.08	7.00	6.20	6.38	7.00	4.40	2.90	6.90	4.23	5.90
Binocular															
Acuity	7	7	7	7	7	6	6	0	6	6	2	6	7	7	5.80
Tension	7	7	7	2	7	3	6	0	5	6	0	3	7	7	4.80
Headaches	7	7	6	0	7	4	7	4	4	6	0	3	7	7	4.90
Unnaturalness	7	7	3	2	6	4	3	0	4	7	0	4	5	7	4.20
Pulling	7	7	6	0	6	7	7	0	4	7	0	1	7	7	4.70
Diplopia	7	7	7	7	7	7	7	7	7	7	7	6	7	7	6.90
Burning	7	7	7	2	7	7	7	2	4	7	6	7	7	7	6.00
Sens. to light	7	7	2	3	3	7	7	3	7	6	6	5	7	6	5.40
Glare	7	7	6	7	4	6	7	6	7	6	6	5	7	7	6.30
Dizziness	7	7	6	4	7	2	7	3	7	7	0	5	5	7	5.30
Eye strain	7	7	6	1	6	6	6	0	4	7	0	3	7	7	4.80
Tired eyes	6	7	5	1	6	7	6	0	4	7	0	4	7	7	4.80
Itching	7	7	5	5	7	7	6	5	7	7	7	7	7	7	6.50
Comfort	7	7	6	2	6	6	6	0	6	7	0	4	6	7	5.00
Average	6.90	7.00	5.60	3.10	6.10	5.60	6.30	2.10	5.40	6.60	2.40	4.50	6.60	6.90	5.35
Subject															
Preference*	4	7	1	1	6	6	4	2	7	4	2	7	4	7	4.42
Avg. Wearing															
Time															
Traditional	14	14	14	5	10	12	8	15	14	14	3	16	5	14	11.20
Binocular	14	14	14	2	10	12	10	2	14	14	1	16	5	14	10.00

APPENDIX G: Summary of Spectacle Trial

Subject # 2

Traditional Refraction:	Binocular Refraction:
OD: -.25-2.25X178	OD: -0.75-2.50X175
OS: -0.75-2.00X004	OS: -1.00-3.00X180 .50 BD

Difference in sphere:	OD 0.50	
	OS 0.25	
Difference in cylinder:	OD 0.25	
	OS 1.00	
Difference in equivalent sphere:	OD 0.63	
	OS 0.75	
Difference in axis	OD 3	
	OS 4	
Difference in aniso	-0.13	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	6.2	15
Binocular:	2.1	2
Overall rating:	Moderately preferred traditional	

Subject # 23

Traditional Refraction:	Binocular Refraction:
OD: 3.75-1.25X093	OD: 3.75-1.25X096
OS: 3.25-1.25X081	OS: 3.00-0.75X089

Difference in sphere:	OD 0.00	
	OS 0.25	
Difference in cylinder:	OD 0.00	
	OS -0.50	
Difference in equivalent sphere:	OD 0.00	
	OS 0.00	
Difference in axis	OD 7	
	OS 0	
Difference in aniso	0.00	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	7.0	14
Binocular:	6.6	14
Overall rating:	Liked both equally	

Subject # 25

Traditional Refraction:	Binocular Refraction:
OD: -1.25-0.25X120	OD: -1.50
OS: -1.25-0.50X049	OS: -1.50 1 BD

Difference in sphere:	OD 0.25	
	OS 0.25	
Difference in cylinder:	OD -0.25	
	OS -0.50	
Difference in equivalent sphere:	OD 0.13	
	OS 0.00	
Difference in axis	OD 0	
	OS 0	
Difference in aniso	0.13	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	7.0	8
Binocular:	6.3	10
Overall rating:	Liked both equally	

Subject # 28

Traditional Refraction:	Binocular Refraction:
OD: 0.25	OD: -0.25-0.25X065
OS: 0.25-0.25X120	OS: 0.25-1.00X133

Difference in sphere:	OD 0.50	
	OS 0.00	
Difference in cylinder:	OD 0.25	
	OS 0.75	
Difference in equivalent sphere:	OD 0.63	
	OS 0.38	
Difference in axis	OD 0	
	OS -13	
Difference in ansio	0.00	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	4.1	14
Binocular:	6.9	14
Overall rating:	Strongly preferred binocular	

Subject # 36

Traditional Refraction:	Binocular Refraction:
OD: 0.25	OD: 0.00-0.50X105
OS: 0.50	OS: 0.00-0.25X092

Difference in sphere:	OD 0.25
	OS 0.50
Difference in cylinder:	OD 0.50
	OS -0.25
Difference in equivalent sphere:	OD 0.50
	OS 0.38
Difference in axis	OD 0
	OS 0
Difference in aniso	0.50

		Avg. wearing time (hrs/day)
Avg. scaling score		
Traditional:	5.6	5
Binocular:	3.1	2
Overall rating:	Strongly preferred traditional	

Subject # 39

Traditional Refraction:	Binocular Refraction:
OD: -2.50	OD: -2.75-0.25X040
OS: -2.75	OS: -3.00-0.50X180

Difference in sphere:	OD 0.25
	OS 0.25
Difference in cylinder:	OD 0.25
	OS 0.50
Difference in equivalent sphere:	OD 0.38
	OS 0.50
Difference in axis	OD -2
	OS -8
Difference in aniso	0.13

		Avg. wearing time (hrs/day)
Avg. scaling score		
Traditional:	6.1	14
Binocular:	5.4	14
Overall rating:	Strongly preferred binocular	

Subject # 45

Traditional Refraction:	Binocular Refraction:
OD: -3.50-0.75X169	OD: -2.75-0.75X180
OS: -1.50-0.50X005	OS: -1.50-0.25X170 1 BD

Difference in sphere:	OD -0.75
	OS 0.00
Difference in cylinder:	OD 0.00
	OS -0.25
Difference in equivalent sphere:	OD -0.75
	OS -0.13
Difference in axis	OD 0
	OS 0
Difference in aniso	-0.13

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	5.9	12
Binocular:	5.6	12
Overall rating:	Moderately preferred binocular	

Subject # 47

Traditional Refraction:	Binocular Refraction:
OD: -4.25	OD: -4.25-0.25X057
OS: -5.50	OS: -5.75 2 BU

Difference in sphere:	OD 0.00
	OS 0.25
Difference in cylinder:	OD 0.25
	OS 0.00
Difference in equivalent sphere:	OD 0.13
	OS 0.25
Difference in axis	OD 5
	OS 1
Difference in aniso	0.63

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	6.6	14
Binocular:	5.6	14
Overall rating:	Strongly preferred traditional	

Subject # 50

Traditional Refraction:	Binocular Refraction:
OD: -3.00-0.50X162	OD: -3.50
OS: -3.00-0.75X035	OS: -3.25-0.75X036

Difference in sphere:	OD 0.50	
	OS 0.25	
Difference in cylinder:	OD -0.50	
	OS 0.00	
Difference in equivalent sphere:	OD 0.25	
	OS 0.25	
Difference in axis	OD 2	
	OS 1	
Difference in aniso	0.13	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	7.0	14
Binocular:	6.9	14
Overall rating:	Liked both equally	

Subject # 52

Traditional Refraction:	Binocular Refraction:
OD: -1.00-1.50X097	OD: -0.75-1.75X095
OS: -0.50-1.75X074	OS: -0.75-1.25X075

Difference in sphere:	OD -0.25	
	OS 0.25	
Difference in cylinder:	OD 0.25	
	OS -0.50	
Difference in equivalent sphere:	OD -0.13	
	OS 0.00	
Difference in axis	OD 1	
	OS 12	
Difference in aniso	0.38	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	5.9	14
Binocular:	7.0	14
Overall rating:	Strongly preferred binocular	

Subject # 57

Traditional Refraction:	Binocular Refraction:
OD: -2.50	OD: -2.75-0.50X167
OS: -2.00-0.75X178	OS: -2.50-1.25X180

Difference in sphere:	OD 0.25	
	OS 0.50	
Difference in cylinder:	OD 0.50	
	OS 0.50	
Difference in equivalent sphere:	OD 0.50	
	OS 0.75	
Difference in axis	OD 5	
	OS 85	
Difference in aniso	0.13	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	4.4	3
Binocular:	2.4	1
Overall rating:	Moderately preferred traditional	

Subject # 64

Traditional Refraction:	Binocular Refraction:
OD: 0.50-1.50X014	OD: 0.75-2.00X011
OS: 0.50-1.00X006	OS: 0.50-1.25X180

Difference in sphere:	OD -0.25	
	OS 0.00	
Difference in cylinder:	OD 0.50	
	OS -0.25	
Difference in equivalent sphere:	OD 0.00	
	OS 0.13	
Difference in axis	OD -11	
	OS 0	
Difference in aniso	0.25	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	5.8	10
Binocular:	6.1	10
Overall rating:	Moderately preferred binocular	

Subject # 71

Traditional Refraction:	Binocular Refraction:
OD: -3.75	OD: -4.75
OS: -3.50-0.50X138	OS: -4.50-0.50X144 2 BU

Difference in sphere:	OD 1.00	
	OS 1.00	
Difference in cylinder:	OD 0.00	
	OS 0.00	
Difference in equivalent sphere:	OD 1.00	
	OS 1.00	
Difference in axis	OD 23	
	OS 70	
Difference in ansio	0.00	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	6.9	5
Binocular:	6.6	5
Overall rating:	Liked both equally	

Subject # 75

Traditional Refraction:	Binocular Refraction:
OD: -9.75-0.75X030	OD: -9.50-1.25X027
OS: -9.50-1.25X045	OS: -9.25-2.00X047 1 BU

Difference in sphere:	OD -0.25	
	OS -0.25	
Difference in cylinder:	OD 0.50	
	OS 0.75	
Difference in equivalent sphere:	OD 0.00	
	OS 0.13	
Difference in axis	OD -8	
	OS -3	
Difference in aniso	0.13	

Avg. scaling score		Avg. wearing time (hrs/day)
Traditional:	2.9	16
Binocular:	2.9	16
Overall rating:	Strongly preferred binocular	