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The continuation of: A comparison of monocular and binocular refractive results in preprespyopes

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Abstract

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THE CONTINUATION OF: A COMPARISON OF MONOCULAR AND BINOCULAR REFRACTIVE RESULTS IN PREPRESPYOPES

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BIOGRAPHICAL SKETCHES

Jody R. Bickford grew up in northern California on her parents' cattle ranch. She was the high school class valedictorian for Lower Lake High School's class of 1987. After high school, Jody attended Santa Rosa Junior College where she was awarded an Associate Degree of Science in biology with highest honors. She then went on to California State University at Chico, California where she was awarded a Bachelor's Degree of Science in biology with a chemistry minor. At CSUC, she was a member of Omicron Theta Epsilon, the biology honor society, and was the 1991 recipient of their Vesta Holt Academic Scholarship. Jody will receive her Doctorate of Optometry in May, 1997 from Pacific University College of Optometry. While at Pacific, she was a member of Beta Sigma Kappa, the international optometric honor society, Phi Theta Upsilon, the optometric fraternity, and the Amigos service organization. Jody belongs to various professional organizations including the AAO, AOA, AOSA, and OEP. She was also recipient of the 1996 Vision Service Plan Scholarship for Clinical Excellence. Upon graduation, Jody will begin a residency program in hospital-based optometry.

Kimberly Tobolt grew up on her family's farm in Moorhead, MN. She graduated with honors from Concordia College in her hometown. She received a Bachelor of Arts degree with a major in biology and a minor in chemistry. While at Concordia, she was a member of the biological honor society, Adopt-A-Grandparent program, and the hockey cheerleading squad. She received the American Foundation for Vision Awareness Minnesota Affiliate Scholarship upon entering Pacific University College of Optometry. A member of the Beta Sigma Kappa International Optometric Honor Society, the National Optometric Student Association, and AOSA, Kimberly's interests in optometry include pediatrics and disease. Upon graduation, she plans on returning to Minnesota and pursuing practice in either a multidisciplinary clinic or private practice. Kimberly and her fiancee Matt enjoy cooking, travel, and many outdoor activities.

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ABSTRACT

It has been reported that binocular refraction methods yield different results than tradition refraction methods in slightly less than 10% of subjects. Binocular refraction is said to provide better balance between the eyes, and more accurate astigmatism measurements. The purpose of this study was to identify individuals whose binocular and traditional prescriptions differed, and to have subjects wear and rate spectacle lenses determined by each method. One hundred thirty prepresbyopic subjects were refracted twice in succession using both refraction methods in counterbalanced order. The AO Vectographic Slide was used for the binocular refractions. Autorefraction results were utilized as a common starting point for both methods. Refractions were judged different if there was: >0.25D difference in either spherical power, cylindrical power, equivalent sphere power, anisometropia (based on equivalent sphere), and vertical prism. They were also considered different if there was an induced cylindrical power due to axis shift of 0.25D or greater. It was found that 69%, or 90 subjects, had significant differences in one or more of these parameters. Thirty-eight subjects elected to participate in the doubly masked, randomized, crossover second phase of the study alternately wearing the results of each refraction method in identical frames. Following a three week wearing schedule, subjects completed a questionnaire. Based upon all subjects, mean sphere significantly differed by 0.22D, mean cyl differed by 0.04D, and mean equivalent sphere by 0.24D. Binocular refraction means were more minus for all three values. In

the clinical trial, 47% of the 38 subjects preferred the binocular prescription, 42% preferred the traditional prescription, and 11% liked both prescriptions equally. In conclusion, a high percentage of subjects in this study yielded statistically more minus spectacle lens prescriptions when refracted binocularly compared to the traditional method. In the clinical lens wear trial, neither refraction method yielded lens prescriptions that were preferred by a majority of the subjects in lens wear trials.

INTRODUCTION

Optometrists realize that most patients want to be binocular, and spend their time seeing with both eyes together. Why then, do we not determine a patient's lens prescription while they are in a binocular state? When we assess a patient's refractive error using traditional refraction methods, most tests are performed with one eye occluded. The complex interrelationship between accommodation and vergence is minimal when the patient is not binocular. It would then make sense to refract in a binocular state, while the patient's eyes are in their normal habitual posture.

This is a continuation of a study begun by Brenda Stephens Offerdahl and Kimberly Rosenthal Tinge. They designed a study to compare results from the traditional refraction method incorporating a standard projected slide to a binocular refraction with the American Optical Vectographic slide. One goal of their study was to determine the percentage of patients whose lens prescriptions would differ using both refraction techniques. They extended it further by allowing subjects with clinically significant differences between refractions to compare the resulting prescriptions in a clinical lens wear trial. We decided to continue their investigation with the goal of recruiting a larger subject pool for a more valid statistical treatment of the data. A more extensive analysis of the clinical lens wear trial subject's lens preference and subjective rating versus prescription difference was also performed.

STATEMENT OF PROBLEM

There are inherent limitations with the traditional means of refraction. Offerdahl and Tinge (7) described four main areas where binocular assessment would theoretically be superior to traditional refraction. The first is a more perfect binocular equalization between eyes. During lens equalization with the traditional refraction method, dissociative prisms are used causing the patient to manifest their phoric posture. This difference in vergence posture permits accommodation to fluctuate via the vergence-accommodation cross-link. If the effect is marked, it could lead to error in the spherical component of the refraction. In theory, the binocular lens balance determination should more valid with the patient manifesting normal associated vergence and accommodative postures.

Suppression is not addressed by traditional refractive means. The AO Vectographic slide allows continuous binocular feedback, which is useful when determining the correct prism or lens balance to minimize suppression. Grolman (1) reported that the critical control afforded by the vectographic technique is indicated by the alternation of acuity preference, as reported by many subjects, when a plus 0.06D and a plano lens were repeatedly interchanged before the two eyes. This indicates a high sensitivity to acuity balance between eyes when viewing targets on the vectographic slide. One such test target which detects binocular instability presents three lines of letters to the patient so that the first letter is seen by both eyes, the second letter only by the left eye, and the third letter only by the right. The order of presentation is then repeated throughout the remaining lines. In our exam protocol, an anisometropia check was performed using this portion of the slide. The patient was asked if any of the letters appeared dimmer or less stable than the others, indicating a less than optimal lens equalization or suppression tendency. For patients prone to suppression, it was our experience that as little as 0.25D change in sphere in either the plus or minus direction provided more stable binocularity.

The third consideration relates to Hering's law of equal innervation and the possibility of a manifest cyclophoria during monocular measurement conditions. The law states that innervation to the extrinsic muscles of one eye is equal to that to the other eye, resulting in movements of the two eyes that are equal and symmetrical (2). If one eye is occluded during axis determination with a significant phoria manifest, the axis could be influenced by the resulting cyclorotation. Under binocular conditions this cyclophoria would be latent so a more accurate axis would be found.

Another very useful function for the binocular method is measuring fixation disparity or associated phorias, which cannot be assessed with traditional refraction. Fixation disparity is a condition in which the images of a bifixated object do not stimulate exactly corresponding retinal points, but are still seen singly if they fall within Panum's areas. It may be considered to be a slight over- or underconvergence, or vertical misalignment, of the eyes (2). Under binocular viewing conditions the reduction to zero of the vertical misalignment of targets, or the associated phoria, is the most accurate and readily accepted method of precise vertical prism prescribing. This has been known for over 30 years (3). Utilizing the vectographic slide for refraction would also allow easy access to a fixation disparity target if one did commonly use this measurement to prescribe.

With these potential benefits in mind, the following questions were posed: 1) Is there a difference between refractive results for traditional and binocular refractions in the areas of spherical power, cylindrical power, equivalent spherical power, cylindrical axis location (from induced astigmatism), and vertical fixation disparity? 2) What proportion of patients will show a difference between traditional refraction and binocular refraction relative to these parameters? 3) Would these potential differences be clinically or statistically significant? 4) If differences do exist using some arbitrary criteria of presumed clinical significance, would these differences be large enough for patients to subjectively appreciate in lens wear trials? 5) Which refraction method would be superior based upon lens wear preference? 6) What parameters of difference are most likely to be predictive of subjective preference for a given refractive method?

REVIEW OF THE LITERATURE

A thorough literature review was completed by Offerdahl and Tinge (7). Their review described the development of binocular refraction techniques and studies comparing traditional and binocular methods were included. In this section, we will reiterate the main points made of the literature review.

The first standard instrument for binocular refraction was the Turville Infinity Balance (TIB), developed by Turville and advocated and modified by Morgan. The technique involved placing a septum between the two eyes, and a chart with left and right fields of letters. Later, Morgan developed the American Optical Project-o-chart slide so the refraction could be done using the TIB in conjunction with a phoropter in a real space 6 meter lane. (4).

Using the TIB and traditional refraction techniques, Morgan conducted a study on 215 of his patients. For spherical power he found a difference of 0.25D in 20% of his patients and a difference of 0.50D or more with 2% of his patients. There was no difference in cylinder power for any of his patients, however, 2% had an axis change of 10 degrees or more. He concluded that a total of 4% had a clinically significant difference in spectacle lens prescriptions using both refraction methods. This 4% included subjects with 0.50D or more difference in sphere power or with 10 degrees or more axis shift. Thirty-two patients also revealed a vertical fixation disparity, and Morgan prescribed the full associated amount. Two individuals were unable to adapt to this prism. Both of these patients were over the age of 50 and needed prism to fuse. Morgan assumed the prism he prescribed was too much for them to adapt to at their age (5).

Morgan also noted the benefits of monitoring suppression with the binocular technique in six of the 215 patients. The left eye sees the left portion of the chart, while the right eye views the right half of the chart. If one eye is suppressing, the corresponding portion of the chart will disappear. These six subjects indicated suppression of central vision in one eye. The addition of vertical prism, base-in prism or convex lenses restored binocular vision in five of them. One patient required vision therapy (5).

Later, with the development of polarization methods, a new chart was developed using polarized overlays. This early prototype had its problems due to poor contrast, lack of brightness, and greater tendency for suppression. In 1967, Grolman designed a better target slide with high resolution letters that were individually polarized on dichroic crystal film. This eliminated the overlays, which had reduced the luminance of the chart by 50%. This, in turn, allowed for better contrast and suppression monitoring (1). The target slide used in this study, the American Optical Vectographic Slide, was of this design.

Only one previously published study could be found that used the AO Vectographic Slide. West and Somers, in 1984, compared five common subjective techniques used for equalization of accommodative stimuli. They used the binocular equalization method with the AO Vectographic slide as the standard technique to which all comparisons were made. They judged this to be the most accurate balance method. They performed five common methods of balancing: vectographic, equal acuity through low plus blur, red-green equalization, 6 meter monocular cross-cylinder test for sphere, and equal loss of acuity with plus blur. Results from this study failed to show any statistical differences between the binocular balance method and other standard equalization techniques with people who had normal binocular vision (6).

The first stage of our study was patterned after Morgan's classic study. The criteria, however, were modified and more analysis parameters were added. The second stage of this study, the spectacle lens wear trial, is novel. Here, lens prescriptions obtained from traditional refraction methods were subjectively compared to those from binocular refraction methods using the AO Vectographic Slide.

METHODS

For consistency and to avoid confounding the results, our portion of the study carefully followed the same protocols as Offerdahl and Tinge. A total of 130 subjects, 75 from the Offerdahl-Tinge subject pool and 61 from ours, were seen at the Forest Grove Family Vision Center. Subjects were recruited from the Pacific University student body, and included optometry students and their spouses. There were 58 male subjects and 72 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 0.67M paragraph and the circle portion of the Bernell Stereofly 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 130 subjects who met the inclusion criteria and were examined by both methods of refraction.

Stage one of the study began by measuring the subjects' refractive errors with an autorefractor. The first 75 subjects were measured on the Canon R1 Autorefractor, and the remaining 55 with the Allergan Humphrey Automatic Refractor. These results provided a common starting point for the researchers in both refraction methods.

Subjects were then given two refractions. The traditional subjective refraction utilized the 20/400 to 20/10 Adult Acuity Slide (Wilson Ophthalmic Corporation). The American Optical Vectographic Slide was used for the binocular refraction. To avoid bias, the refractions were performed by two different researchers without access to the other's findings. 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 for the second refraction with the other examiner. A strict exam protocol was followed to ensure consistency (see Appendices A and B).

The second stage of the study involved only the subjects whose two refraction results showed differences which were judged to be clinically significant in the following parameters: spherical power, cylindrical power, cylinder axis (as converted to induced cylinder power), equivalent spherical power, and anisometropia (based on equivalent spherical power). A difference greater than 0.25D in any one parameter was considered significant. A difference in axis that would induce a 0.25D or greater equivalent difference in cylinder power was also considered significant (see Appendix C), as was any amount of vertical fixation disparity detected with the vectographic slide. Ninety subjects showed one or more 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 (BSBVA) for each refraction. Any vertical prism required to neutralize a fixation disparity on the vectographic slide was prescribed in full and split equally between the two eyes when greater than 1 prism diopter. Although we realize that lens prescriptions are often modified based upon practitioner's clinical wisdom, for consistency the BSBVA was prescribed to avoid confounding the variables. Because binocular refractive methods are often used for detecting and prescribing for vertical disparities, we elected to prescribe vertical prism from the binocular refraction only, although standard Von Graefe phorias were taken and recorded for the traditional refraction.

A total of thirty-eight subjects from the first phase chose to participate in the second stage of the study. These subjects were required to purchase one pair of glasses while a second identical pair, differing only in prescription, was supplied by the researchers. To avoid subject or researcher bias, an independent assistant inconspicuously 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. The assistant tagged the inside of one temple of each pair of glasses with a colored sticker for differentiation and recorded it on a master list. This information was not revealed to the researchers until all of the glasses had been dispensed and the trials completed. Subjects were randomly given one prescription to wear for one week and the other one for the second week. 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 each dispensing subjects were given a survey form. The form included instructions, a space to record hours each prescription was worn, a number scale to rate 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 (7).

After all the data and questionnaires were collected, data was analyzed to answer the original questions that prompted this investigation.

RESULTS

Our results were combined with Offerdahl and Tinges' and analyzed. The number of subjects meeting the criteria for inclusion in stage one totaled 130, or 260 eyes. Data from all subjects are listed in Appendix E. Of these 130 subjects, 90 (69%) met one or more criterion for differences in refraction results. The percentage of total subjects by qualifying criteria is summarized in Table 1.

TABLE 1: PERCENTAGE OF SUBJECTS BY QUALIFYING CRITERIA

Qualifying Criteria	% of Total 130 Subjects	% of 90 Qualifying Subjects	% of 38 Trial Subjects
Sph Power >0.25 D	38	54	61
Eq Sph >0.25 D	45	66	68
Cyl Power >0.25 D	25	37	47
Induced Cyl Power >/=0.25 D	20	29	32
Aniso >0.25 D	9	13	11
Vertical Prism	12	17	21

Sixty-two (69%) subjects qualified by more than one of the six parameters, with the majority qualifying due to a spherical or equivalent sphere difference.

Of the 69% of subjects who met the criteria for stage two, 38 decided to participate in the spectacle lens trial. Bar graphs were generated showing differences of sphere (Figure 1), equivalent sphere (Figure 2), cylinder power (Figure 3), induced cylinder power (Figure 4), anisometropia (Figure 5), and vertical prism (Figure 6) for the 90 subjects who qualified and the 38 clinical trial subjects. The primary purpose of the graphs is to show the magnitude and distribution of the differences between traditional and binocular refractions. The mean differences for each parameter can be found in Table 2. The mode values for the 90 subjects who qualified are as follows: sphere power 0.25D, equivalent sphere power 0.13D, cylinder power 0.00D, induced cylinder power 0.00D, and anisometropia -0.13D. The second purpose of the graphs is to allow a comparison between the spectacle trial group in stage two and the total subjects who qualified in stage one. Figures 1 through 6 show that the subjects who continued on through stage two were representative of the larger stage one group who qualified.

Statistical analyses were performed on the total sample of 130 subjects, the 90 who qualified, and the 38 subjects who completed the spectacle lens trial (see Table 2). Mean sphere, equivalent sphere, and cylinder power differences were statistically different between refractive methods. The binocular refraction means were more minus for all three values. Binocular refraction yielded approximately 0.25D more minus for both mean and equivalent sphere, which we had designated as being clinically significant prior to data collection. For the total 130 subjects, axis differences between the two refractions were found for more than 50% of eyes

TABLE 2. STATISTICAL ANALYSIS OF THE TOTAL SAMPLE, THE SUBJECTS WHO QUALIFED, AND THE SPECTACLE LENS TRIAL SUBJECTS

		TRADITIONAL		BINOCULAR				
	PARAMETER	MEAN	SD	MEAN	SD	DIFF	P	r
130 SAMPLE	SPHERE	-2.04	2.26	-2.26	2.28	-0.22	<.001	.99
	EQ SPHERE	-2.29	2.31	-2.53	2.32	-0.24	<.001	.99
	CYL PWR	-0.51	0.63	-0.56	0.67	-0.04	.02	.83
	ANISO	-0.02	.064	-0.03	0.64	-0.01	.73	.90
	INDUC CYL	N = 137 EYES		0.15	0.15	26 EYES > .25 D		
	VERT PRSM	N =15 SUBJ'S		.95 PD	.47 PD			
90 QULIFIED	SPHERE	-2.27	2.44	-2.55	2.44	-0.28	<.001	.99
	EQ SPHERE	-2.55	2.45	-2.87	2.45	-0.32	<.001	.99
	CYL PWR	-0.56	0.69	-0.63	0.73	-0.07	.007	.81
	ANISO	0.03	0.74	0.05	0.73	-0.02	.65	.87
	INDUC CYL	N = 101 EYES		0.15	0.17	18 EYES >. 25D		
	VERT PRSM	N = 15 SUBJ'S		.97 PD	.48 PD			
38 TRIALS	SPHERE	-1.83	2.31	-2.11	2.31	-0.28	<.001	.98
	EQ SPHERE	-2.14	2.23	-2.49	2.27	-0.35	<.001	.98
	CYL PWR	-0.63	0.67	-0.76	0.79	-0.13	.007	.77
	ANISO	0.09	0.66	-0.16	0.63	-0.07	.08	.83
	INDUC CYL	N = 48 EYES		-0.16	0.17	8 EYES > .25 D		
	VERT PRSM	N = 8 SUBJ'S		1.13 PD	.58 PD			

FIGURE 1: DIFFERENCES IN SPHERE POWER BETWEEN THE QUALIFYING SUBJECTS AND THE TRIAL SUBJECTS

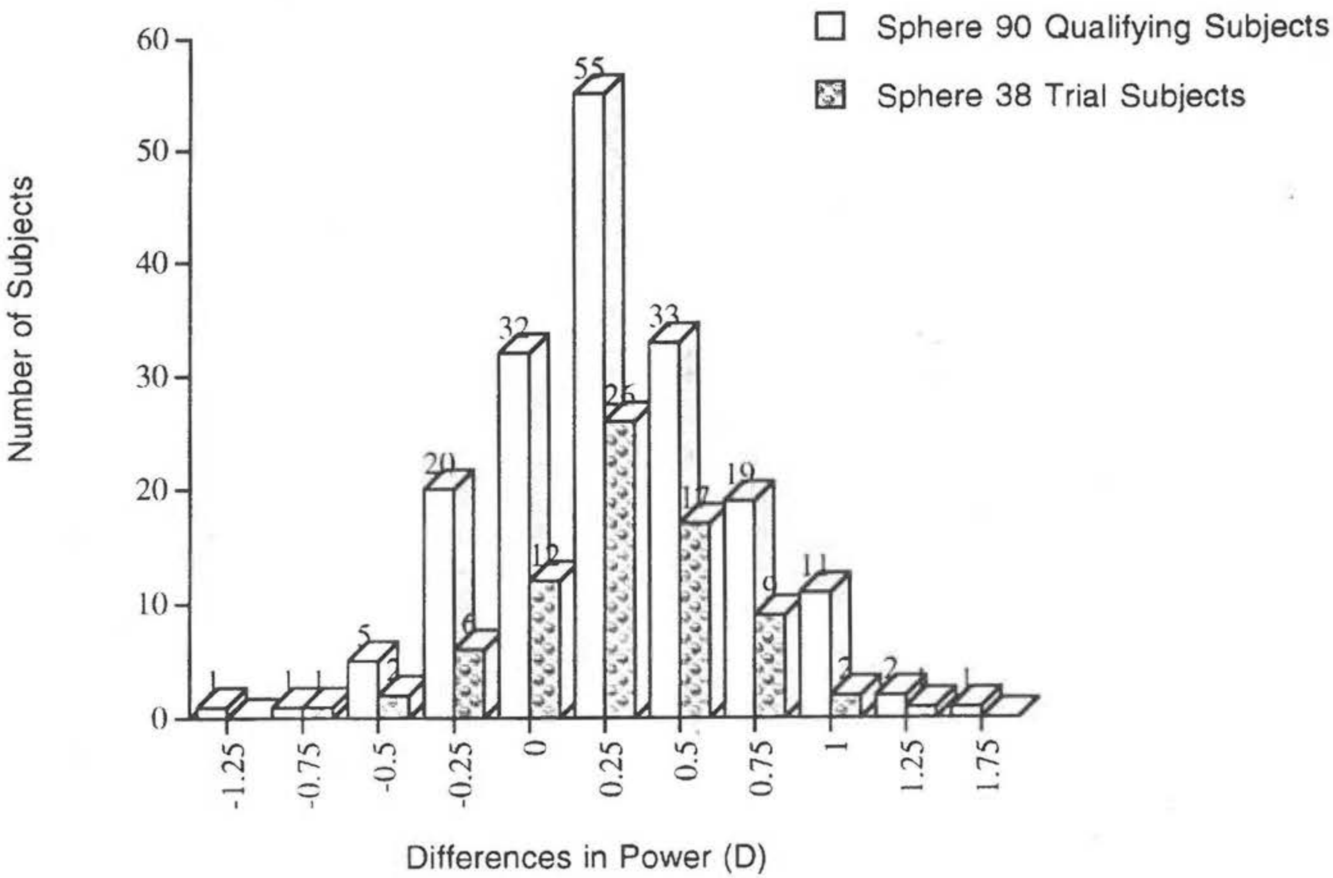


FIGURE 2: DIFFERENCES IN EQUIVALENT SPHERE POWER BETWEEN THE QUALIFIED SUBJECTS AND THE TRIAL SUBJECTS

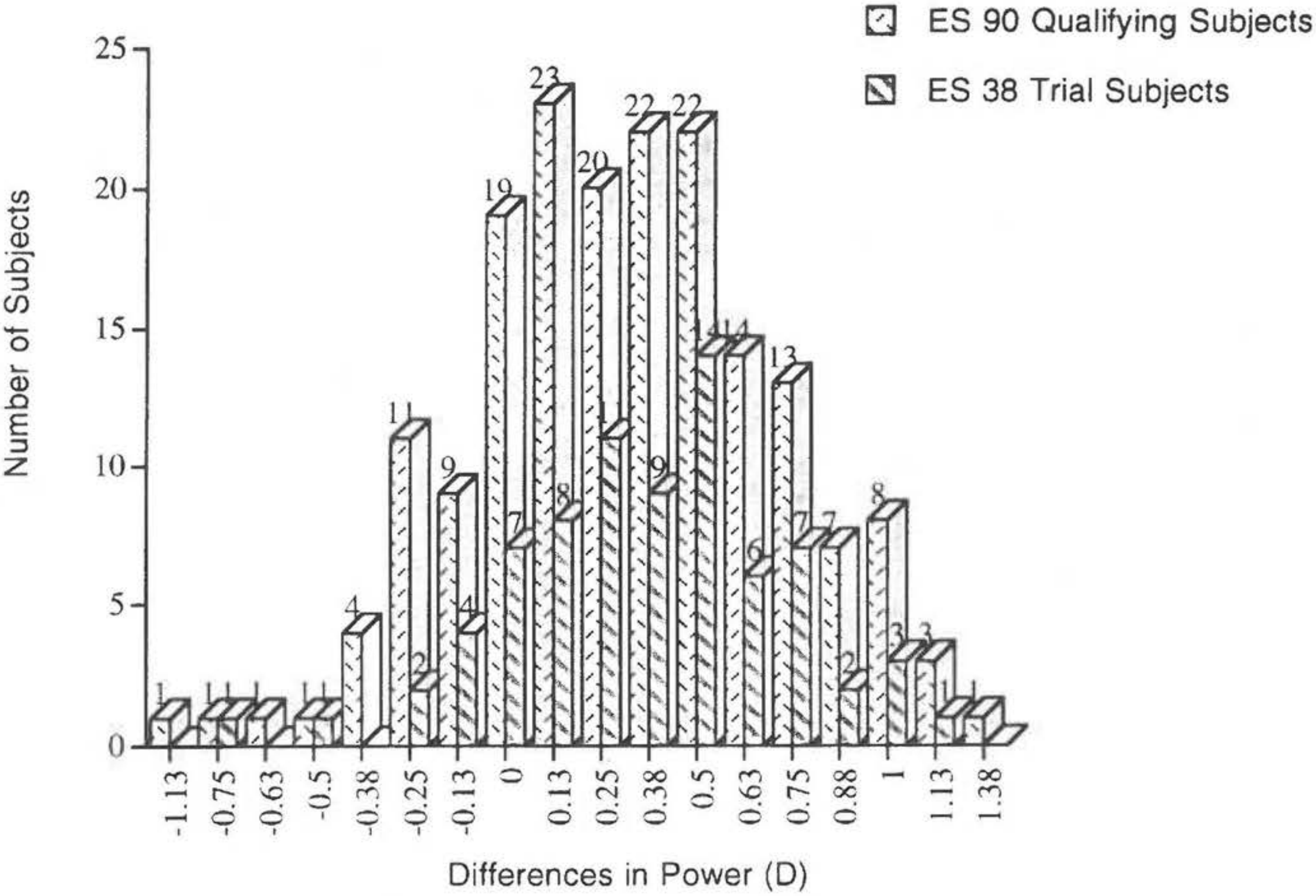


FIGURE 3: DIFFERENCES IN CYLINDER POWER BETWEEN THE QUALIFYING SUBJECTS AND THE TRIAL SUBJECTS

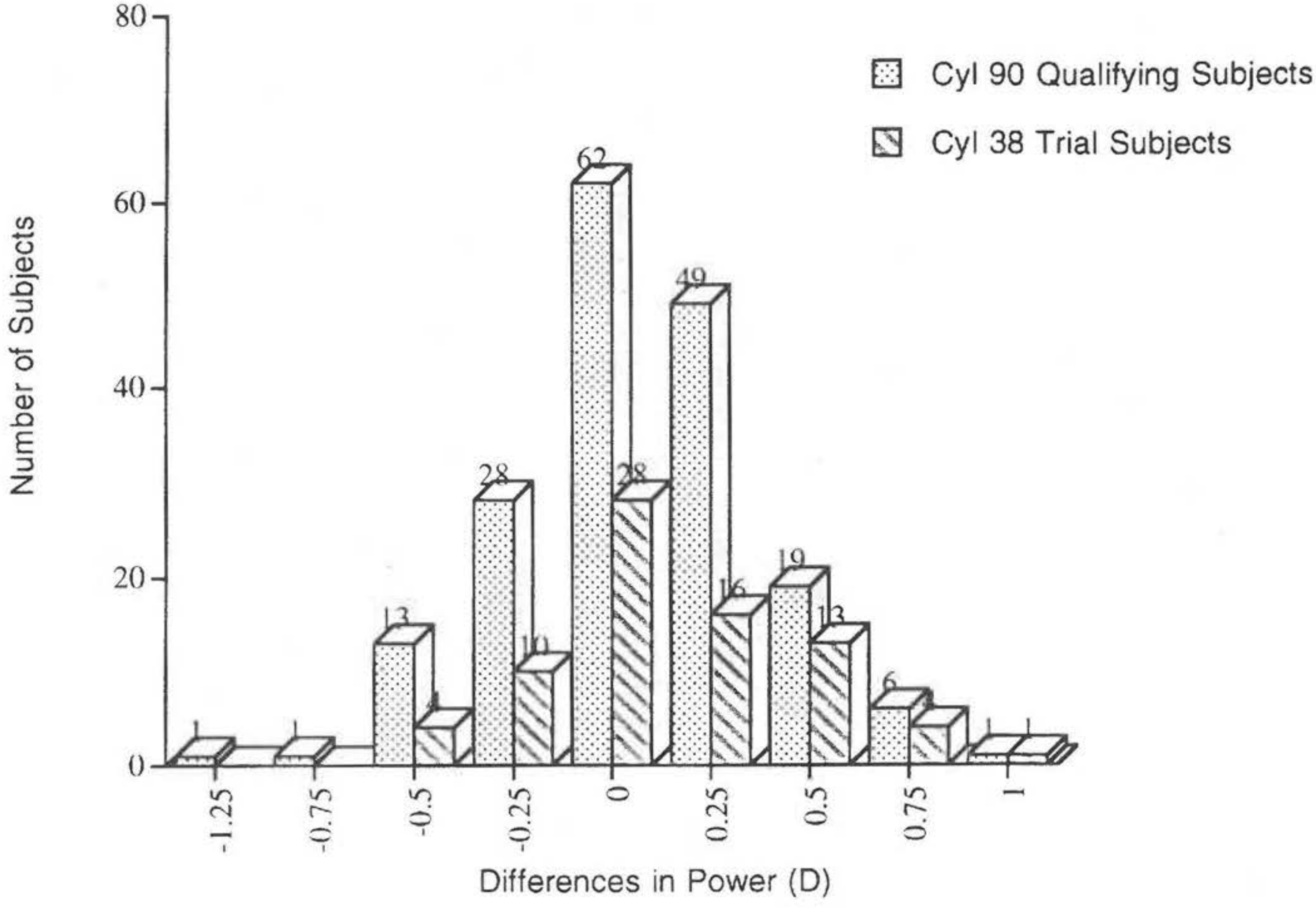


FIGURE 4: DIFFERENCES IN INDUCED CYLINDER POWER BETWEEN THE QUALIFYING SUBJECTS AND THE TRIAL SUBJECTS

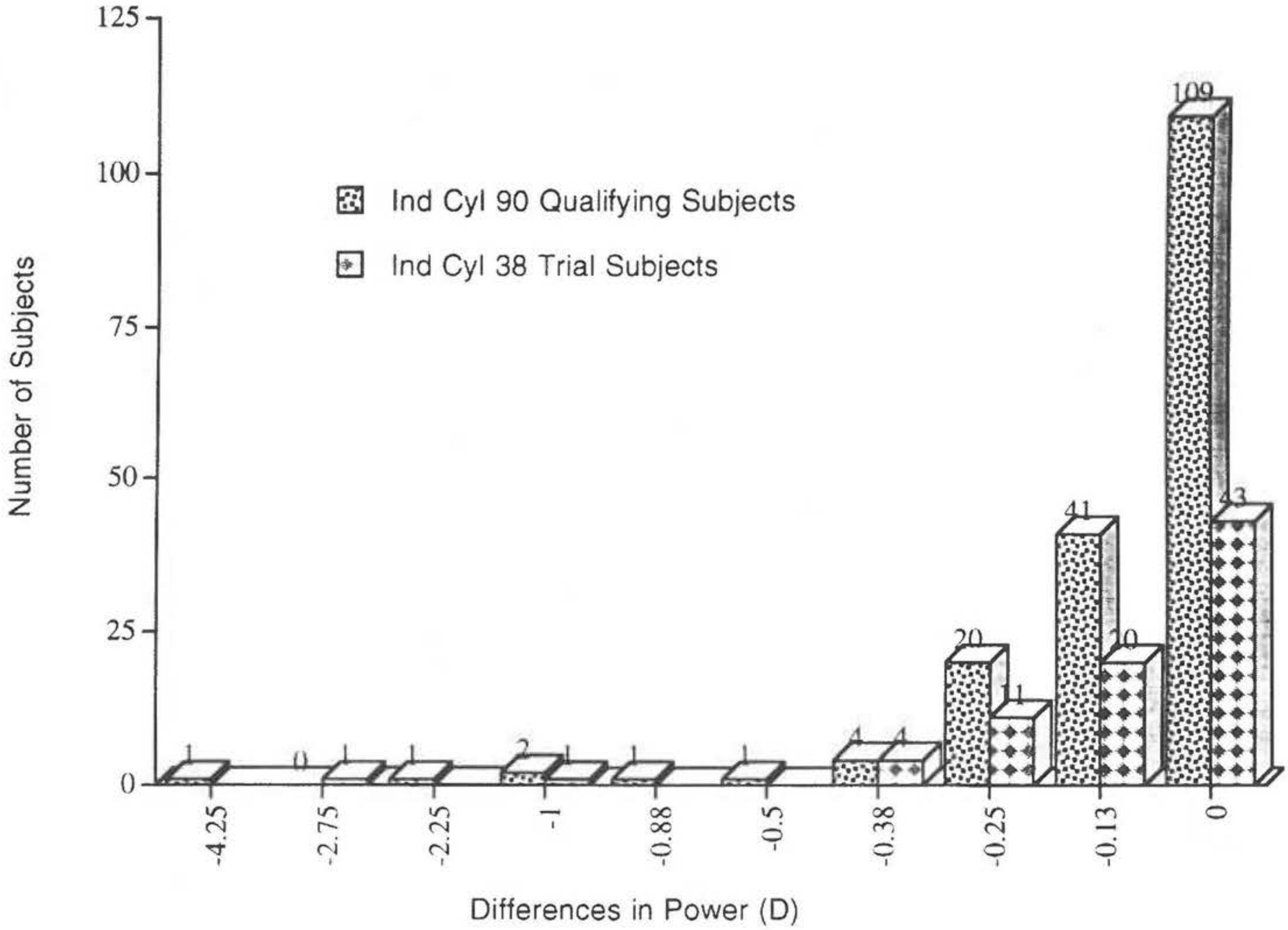


FIGURE 5: DIFFERENCES IN ANISOMETROPIA BETWEEN THE QUALIFYING SUBJECTS AND THE TRIAL SUBJECTS

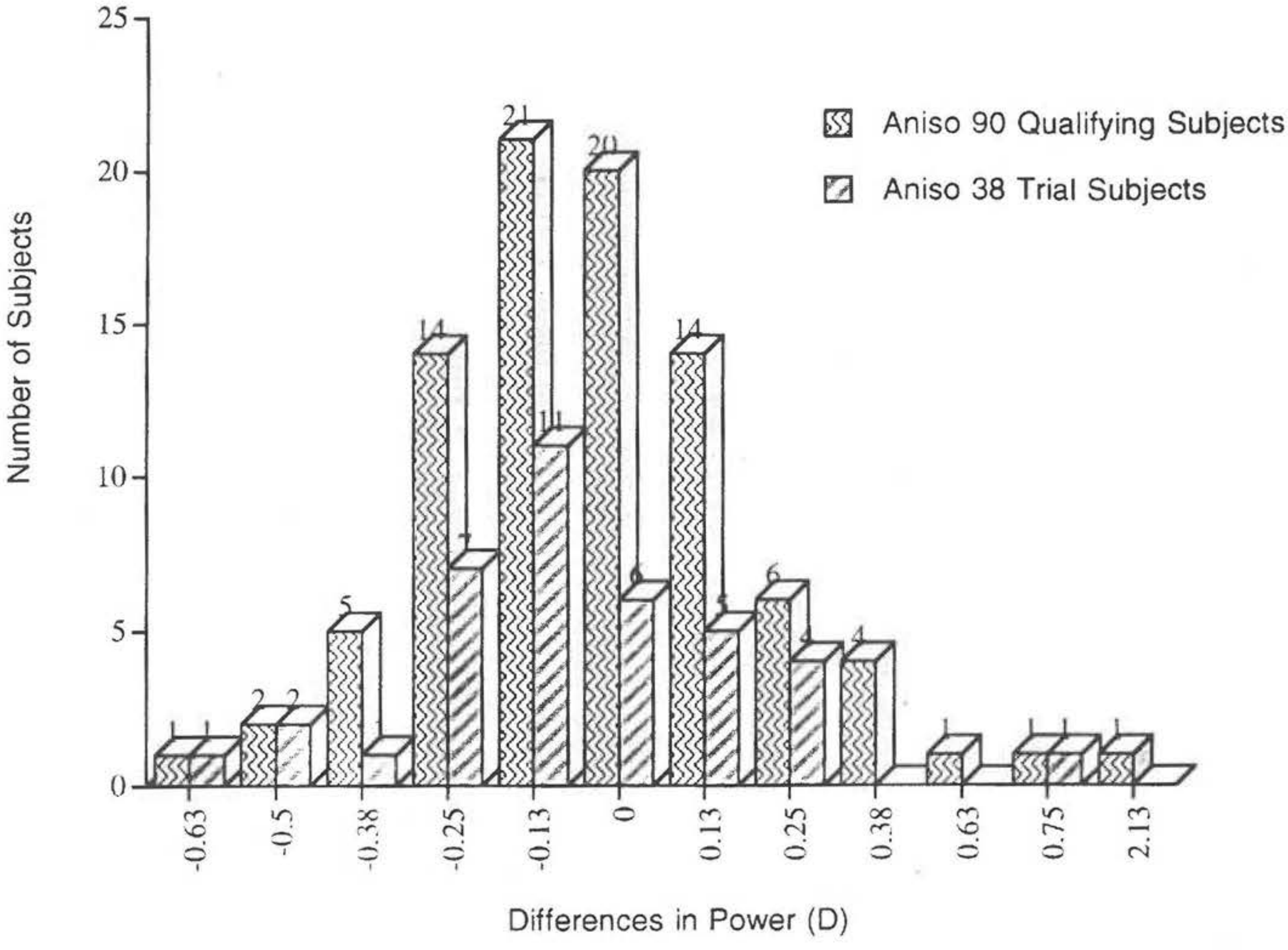
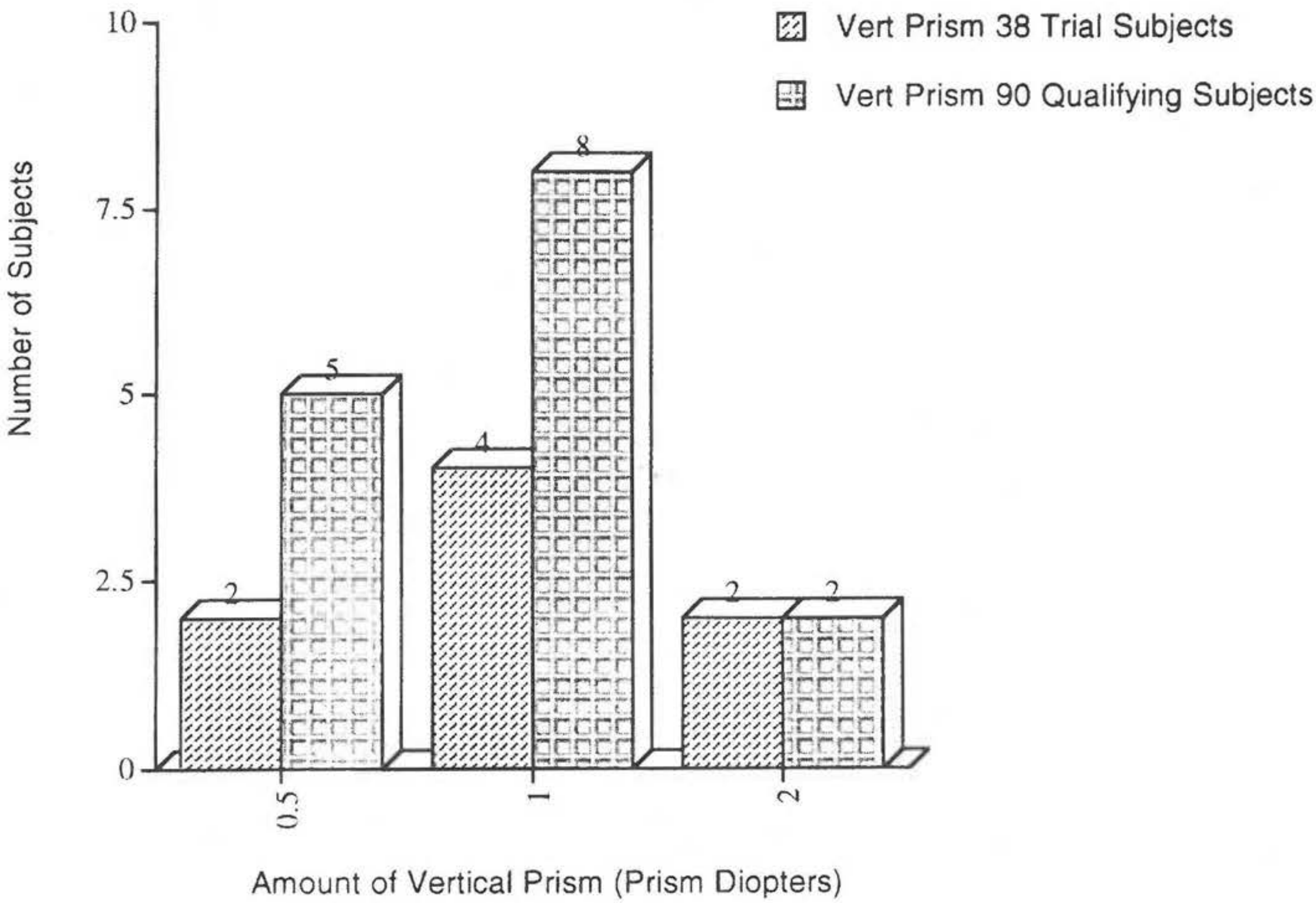


FIGURE 6: DIFFERENCES IN VERTICAL PRISM BETWEEN THE QUALIFYING SUBJECTS AND THE TRIAL SUBJECTS



examined. In 20% of all eyes examined, the axis change induced greater than a 0.25D cylinder power change. Mean anisometropias, which were based on equivalent spheres, were not significantly different between the two refraction methods. Twelve percent of the total 130 subjects revealed a vertical fixation disparity with the vectographic slide, with a mean prism amount of 0.95 prism diopters.

All 38 subjects in stage two of the spectacle lens trial completed and returned their questionnaires. A summary of their ranking of various asthenopic factors with each prescription and their preferences can be found in Appendix F. Forty-two percent of stage two subjects preferred lenses from the traditional refraction, 47% preferred binocular refraction lenses, and 11% liked both equally. In addition to selecting the spectacle lenses they liked best, subjects were asked to rate the strength of this choice. Of those preferring lenses from the traditional refraction, 44% strongly preferred, 37% moderately, and 19% slightly preferred the prescription. On the binocular refraction side, 50% strongly, 33% moderately and 17% slightly preferred the binocular lenses. Table 3 was constructed to illustrate patterns between preference level, number of qualifying criteria, and numbers of subjects having clinically significant differences in qualifying criteria. This table shows no obvious patterns as to why subjects chose either the traditional or binocular prescription as their preference for wear.

A second analysis was made to try to interpret why subjects choose the lens prescription they did. In the questionnaire, subjects were asked to rank various symptoms with 0 being total intolerance to 7 being complete satisfaction. Two tables were constructed to

TABLE 3. PREFERENCE LEVELS, NUMBERS OF QUALIFYING PARAMETERS, AND NUMBERS OF SUBJECTS HAVING CLINICALLY SIGNIFICANT DIFFERENCES IN PARAMETERS

	PREFERENCE LEVEL	SUBJ'S	NUMBERS OF QUALIFYING PARAMETERS FOR EACH LEVEL						NUMBERS OF SUBJECTS AT EACH LEVEL WITH CLINICALLY SIGNIFICANT DIFFERENCE PARAMETERS (<.25 D OR ANY VERT PRISM)					
		#	1	2	3	4	5	6	SPH	EQ SPH	CYL	ANISO (EQ SPH)	IND CYL	VERT PRISM
TRADITIONAL	STRONG	7	2	3	2	0	0	0	4	5	2	1	1	1
	MODERATE	7	1	2	3	0	1	0	6	6	3	0	3	1
	SLIGHT	3	0	1	0	1	1	0	3	2	3	1	2	0
	TRADITIONAL SUBTOTALS	17	3	6	5	1	2	0	13	13	8	2	5	2
	EQUAL	4	0	3	1	0	0	0	2	1	3	0	1	2
BINOCULAR	STRONG	9	2	6	1	0	0	0	4	6	4	1	1	2
	MODERATE	5	0	2	1	1	1	0	4	4	2	1	3	2
	SLIGHT	3	2	0	1	0	0	0	0	2	1	1	1	0
	BINOCULAR SUBTOTALS	17	4	8	3	1	1	0	8	12	7	3	6	4
	GRAND TOTALS	38	7	17	9	2	3	0	23	26	18	5	12	8

analyze this data. Table 4A includes subjects who moderately or strongly preferred the binocular prescription, while Table 4B lists subjects who moderately or strongly liked the traditional lenses. Both tables include an overall difference score for each subject. This score is the mean of the rankings for all symptoms for the traditional refraction subtracted from the mean of the symptom rankings for the binocular refraction. A list of symptoms ranked 0, 1, or 2 for the non-preferred lenses were also incorporated. Each symptom is listed in tables 4A and 4B by a number (see Table 5).

TABLE 5: SYMPTOM NUMBER FOR REFERENCE TO TABLES 4A AND 4B

1	acuity	5	pulling	9	glare	13	itching
2	tension	6	diplopia	10	dizziness	14	comfort
3	headaches	7	burning	11	eye strain		
4	unnatural	8	sens. to light	12	tired eyes		

Inclusion of each subject's habitual lens prescription allowed comparison to both the binocular and traditional refractions in this lens trial group. Figures bolded show positive factors between the two prescriptions that we felt attributed to each subject's lens preference.

Interesting findings can be found within these tables. Comparing the overall difference scores in table 4A with those in 4B, the values are generally higher for subjects preferring the traditional prescription than for those preferring the binocular. Some binocular-preferring subjects even show a negative score indicating that while they said they preferred the binocular prescription, their symptom ranking suggests they preferred the other. This difference in overall

TABLE 4A. SUBJECTS WHO STRONGLY OR MODERATELY PREFER THE BINOCULAR PRESCRIPTION
DIFFERENCE SCORES (BINOC-TRAD) COMPARED WITH THE SYMPTOMS DOWNSCORED FOR THE OTHER RX AT 0*, 1.O, OR 2.0.

	SUBJ #	PREF LEVEL	O. A. DIFF SCORE	SYMPTOMS SCORED 0,1, OR 2.	HABITUAL RX	RX 1 TRADITIONAL	RX 2 BINOCULAR	TRAD EQ SPH	BINOC EQ SPH	TRAD CYL	BINOC CYL	INDUC CYL CHNGE	TRAD ANIS0	BINOC ANISO	TRD PH	BIN PH
1	28	STRNG	2.79	11,12	-2.50 -2.50	-2.75 -2.75	-2.50-0.25 X 20 -2.75 ***1 BD***	-2.75 -2.75	-2.625 -2.75	0.00 0.00	***-0.25***	0.00 0.00	0.00	0.125	5 ES	5 ES
2	78	STRNG	1.93	1, 2, 4*, 5	-1.00-0.25X 110 -3.25- 0.50X 150	-0.50-1.00 X 104 -3.25	-1.25-1.00 X 104 -3.75	-1.00 -3.25	***-1.75*** -3.75	-1.00 0.00	-1.00	0.00 0.00	2.25	2.00	3 ES	1 ES
3	75	STRNG	1.64	2, 4, 14 5,10,11,12,	-9.00 -1.00X 27 -9.25 -1.25 X 45	-9.75 -0.75 X 30 -9.50 - 1.25 X 45	-9.50-1.25 X 27 -9.25 -2.00 X 47 ***1 BU***	-10.12 -10.12	-10.12 -10.25	- 0.50 - 1.25	***-1.25*** -2.00	-0.10 ***-0.11***	0.00	0.125	4 ES	4 ES
4	125	STRNG	1.61	NONE	-3.00 - 0.50 X 05 -3.25 - 0.50X 180	-2.50 - 0.50 X 1 -3.00 - 0.25 X 3	-3.25-0.25 X17 -3.25-0.25 X 180	-2.75 -3.125	**-3.37** ***-3.62***	- 0.50 - 0.25	-0.25 -0.25	-0.01 0.00	0.375	0.25	1.5 X0	1.5 XO
5	84	STRNG	1.50	1, 4,	-2.25-.50 X 180 -2.00 - 0.25 X 15	-2.00-0.50 X 170 -2.00-0.50 X 21	-2.50-0.50 X 175 -2.25-0.50 X 21	-2.25 -2.25	***-2.75*** -2.50	-0.50 -0.50	-0.50 -0.50	-0.08 0.00	0.00	***-0.25***	1.5 ES	0
6	109	MOD	1.35	5,	-2.25-0.75 X 175 -2.50-1.00 X 175	-2.25 -2.00-0.50 X 170	-2.50-0.25 X 167 -2.50-0.50 X 175 ***.50 BU***	-2.25 -2.25	***-2.625*** ***-2.75***	0.00 -0.50	-0.25 -0.50	0.00 ***0.30***	0.00	0.125	1 ES	.50 ES
7	19	MOD	1.14	2,11,12		0.50-0.50 X 162 0.50-1.00 X 113	0.50-1.00 X 73 1.00-1.00 X 110	+0.25 0.00	0.00 +0.50	-0.50 -1.00	-1.00 -1.00	0.03 -0.10	+0.25	**-0.50**		
8	52	STRNG	1.14	NONE	-1.00-1.50 X 104 -1.00-1.25 X 75	-1.00-1.50 X 97 -0.50-1.75 X 74	-0.75-1.75 X 95 -0.75-1.25 X 75	-1.75 -1.375	-1.625 -1.375	-1.50 -1.75	-1.75 -1.25	**-0.11** -0.05	-0.375	-0.25	0	2 ES
9	126	STRNG	0.71	NONE	+1.00-1.50 X 165 +1.25 -3.00 X 06	+1.25 -2.00 X 165 +1.75 -3.50 X 10	+1.25 -2.50 X 164 +1.75 -4.25 X 12	0.25 -0	0.00 ***-0.375***	-2.00 -3.50	-2.50 ***-4.25***	***-0.08*** ***-0.26***	0.25	0.375	0.5 XO	1.5 XO
10	95	MOD	0.57		-1.50 -1.50- 0.50 X 25	-1.25-.25 X 163 -1.50	-1.50-0.25X150 -2.00	-1.37 -1.50	***-1.62*** ***-2.00***	-0.25 0.00	-0.25 0.00	***-0.11*** 0.00	.125	.125	.50 EX	.50 ES
11	64	MOD	0.35	2	-8.25 - 0.50 X 45 -6.75 - 0.75 X 135	0.50-1.50X14 0.50-1.00X06	0.75 -2.00 X 11 0.50-1.25 X 180	-0.25 0.00	-0.25 -.125	-1.50 -1.00	***-2.00*** -1.25	***-0.18*** ***-0.23***	-0.25	-0.125	3 EX	1 EX
12	39	STRNG	-0.7	6	-2.25- 0.25 X 45 - 2.75 0.50 X 180	-2.50 -2.75	-2.75-0.25 X 40 -3.00-0.50 X 180 ***1 BD OS***	-2.50 -2.75	***-2.87*** ***-3.25***	0 0	***-0.25*** ***-0.50***	0.00 0.00	0.25	0.375	**7 ES**	3 ES
13	45	MOD	-0.30	9	-3.75- 1.00 X 02 - 2.75 1.00 X 12	-3.50-0.75 X 169 -1.50-0.50 X 05	-2.75- 0.75 X 180 -1.50-0.25 X 170	-3.875 -1.75	-3.12 -1.62	- 0.75 -0.50	-0.75 -0.25	***-0.28*** ***-0.19***	-2.12	***-1.50***	2 EX	3 EX
14	90	STRNG	-0.30	1	-1.00-0.50 X 95 -1.00-0.50 X 105	-0.50-0.50 X 97 -0.50-0.50 X 90	-1.00 -0.50 X 87 -1.25 -0.50 X 85	-0.75 -0.75	- ***1.25*** ***-1.50***	-0.50 -0.50	-0.50 -0.50	***-0.17***	0	0.25	1.5 XO	1 XO

TABLE 4B. SUBJECTS WHO STRONGLY OR MODERATELY PREFER THE TRADITIONAL PRESCRIPTION DIFFERENCE SCORES (TRAD-BINOC) COMPARED WITH THE SYMPTOMS DOWNSCORED FOR THE OTHER RX AT 0*, 1.O, OR 2.0.

	SUBJ #	PREF LEVEL	O. A. DIFF SCORE	SYMPTOMS SCORED 0,1, OR 2.	HABITUAL RX	RX 1 TRADITIONAL	RX 2 BINOCULAR	TRAD EQ SPH	BINOC EQ SPH	TRAD CYL	BINOC CYL	INDUC CYL CHNGE	TRAD ANIS0	BINOC ANISO	TRD PH	BIN PH
1	2	MOD	4.07	1, 2, 4, 5, 7, 11, 12,	-0.50-1.50 X 180 -0.50-1.50 X 180	-0.25-2.25 X 178 -0.75-2.00 X 4	-0.75-.2.50 X 175 -1.00-1.00 X 180 *.5 BD*	1.375 -1.75	-2.00 -2.50	-2.25 ***-2.00***	.2.50 -1.00	***0.24*** ***0.33***	0.375	0.50	1 XO	0
2	104	STRNG	2.92	2, 3, 4, 5*, 10, 11*, 12	-0.75 -0.75	-0.50 - 0.25 X 40 -0.50 - 0.25 X 74	-0.75 - 0.50 X 42 -1.00	***-0.625*** ***-0.625***	-1.00 -1.00	- ***0.25*** - ***0.25***	- 0.50 0.00	0.00 0.03	0.00	0.00	1 ES	1 ES
3	36	STRNG	2.60	3*, 4, 5*, 11, 12	NONE WORN	+0.25 +0.50	PL -0.50 X 105 PL -0.25 X 90	***0.25*** ***0.50***	-0.25 -0.125	***0.00*** ***0.00***	-0.50 -0.25	0.00 0.00	-0.25	-0.125	0	2 ES
4	106	MODY	2.36	2, 4, 5, 11, 12, 14	-2.00 - 0.50 X 60 -1.75 - 0.25 X 105	-2.25 - 0.50 X 16 -1.75 - 0.25 X 153	-2.75 -0.75 X 15 -2.00 -0.50 X 172	***-2.50*** -1.875	-3.125 -2.25	-0.50 - 0.25	- 0.75 -0.50	0.02 ***0.24***	***-0.625***	-0.875	1 XO	0
5	57	MOD	1.93	1,2*,3*,4*,5*, 10*,11*,12*, 14*	-2.25 -2.25 -0.25 X 13	-2.50 -2.00 -0.75 X 178	-2.75 - 0.50 X 167 -2.50-1.25 X 180	-2.50 -2.375	-2.75 -2.50	***0.00*** ***-0.75***	- 0.50 -1.25	0.00 0.07	***-0.125***	0.125	0	4 ES
6	66	STRNG	1.70	3, 14		-0.50-1.75 X 84 -1.00-1.00 ***X 95***	-0.50-1.50 X 83 -1.75-1.25 X 70	-1.375 ***-1.50***	-2.50 -2.375	-1.75 -1.00	-1.50 -1.25	0.05 ***0.94***	0.125	-0.125		
7	107	MOD	1.60	2, 5	-1.00-0.75 X 85 -1.50-0.50X 82	0.00-125 X 83 -1.00-.75 X 88	-0.25-1.25 X 89 -1.25-0.50 X 81	-.625 -1.37	-0.87 -1.50	-1.25 -0.75	-1.25 - 0.50	***-0.25*** ***-0.15***	+0.75	+0.625	3 ES	.50 ES
8	77	MOD	1.50	5	NONE WORN	-0.75-0.25 X 125 -0.75 - 0.50 X 85	-0.25-0.25 X127 0.00 -0.50 X 90	***-0.625*** ***-0.50***	0.125 -0.25	-0.25 - 0.50	-0.25 -0.50	0.02 0.08	***0.125***	0.375	3.5 X0	*5 XO*
9	117	STRNG	1.36	1 0,14	-0.50-0.25 X 45 -1.00-0.25 X 88	-0.75-0.50 ***X 101*** -1.25	-1.50-0.25 X 91 -2.00-0.25 X 87	***-1.00*** ***-1.25***	-1.63 -2.12	0.50 0.00	-0.25 -0.25	-.08 0.00	+0.25	+0.50	4 EX	4 EX
10	92	MOD	1.36	10	-1.50 -1.50 X 176 -1.75 - 0.50 X 167	- 1.25 -1.75 X 180 -1.50 - 1.25 X 167	-1.75 -1.75 X 180 -2.25 - 1.25 X 170	***-2.12*** ***-2.12***	-2.62 -2.87	-1.75 -1.25	-1.75 -1.25	0.00 ***-0.13***	***0.00***	+0.25	1.5 ES	.5 ES
11	112	STRNG	1.07	10	-2.00-0.50 X 165 -0.75-0.50 X 179	-2.00-0.50 X 178 -1.00	-2.00-1.00X 177 -1.00-0.25 X 2	-2.25 -1.00	-2.50 -1.125	***-0.50*** ***0.00***	-1.00 -0.25	0.03 0.01	-1.125	-1.375	3 ES	1.5 ES
12	91	STRNG	1.0	NONE	-0.75-0.75 X 90 -0.75-0.75 X 80	-0.75-0.75 X 90 -1.00-0.50 X 84	-0.75-0.50 X 94 -1.25-0.75 X 79	-1.125 ***-1.25***	-1.00 -1.625	-0.75 -0.50	-0.50 -0.75	0.08 0.10	***0.125***	0.625	1 XO	1 XO
13	47	STRNG	0.9	NONE	-4.00 .5 BU -5.50	-4.25 -5.50	- 4.25-0.25 X 57 -5.75 ***2 BU***	-4.25 -5.50	-4.25 -5.75	0.00	-0.25	0.00 0.00	-1.25	-1.375	3 XO	3 XO
14	124	MOD	0.65	NONE	-3.25 -3.25	-2.75 -3.00	-3.25 -3.25 -0.50 X 17	-275 -3.00	-325 -325	0.00 ***0.00***	0.00 -0.50	0.00 0.00	+0.25	+0.25	0.5 ES	5.5 ES
15	23	MOD	0.40	NONE	+3.50-1.00 X 105 +3.50 -1.75 X 072	+3.75-1.25X 93 +3.25 -1.25 X 81	+3.75-1.25X 96 +3.00 -0.75 X 89	+3.125 +2.625	+3.125 +2.625	-1.00 ***-1.75***	-1.25 -1.25	***-0.13*** ***-0.28***	+.50	+.50	2 ES	2 EX

difference scores between these two groups of subjects would indicate that the strong-moderate rating was more meaningful for subjects preferring lenses from the traditional refraction. Also note that we would expect a higher overall difference value to indicate a preference level of strongly liking a prescription. The subjects who liked the binocular lenses seemed to follow this expectation more closely than those who preferred the traditional.

To analyze symptoms ranked as 0,1, or 2 for subjects in Tables 4A and 4B, no specific patterns could be found between these symptoms and the non-preferred lens prescription. This may be due the subjectivity of this type of data collection.

To provide for a more simple analysis of tables 4A and 4B, Table 5 compares the number of subjects in each parameter which made a positive difference for each prescription preference. For instance, 8 subjects who moderately or strongly preferred the binocular lenses received more minus in equivalent sphere on the binocular prescription than in the traditional prescription. These subjects, therefore, preferred a more minus lens prescription.

TABLE 6: COMPARISON OF NUMBER OF SUBJECTS FOR EACH LENS PREFERENCE WITH FACTORS MAKING A POSITIVE DIFFERENCE

FACTOR WHICH MADE A POSITIVE DIFFERENCE	BINOCULAR PREF	RX N=14	TRAD PREF	RX N=15
	SUBJECTS	EYES	SUBJECTS	EYES
Vertical prism	4		2	
Increase minus equivalent sphere	8	13	2	3
Increase positive equivalent sphere	0	0	6	9
Cylinder axis inducing power change	8	11	6	9
Anisometropia	3		5	
Increase minus cylinder power	5	6	3	3
Decrease minus cylinder power	0	0	5	8

This table reveals that for both groups cylinder power and induced cylinder from axis change may have played an important role in determining prescription preference. Fifty-seven percent or a total of eight subjects preferring the binocular prescription liked an increase in cylinder power. In turn, three of these subjects also had an induced cyl change due to axis difference. The remaining two had no induced power. On the other hand, five subjects or 33% of subjects preferring the traditional prescription liked wearing a decrease in minus cylinder power. All five of these subjects also had none or a very small amount of induced cylinder power. To summarize, subjects preferred lens prescriptions that had both an increase in cylinder and an induced cylinder power. The opposite may also hold true, subjects liked a decrease in minus cylinder power without an axis change.

Table 6 reveals that for subjects preferring the binocular lenses, many received a more minus equivalent sphere and therefore liked it. On the other hand, people who liked the traditional preferred a more positive prescription in the parameter of equivalent sphere. For anisometropia and vertical prism, there was no discernable pattern shown.

DISCUSSION

It was found that there are statistically and clinically significant differences in refractive results between the traditional refraction and the binocular refraction with the AO Vectographic Slide. These differences were statistically significant for mean sphere, equivalent sphere, and cylinder power. Mean differences in sphere and equivalent sphere were judged to be clinically significant (0.25D or more). For all these parameters, each revealed a difference in the more minus direction for the binocular refraction. It is our hunch that the more minus result from the binocular refraction with the AO Vectographic Slide is due to the target having relatively lower contrast than the target used for the traditional refraction. Subjects may have selected more minus power in an attempt to increase the contrast between the letters and the background. The result would be a more minus prescription for 20/20 vision with the vectographic target. Some practitioners might interpret this as a negative tradeoff for using this particular method of binocular refraction.

Combining all parameters, we found the proportion of subjects who had a difference between refractions to be 69%. Morgan found that in slightly less than 10% of his 215 patients the binocular prescription departed "significantly" from that which would have been given ordinarily. A "significant departure" to him was more than a 0.50D difference in sphere, more than a 0.25D difference in cylinder, ten degrees or more difference in the axis of the cylinder, and/or the incorporation of prism power in the prescription (2). Two percent of these patients showed a difference greater than 0.50D in spherical power. In contrast, 27% of our total 130 subjects had greater than a 0.50D change. Twenty percent of Morgan's patients had only a 0.25D change in spherical power, our research yielded 58%. Morgan also found that none of his patients had a cylinder power change, but 2% had an axis change ten degrees or more. In this study, we found 25% to have a cylinder power change of greater than 0.25D, and 20% having an axis change inducing 0.25D or more power. For vertical prism, Morgan prescribed prism to 32 or 25% of his subjects, whereas we found only 12% had a vertical fixation disparity. It is evident that in most parameters we had a larger number of subjects with a difference between the traditional and binocular refraction methods. Why did a total of 69% of our subjects have a clinically significant difference between refractions, as compared to Morgan's 10%? Many factors could play into this discrepancy, including differences in instrumentation, stricter criteria, and our inclusion of additional parameters: equivalent sphere power, and induced cylinder due to axis change.

Analysis of the clinical lens trials, which included a comparison of the level of prescription preference and symptom ranking, revealed parameters that may have played a significant role in why subjects chose as they did. Binocular-preferring subjects seemed to prefer an induced cylinder power, a more minus cylinder power, and a more minus spherical equivalent power. No or little induced cylinder, and a more positive cylinder power and spherical equivalent power seemed to be the preference for the traditional-preferring subjects. We assumed these were the differences that were large enough for patients to appreciate. These parameters, according to our analysis, were important factors when lens preference was decided. We cannot predict from our data, however, which refraction method would be superior based on lens wear preference. An almost equal number of subjects preferred the binocular prescription over the traditional, and individual preferences are hard to predict for the clinician.

According to this study, a clinician has approximately a fifty-fifty chance of a patient preferring a binocular prescription over a traditional prescription. Perhaps these odds could justify a binocular refraction for the patient who is unhappy with a traditionally derived lens prescription. We should also not lose sight of how this method may help individuals with cyclophorias, suppression, and vertical fixation disparities. They may only represent a small proportion of patients needing lens prescriptions, but the binocular refraction method could conceivably produce superior results with them, yielding a more accurate and comfortable lens prescription.

We feel this study has contributed to the optometric knowledge about binocular refraction. To date, it is the largest controlled comparison of binocular refraction using the AO Vectographic Slide versus traditional refraction. Stricter criteria, and more parameters were compared than any previous study. Lastly, it is the only study to incorporate a doubly masked, randomized, crossover spectacle lens wear trial. It is our hope that this research will benefit many clinicians using or considering adoption of binocular refraction in their practice.

CONCLUSIONS

1) Differences do exist between the refractive results of a traditionally derived prescription and a prescription derived binocularly utilizing the AO Vectographic Slide.

2) The proportion of subjects who had a difference are as follows: 38% of the total 130 subjects had a difference in sphere, 25% percent had a difference in cylindrical power, 45% in equivalent sphere, and 20% in induced cylinder. For more than 50% of total eyes examined there was an axis change, with 10% inducing a greater than 0.25D cylinder power change. Twelve percent of the total 130 subjects measured a fixation disparity.

3) Are these differences statistically or clinically significant? Mean sphere, equivalent sphere, and cylinder power differences were statistically significant. The binocular refraction method resulted in approximately a 0.25D more minus in both mean sphere and equivalent sphere parameters. This was designated as clinically significant. Cylinder power was also in the more minus direction but was not clinically significant.

4) According to our analysis of lens preferences and the symptomology rankings assigned to each prescription, equivalent

sphere, cylinder power, and cylinder power induced by axis change were important factors when deciding which prescription was superior. Clinical wisdom suggests that these differences were large enough for patients to subjectively appreciate in lens wear trials.

5) In the clinical trial, 47% preferred the binocular prescription, 42% preferred the traditional prescription, and 11% liked both prescriptions equally. From these percentages, we cannot predict which refraction method would be superior based upon lens wear preference.

6) The parameters of difference that are most likely to be predictive of subjective preference for these two refraction methods were mentioned in number 4. Equivalent sphere, cylinder power, and induced cylinder power seemed to be predominant parameters. However, an equal number of subjects preferred the traditional refraction over the binocular method, indicating that these parameters can increase or decrease in power and the preference would be based on the individual case.

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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 or Allergan Humphrey Automatic Refractor.
   B. Each eye measured with the other eye unoccluded.

III. Traditional 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.

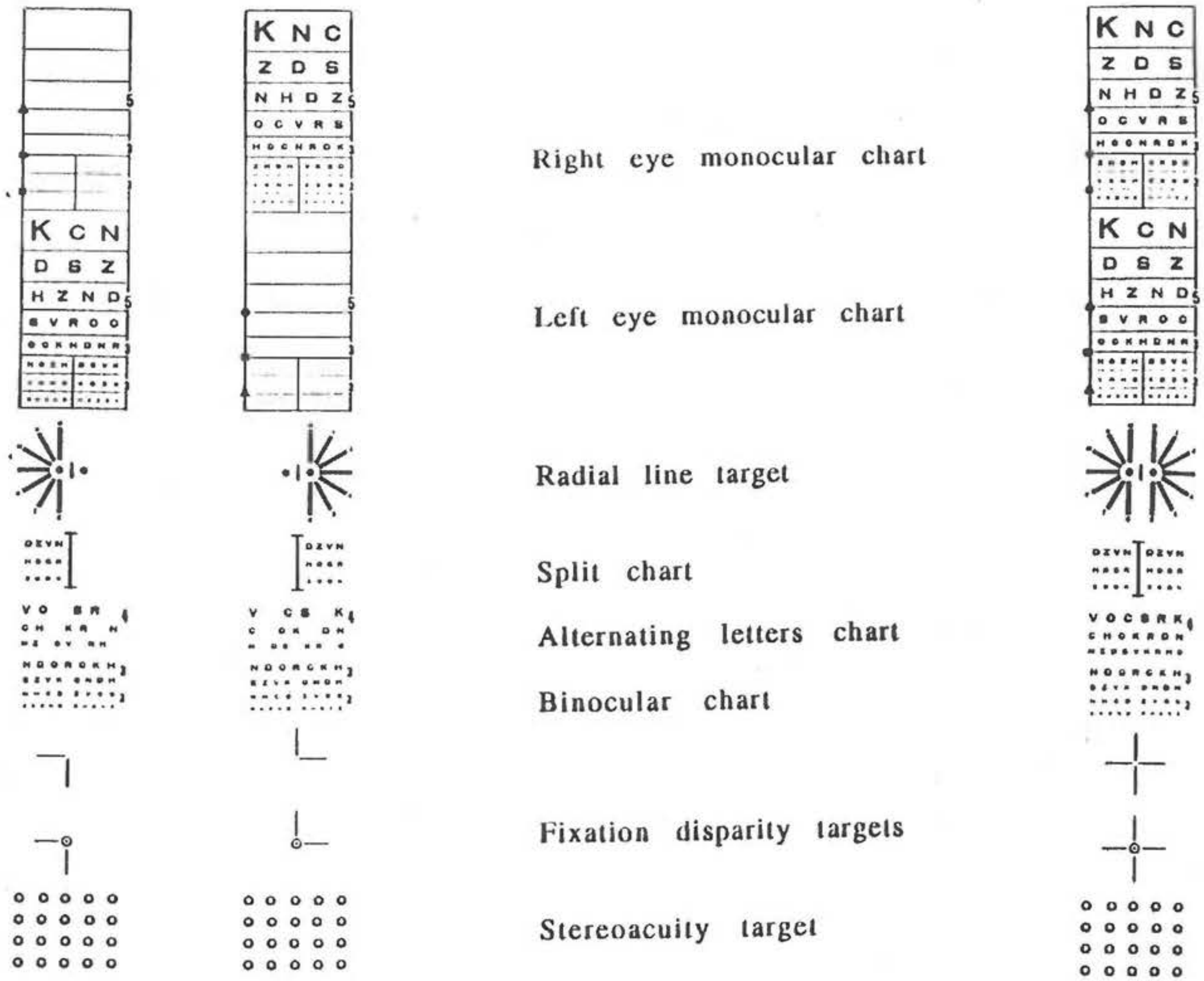
I. Lateral Phoria

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.

Appendix B


Right eye monocular chart
Left eye monocular chart
Radial line target
Split chart
Alternating letters chart
Binocular chart
Fixation disparity targets
Stereoacuity target

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!

					SUBJECTIVE REFRACTION										ANALYSIS									
SUB #	BIN AR				MONOCULAR (RX 1)				BINOCULAR (RX 2)					BIN AR ES	RX 1 ES	ANISO RX1	RX 2 ES	ANISO RX 2	^SPH 1:2	^CYL1:2	^X 1:2	ABS ^ X	^ES 1:2	^ANISO
1	0.12	-0.37	X	14	0.50				0.25	-0.25	X	163		-0.07	0.50	0.13	0.13	0.00	0.25	0.25	0.00	0.00	0.38	-0.13
	0.25	-0.75	X	136	0.50	-0.25	X	180	0.25	-0.25	X	175		-0.13	0.38		0.13		0.25	0.00	5.00	5.00	0.25	
2*	-1.00	-1.50	X	179	-0.25	-2.25	X	178	-0.75	-2.50	X	175		-1.75	-1.38	0.38	-2.00	0.50	0.50	0.25	3.00	3.00	0.63	0.13
	-1.00	-2.50	X	171	-0.75	-2.00	X	4	-1.00	-3.00	X	180	.5 BD	-2.25	-1.75		-2.50		0.25	1.00	-176.00	4.00	0.75	
3	-0.37	-0.75	X	112	0.00				-0.25					-0.75	0.00	-0.25	-0.25	0.00	0.25	0.00	0.00	0.00	0.25	0.25
	0.00	-0.50	X	103	0.75	-1.00	X	90	0.00	-0.50	X	90		-0.25	0.25		-0.25		0.75	-0.50	0.00	0.00	0.50	
4	-1.87	-0.25	X	141	-1.00	-0.50	X	136	-1.00	-0.50	X	130		-2.00	-1.25	-0.13	-1.25	-0.13	0.00	0.00	6.00	6.00	0.00	0.00
	-1.62	-0.50	X	68	-1.00	-0.25	X	58	-1.00	-0.25	X	68		-1.87	-1.13		-1.13		0.00	0.00	-10.00	10.00	0.00	
5*	-3.37	-0.37	X	170	-3.00	-0.75	X	165	-3.00	-1.00	X	170		-3.56	-3.38	-0.38	-3.50	0.13	0.00	0.25	-5.00	5.00	0.13	0.50
	-3.25	-0.75	X	150	-3.00				-3.25	-0.75	X	167		-3.63	-3.00		-3.63		0.25	0.75	-167.00	0.00	0.63	
6	0.00	-0.25	X	89	0.00	-0.25	X	90	0.00	-0.50	X	85		-0.13	-0.13	0.00	-0.25	-0.13	0.00	0.25	5.00	5.00	0.13	-0.13
	0.00	-0.87	X	90	0.25	-0.75	X	76	0.25	-0.75	X	80		-0.44	-0.13		-0.13		0.00	0.00	-4.00	4.00	0.00	
7	-2.87	-0.62	X	155	-2.75				-3.00					-3.18	-2.75	0.63	-3.00	0.50	0.25	0.00	0.00	0.00	0.25	-0.13
	-3.00	-0.50	X	50	-3.25	-0.25	X	96	-3.50					-3.25	-3.38		-3.50		0.25	-0.25	96.00	0.00	0.13	
8	-1.50	-1.75	X	100	-1.00	-2.00	X	95	-1.00	-2.00	X	94		-2.38	-2.00	-0.13	-2.00	-0.13	0.00	0.00	1.00	1.00	0.00	0.00
	-1.75	-1.37	X	97	-1.25	-1.25	X	92	-1.25	-1.25	X	95		-2.44	-1.88		-1.88		0.00	0.00	-3.00	3.00	0.00	
9	0.37	-0.75	X	13	0.50	-0.50	X	15	0.25	-0.25	X	15		-0.01	0.25	-0.13	0.13	0.25	0.25	-0.25	0.00	0.00	0.13	0.38
	0.12	-0.62	X	169	0.50	-0.25	X	176	0.25	-0.75	X	175		-0.19	0.38		-0.13		0.25	0.50	1.00	1.00	0.50	
10	-6.75	-0.50	X	162	-6.50				-6.50					-7.00	-6.50	0.00	-6.50	0.13	0.00	0.00	0.00	0.00	0.00	0.13
	-5.62	-0.37	X	43	-6.50				-6.50	-0.25	X	178	.5 BU	-5.81	-6.50		-6.63		0.00	0.25	-178.00	0.00	0.13	
11	-2.25	-1.00	X	5	-2.25	-1.00	X	5	-2.25	-1.00	X	64		-2.75	-2.75	-0.25	-2.75	0.00	0.00	0.00	-59.00	59.00	0.00	0.25
	-2.37				-2.50				-2.75					-2.37	-2.50		-2.75		0.25	0.00	0.00	0.00	0.25	
12	-2.12	-1.00	X	154	-2.00				-2.75					-2.62	-2.00	0.00	-2.75	-0.13	0.75	0.00	0.00	0.00	0.75	-0.13
	-2.25	-0.37	X	129	-2.00				-2.50	-0.25	X	165		-2.44	-2.00		-2.63		0.50	0.25	-165.00	0.00	0.63	
13	0.37	-1.12	X	132	0.25	-0.25	X	130	0.00					-0.19	0.13	0.13	0.00	0.00	0.25	-0.25	130.00	0.00	0.13	-0.13
	0.25	-0.50	X	27	0.25	-0.50	X	25	0.25	-0.50	X	25		0.00	0.00		0.00		0.00	0.00	0.00	0.00	0.00	
14	-0.62	-0.62	X	124	-0.25				0.00					-0.93	-0.25	0.25	0.00	0.50	-0.25	0.00	0.00	0.00	-0.25	0.25
	-0.87	-0.37	X	140	-0.50				-0.50					-1.06	-0.50		-0.50		0.00	0.00	0.00	0.00	0.00	
15	-1.50	-0.25	X	11	-1.25	-0.50	X	10	-1.25	-0.25	X	5		-1.63	-1.50	0.13	-1.38	0.38	0.00	-0.25	5.00	5.00	-0.13	0.25
	-1.75	-0.75	X	125	-1.50	-0.25	X	117	-1.50	-0.50	X	130		-2.13	-1.63		-1.75		0.00	0.25	-13.00	13.00	0.13	
16	-5.87	-0.37	X	171	-4.75				-5.75					-6.06	-4.75	-0.25	-5.75	-0.25	1.00	0.00	0.00	0.00	1.00	0.00
	-5.50	-0.87	X	173	-4.50				-5.25	-0.50	X	142	1 BU	-5.94	-4.50		-5.50		0.75	0.50	-142.00	0.00	1.00	
17	-1.37	-1.37	X	172	-1.00	-0.75	X	180	-1.00	-1.00	X	178		-2.06	-1.38	0.75	-1.50	0.50	0.00	0.25	2.00	2.00	0.13	-0.25
	-2.00	-0.75	X	11	-1.75	-0.75	X	10	-1.50	-1.00	X	5		-2.38	-2.13		-2.00		-0.25	0.25	5.00	5.00	-0.13	
18	-6.62	-1.00	X	164	-6.00	-0.50	X	180	-6.50	-0.50	X	5		-7.12	-6.25	1.38	-6.75	1.00	0.50	0.00	175.00	5.00	0.50	-0.38
	-7.62	-0.75	X	165	-7.50	-0.25	X	171	-7.75					-8.00	-7.63		-7.75		0.25	-0.25	171.00	0.00	0.13	
19*	0.00	-0.87	X	83	0.50	-0.50	X	162	0.50	-1.00	X	73		-0.44	0.25	0.25	0.00	-0.50	0.00	0.50	89.00	89.00	0.25	-0.75
	0.25	-1.50	X	117	0.50	-1.00	X	113	1.00	-1.00	X	110		-0.50	0.00		0.50		-0.50	0.00	3.00	3.00	-0.50	
20	-8.50	-0.50	X	70	-8.50	-0.50	X	70	-8.50	-0.50	X	75		-8.75	-8.75	0.00	-8.75	0.00	0.00	0.00	-5.00	5.00	0.00	0.00
	-8.37	-0.50	X	134	-8.75				-8.50	-0.50	X	75		-8.62	-8.75		-8.75		-0.25	0.50	-75.00	0.00	0.00	
21	-6.87	-1.50	X	15	-6.50	-1.75	X	12	-6.50	-1.25	X	15		-7.62	-7.38	-0.25	-7.13	-0.25	0.00	-0.50	-3.00	3.00	-0.25	0.00
	-6.87	-1.75	X	164	-6.50	-1.25	X	172	-6.50	-0.75	X	166		-7.75	-7.13		-6.88		0.00	-0.50	6.00	6.00	-0.25	
22	-1.00	-0.37	X	4	-1.00	-0.50	X	175	-1.00	-0.25	X	168		-1.19	-1.25	0.00	-1.13	0.00	0.00	-0.25	7.00	7.00	-0.13	0.00
	-1.12	-0.25	X	169	-1.00	-0.50	X	23	-1.00	-0.25	X	22		-1.25	-1.25		-1.13		0.00	-0.25	1.00	1.00	-0.13	
23*	2.25	-2.00	X	99	3.75	-1.25	X	93	3.75	-1.25	X	96		1.25	3.13	0.50	3.13	0.50	0.00	0.00	-3.00	3.00	0.00	0.00
	2.50	-1.37	X	94	3.25	-1.25	X	81	3.00	-0.75	X	89		1.82	2.63		2.63		0.25	-0.50	-8.00	8.00	0.00	
24	-6.75	-0.37	X	1	-6.75				-6.50					-6.94	-6.75	-0.63	-6.50	-0.75	-0.25	0.00	0.00	0.00	-0.25	-0.13
	-6.00	-0.87	X	170	-6.00	-0.25	X	9	-5.75					-6.44	-6.13		-5.75		-0.25	-0.25	9.00	0.00	-0.38	
25*	-1.25	-0.62	X	122	-1.25	-0.25	X	120	-1.50					-1.56	-1.38	0.13	-1.50	0.00	0.25	-0.25	120.00	0.00	0.13	-0.13
	-1.37	-0.62	X	94	-1.25	-0.50	X	49	-1.50				1 BD	-1.68	-1.50		-1.50		0.25	-0.50	49.00	0.00	0.00	
26	-1.12	-0.62	X	114	-0.75	-0.25	X	92	-0.75	-0.25	X	86		-1.43	-0.88	-0.25	-0.88	-0.13	0.00	0.00	6.00	6.00	0.00	0.13
	-1.37	-0.50	X	102	-0.50	-0.25	X	52	-0.75					-1.62	-0.63		-0.75		0.25	-0.25	52.00	0.00	0.13	
27	0.12				0.25				-0.25	-0.25	X	65		0.12	0.25	0.13	-0.38	-0.13	0.50	0.25	-65.00	0.00	0.63	-0.25

	0.50	-0.62	X	112	0.25	-0.25	X	120	0.25	-1.00	X	133		0.19	0.13		-0.25		0.00	0.75	-13.00	13.00	0.38	
28*	-3.12	-0.25	X	164	-2.75				-2.50	-0.25	X	20		-3.25	-2.75	0.00	-2.63	0.13	-0.25	0.25	-20.00	0.00	-0.13	0.13
	-2.75	-0.25	X	143	-2.75				-2.75				1 BD	-2.88	-2.75		-2.75		0.00	0.00	0.00	0.00	0.00	
29	0.12	-1.62	X	111	-0.50				-0.50	-0.50	X	99		-0.69	-0.50	0.25	-0.75	0.25	0.00	0.50	-99.00	0.00	0.25	0.00
	-0.37	-1.12	X	81	-0.25	-1.00	X	73	-0.75	-0.50	X	70	.5 BU	-0.93	-0.75		-1.00		0.50	-0.50	3.00	3.00	0.25	
30	1.75	-2.00	X	15	0.25	-0.75	X	5	0.50	-0.75	X	5		0.75	-0.13	-0.88	0.13	-0.63	-0.25	0.00	0.00	0.00	-0.25	0.25
	1.75	-1.25	X	163	1.25	-1.00	X	5	1.00	-0.50	X	8		1.13	0.75		0.75		0.25	-0.50	-3.00	3.00	0.00	
31	-6.75	-0.62	X	154	-7.00				-6.75					-7.06	-7.00	-0.75	-6.75	-0.88	-0.25	0.00	0.00	0.00	-0.25	-0.13
	-6.25				-6.25				-5.75	-0.25	X	100		-6.25	-6.25		-5.88		-0.50	0.25	-100.00	0.00	-0.38	
32	-0.87	-0.37	X	31	-1.00				-1.25					-1.06	-1.00	-1.00	-1.25	-1.00	0.25	0.00	0.00	0.00	0.25	0.00
	-0.37	-0.75	X	143	0.00				-0.25					-0.75	0.00		-0.25		0.25	0.00	0.00	0.00	0.25	
33	-5.87	-1.12	X	146	-6.25	-1.25	X	118	-6.25	-1.00	X	116		-6.43	-6.88	0.75	-6.75	0.88	0.00	-0.25	2.00	2.00	-0.13	0.13
	-7.00	-0.62	X	79	-7.00	-1.25	X	67	-7.00	-1.25	X	71		-7.31	-7.63		-7.63		0.00	0.00	-4.00	4.00	0.00	
34	-3.50	-0.50	X	165	-3.00	-0.25	X	170	-3.00	-0.25	X	180		-3.75	-3.13	0.13	-3.13	0.00	0.00	0.00	-10.00	10.00	0.00	-0.13
	-3.25	-1.00	X	158	-3.00	-0.50	X	9	-3.00	-0.25	X	165		-3.75	-3.25		-3.13		0.00	-0.25	-156.00	24.00	-0.13	
35	0.12	-0.37	X	23	0.25				0.00	-0.25	X	65		-0.07	0.25	0.50	-0.13	0.50	0.25	0.25	-65.00	0.00	0.38	0.00
	-0.75	-0.25	X	127	-0.25				-0.50	-0.25	X	8	1 BD	-0.88	-0.25		-0.63		0.25	0.25	-8.00	0.00	0.38	
36*	0.00	-0.87	X	119	0.25				0.00	-0.50	X	105		-0.44	0.25	-0.25	-0.25	-0.38	0.25	0.50	-105.00	0.00	0.50	-0.13
	0.25	-0.62	X	109	0.50				0.00	0.25	X	92		-0.06	0.50		0.13		0.50	-0.25	-92.00	0.00	0.38	
37	0.12	-0.37	X	124	1.00	-0.25	X	175	0.75					-0.07	0.88	0.13	0.75	0.13	0.25	0.25	0.00	0.00	0.13	0.00
	0.00	-0.25	X	123	0.75				0.75	-0.25	X	5		-0.13	0.75		0.63		0.00	0.25	-5.00	0.00	0.13	
38	-3.75	-1.50	X	22	-5.00	-0.75	X	10	-5.00	-1.00	X	12		-4.50	-5.38	-0.25	-5.50	-0.38	0.00	0.25	-2.00	2.00	0.13	-0.13
	-4.25	-1.25	X	163	-4.75	-0.75	X	172	-4.75	-0.75	X	180		-4.88	-5.13		-5.13		0.00	0.00	-8.00	8.00	0.00	
39*	-2.75	-0.25	X	75	-2.50				-2.75	-0.25	X	40		-2.88	-2.50	0.25	-2.88	0.38	0.25	0.25	-40.00	0.00	0.38	0.13
	-3.25	-0.62	X	136	-2.75				-3.00	-0.50	X	180		-3.56	-2.75		-3.25		0.25	0.50	-180.00	0.00	0.50	
40	0.12	-0.25	X	113	0.25				0.25					-0.01	0.25	0.00	0.25	0.38	0.00	0.00	0.00	0.00	0.00	0.38
	0.00	-0.25	X	138	0.25				0.00	-0.25	X	165		-0.13	0.25		-0.13		0.25	0.25	-165.00	0.00	0.38	
41	-3.37	-1.00	X	122	-4.00				-4.00					-3.87	-4.00	0.00	-4.00	0.13	0.00	0.00	0.00	0.00	0.00	0.13
	-4.12	-0.50	X	80	-3.75	-0.50	X	62	-4.00	-0.25	X	65	.5 BD	-4.37	-4.00		-4.13		0.25	-0.25	-3.00	3.00	0.13	
42	0.00	-0.62	X	103	0.00				0.00					-0.31	0.00	-0.13	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.25
	0.00	-0.37	X	70	0.25	-0.25	X	100	0.00	-0.25	X	106		-0.19	0.13		-0.13		0.25	0.00	-6.00	6.00	0.25	
43	-0.25	-0.75	X	116	-0.25	-0.50	X	105	0.00	-0.75	X	115		-0.63	-0.50	-0.13	-0.38	0.13	-0.25	0.25	-10.00	10.00	-0.13	0.25
	0.00	-0.75	X	76	-0.25	-0.25	X	60	-0.25	-0.50	X	75	1 BD	-0.38	-0.38		-0.50		0.00	0.25	-15.00	15.00	0.13	
44	-0.37	-1.25	X	103	-0.25	-1.00	X	100	-0.25	-1.00	X	100		-1.00	-0.75	0.00	-0.75	0.13	0.00	0.00	0.00	0.00	0.00	0.13
	-1.00	-0.37	X	106	-0.75				-0.75	-0.25	X	80		-1.19	-0.75		-0.88		0.00	0.25	-80.00	0.00	0.13	
45*	-3.12	-1.12	X	155	-3.50	-0.75	X	169	-2.75	-0.75	X	180		-3.68	-3.88	-2.13	-3.13	-1.50	-0.75	0.00	-11.00	11.00	-0.75	0.63
	-2.00	-0.62	X	155	-1.50	-0.50	X	5	-1.50	-0.25	X	170	1 BD	-2.31	-1.75		-1.63		0.00	-0.25	-165.00	15.00	-0.13	
46	-6.25	-2.75	X	18	-6.25	-3.50	X	21	-7.25	-3.25	X	16		-7.63	-8.00	1.25	-8.88	0.63	1.00	-0.25	5.00	5.00	0.88	-0.63
	-6.75	-3.75	X	158	-7.00	-4.50	X	161	-7.25	-4.50	X	160		-8.63	-9.25		-9.50		0.25	0.00	1.00	1.00	0.25	
47*	-3.37	-1.00	X	15	-4.25				-4.25	-0.25	X	57		-3.87	-4.25	1.25	-4.38	1.38	0.00	0.25	0.00	0.00	0.13	0.13
	-5.50	-0.75	X	158	-5.50				-5.75				2 BU	-5.88	-5.50		-5.75		0.25	0.00	0.00	0.00	0.25	
48	-1.75	-0.87	X	163	-2.25	-0.75	X	2	-1.75	-0.50	X	10		-2.19	-2.63	0.25	-2.00	0.50	-0.50	-0.25	-8.00	8.00	-0.63	0.25
	-2.37	-0.50	X	171	-2.50	-0.75	X	15	-2.25	-0.50	X	15		-2.62	-2.88		-2.50		-0.25	-0.25	0.00	0.00	-0.38	
49	-1.87	-0.87	X	77	-1.50	-0.75	X	87	-1.75	-0.75	X	85		-2.31	-1.88	0.50	-2.13	0.38	0.25	0.00	2.00	2.00	0.25	-0.13
	-2.00	-1.37	X	80	-1.75	-1.25	X	70	-1.75	-1.50	X	69		-2.69	-2.38		-2.50		0.00	0.25	1.00	1.00	0.13	
50*	-3.12	-0.75	X	178	-3.00	-0.50	X	162	-3.50					-3.50	-3.25	0.13	-3.50	0.13	0.50	-0.50	162.00	0.00	0.25	0.00
	-3.50	-0.75	X	69	-3.00	-0.75	X	35	-3.25	-0.75	X	36		-3.88	-3.38		-3.63		0.25	0.00	-1.00	1.00	0.25	
51	-2.87	-1.62	X	5	-2.50	-1.50	X	5	-2.75	-1.75	X	4		-3.68	-3.25	0.13	-3.63	-0.25	0.25	0.25	1.00	1.00	0.38	-0.38
	-3.62	-0.62	X	148	-3.25	-0.25	X	172	-3.25	-0.25	X	160		-3.93	-3.38		-3.38		0.00	0.00	12.00	12.00	0.00	
52*	-1.12	-2.25	X	103	-1.00	-1.50	X	97	-0.75	-1.75	X	95		-2.25	-1.75	-0.38	-1.63	-0.25	-0.25	0.25	2.00	2.00	-0.13	0.13
	-1.00	-2.00	X	83	-0.50	-1.75	X	74	-0.75	-1.25	X	75		-2.00	-1.38		-1.38		0.25	-0.50	-1.00	1.00	0.00	
53	-1.12	-0.87	X	120	-1.50				-1.25					-1.56	-1.50	-0.75	-1.25	-0.63	-0.25	0.00	0.00	0.00	-0.25	0.13
	-0.87	-0.50	X	169	-0.50	-0.50	X	180	-0.25	-0.75	X	2		-1.12	-0.75		-0.63		-0.25	0.25	178.00	2.00	-0.13	
54	-1.62	-0.62	X	154	-0.75	-0.25	X	70	-1.75	-0.25	X	171		-1.93	-0.88	0.88	-1.88	-1.25	1.00	0.00	-101.00	79.00	1.00	-2.13
	-2.25	-0.37	X	116	-1.75				-0.50	-0.25	X	30		-2.44	-1.75		-0.63		-1.25	0.25	-30.00	0.00	-1.13	

55	-0.87	-0.37	X	135	-0.75				-0.75					-1.06	-0.75	0.00	-0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-0.75	-0.25	X	120	-0.75				-0.75					-0.88	-0.75		-0.75		0.00	0.00	0.00	0.00	0.00	
56	-5.12	-2.12	X	6	-6.50	-1.50	X	180	-7.25	-1.00	X	5		-6.18	-7.25	-1.63	-7.75	-1.75	0.75	-0.50	175.00	5.00	0.50	-0.13
	-4.50	-2.12	X	173	-4.75	-1.75	X	90	-5.75	-0.50	X	5		-5.56	-5.63		-6.00		1.00	-1.25	85.00	85.00	0.38	
57*	-2.37	-0.62	X	26	-2.50				-2.75	-0.50	X	167		-2.68	-2.50	-0.13	-3.00	0.13	0.25	0.50	-167.00	0.00	0.50	0.25
	-2.87	-0.75	X	152	-2.00	-0.75	X	178	-2.50	-1.25	X	180		-3.25	-2.38		-3.13		0.50	0.50	-2.00	2.00	0.75	
58	0.00				0.00				-0.25					0.00	0.00	-0.25	-0.25	-0.50	0.25	0.00	0.00	0.00	0.25	-0.25
	0.25	-0.75	X	136	0.25				0.25					-0.13	0.25		0.25		0.00	0.00	0.00	0.00	0.00	
59	-3.62				-3.75				-4.00					-3.62	-3.75	-0.38	-4.00	-0.50	0.25	0.00	0.00	0.00	0.25	-0.13
	-3.12	-0.87	X	137	-3.25	-0.25	X	142	-3.25	-0.50	X	140		-3.56	-3.38		-3.50		0.00	0.25	2.00	2.00	0.13	
60*	-3.75				-3.50	-0.25	X	180	-3.25	-0.25	X	20		-3.75	-3.63	0.88	-3.38	0.88	-0.25	0.00	160.00	20.00	-0.25	0.00
	-4.12	-0.50	X	158	-4.50				-4.00	-0.50	X	70		-4.37	-4.50		-4.25		-0.50	0.50	-70.00	0.00	-0.25	
61	-0.37	-1.62	X	14	-2.00	-0.25	X	170	-2.25					-1.18	-2.13	2.38	-2.25	2.25	0.25	-0.25	170.00	0.00	0.13	-0.13
	-3.37	-1.62	X	167	-4.25	-0.50	X	20	-4.50					-4.18	-4.50		-4.50		0.25	-0.50	20.00	0.00	0.00	
62	-4.37	-0.50	X	124	-4.50	-0.25	X	124	-4.75	-0.25	X	100		-4.62	-4.63	-0.13	-4.88	-0.38	0.25	0.00	24.00	24.00	0.25	-0.25
	-4.25				-4.50				-4.50					-4.25	-4.50		-4.50		0.00	0.00	0.00	0.00	0.00	
63	0.12	-0.62	X	132	-0.50	-0.25	X	124	-0.25	-0.25	X	135		-0.19	-0.63	-0.13	-0.38	0.13	-0.25	0.00	-11.00	11.00	-0.25	0.25
	0.00	-0.50	X	162	-0.25	-0.50	X	1	-0.50					-0.25	-0.50		-0.50		0.25	-0.50	1.00	0.00	0.00	
64*	0.87	-1.25	X	25	0.50	-1.50	X	14	0.75	-2.00	X	11		0.25	-0.25	-0.25	-0.25	-0.13	-0.25	0.50	3.00	3.00	0.00	0.13
	0.62	-0.87	X	177	0.50	-1.00	X	6	0.50	-1.25	X	180		0.19	0.00		-0.13		0.00	0.25	-174.00	6.00	0.13	
65	-2.62	-0.75	X	1	-1.75				-1.75	-0.25	X	95		-3.00	-1.75	0.25	-1.88	0.13	0.00	0.25	-95.00	0.00	0.13	-0.13
	-1.87	-0.37	X	175	-2.00				-2.00					-2.06	-2.00		-2.00		0.00	0.00	0.00	0.00	0.00	
66*	-1.37	-1.50	X	86	-0.50	-1.75	X	84	-1.75	-1.50	X	83		-2.12	-1.38	0.13	-2.50	-0.13	1.25	-0.25	1.00	1.00	1.13	-0.25
	-2.25	-1.25	X	84	-1.00	-1.00	X	95	-1.75	-1.25	X	70		-2.88	-1.50		-2.38		0.75	0.25	25.00	25.00	0.88	
67	-0.37	-1.75	X	123	0.00	-0.50	X	110	-0.50	-1.00	X	105		-1.25	-0.25	-0.25	-1.00	-0.13	0.50	0.50	5.00	5.00	0.75	0.13
	-0.25	-1.12	X	94	0.00				-0.50	-0.75	X	77		-0.81	0.00		-0.88		0.50	0.75	-77.00	0.00	0.88	
68	-0.50	-0.50	X	151	-0.50				-0.50					-0.75	-0.50	0.00	-0.50	-0.25	0.00	0.00	0.00	0.00	0.00	-0.25
	-0.37	-0.37	X	136	-0.50				-0.25					-0.56	-0.50		-0.25		-0.25	0.00	0.00	0.00	-0.25	
69	-2.25	-0.25	X	84	-1.50	-0.50	X	110	-2.00	-0.75	X	105		-2.38	-1.75	-0.13	-2.38	-0.13	0.50	0.25	5.00	5.00	0.63	0.00
	-2.00	-0.87	X	1	-1.50	-0.25	X	75	-2.00	-0.50	X	83	1 BU	-2.44	-1.63		-2.25		0.50	0.25	-8.00	8.00	0.63	
70	-0.25	-1.50	X	32	-1.25	-0.50	X	38	-1.50	-0.25	X	15		-1.00	-1.50	-0.13	-1.63	-0.13	0.25	-0.25	23.00	23.00	0.13	0.00
	-1.37	-1.12	X	40	-1.25	-0.25	X	40	-1.25	-0.50	X	150		-1.93	-1.38		-1.50		0.00	0.25	-110.00	70.00	0.13	
71*	-4.12	-0.87	X	167	-3.75				-4.75					-4.56	-3.75	0.00	-4.75	0.00	1.00	0.00	0.00	0.00	1.00	0.00
	-4.12	-1.00	X	144	-3.50	-0.50	X	138	-4.50	-0.50	X	144	2 BU	-4.62	-3.75		-4.75		1.00	0.00	-6.00	6.00	1.00	
72	-1.25	-1.87	X	26	-2.50	-0.75	X	55	-2.25	-1.00	X	65		-2.19	-2.88	-3.25	-2.75	-3.25	-0.25	0.25	-10.00	10.00	-0.13	0.00
	0.62	-1.37	X	38	0.75	-0.75	X	101	1.00	-1.00	X	100		-0.07	0.38		0.50		-0.25	0.25	1.00	1.00	-0.13	
73	-0.12	-0.25	X	104	-0.50				-0.50					-0.25	-0.50	0.38	-0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.13
	-0.62	-1.25	X	173	-0.50	-0.75	X	173	-0.50	-1.00	X	172		-1.25	-0.88		-1.00		0.00	0.25	1.00	1.00	0.13	
74	-0.37	-0.75	X	173	-0.25	-0.75	X	165	-0.25	-1.00	X	173		-0.75	-0.63	-0.75	-0.75	-0.88	0.00	0.25	-8.00	8.00	0.13	-0.13
	0.50	-1.37	X	165	0.50	-0.75	X	172	0.50	-0.75	X	175		-0.19	0.13		0.13		0.00	0.00	-3.00	3.00	0.00	
75*	-9.50	-2.12	X	135	-9.75	-0.75	X	30	-9.50	-1.25	X	27		-10.56	-10.13	0.00	-10.13	0.13	-0.25	0.50	3.00	3.00	0.00	0.13
	-7.50	-2.00	X	69	-9.50	-1.25	X	45	-9.25	-2.00	X	47	1 BU	-8.50	-10.13		-10.25		-0.25	0.75	-2.00	2.00	0.13	
76	0.00				0.00				0.00					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-2.50	-0.50	x	15	0.00				0.00					-2.75	0.00		0.00		0.00	0.00	0.00	0.00	0.00	
77*	0.25	-0.25	x	111	0.75	-0.25	x	125	0.25	-0.25	x	127		0.13	0.63	0.13	0.13	0.38	0.50	0.00	-2.00	2.00	0.50	0.25
	-0.50	-0.75	x	80	0.75	-0.50	x	85	0.00	-0.50	x	90		-0.88	0.50		-0.25		0.75	0.00	-5.00	5.00	0.75	
78*	-1.00	-0.50	x	105	-0.50	-1.00	x	104	-1.25	-1.00	x	104		-1.25	-1.00	2.25	-1.75	2.00	0.75	0.00	0.00	0.00	0.75	-0.25
	-3.50	-0.50	x	172	-3.25				-3.75					-3.75	-3.25		-3.75		0.50	0.00	0.00	0.00	0.50	
79	-6.00	-1.00	x	166	-4.75	-0.75	x	170	-5.00	-0.50	x	150		-6.50	-5.13	-0.25	-5.25	-0.25	0.25	-0.25	20.00	20.00	0.13	0.00
	-5.60	-1.00	x	14	-4.50	-0.75	x	26	-4.50	-1.00	x	25		-6.00	-4.88		-5.00		0.00	0.25	1.00	1.00	0.13	
80	-9.00	-2.75	x	178	-6.00				-6.25	-0.25	x	25		-10.38	-6.00	-0.25	-6.38	-0.25	0.25	0.25	-25.00	0.00	0.38	0.00
	-8.25	-0.25	x	168	-5.75				-6.00	-0.25	x	112		-8.38	-5.75		-6.13		0.25	0.25	-112.00	0.00	0.38	
81	-2.75	-0.25	x	159	-2.25				-2.25					-2.88	-2.25	-0.25	-2.25	-0.13	0.00	0.00	0.00	0.00	0.00	0.13
	-2.50	-0.50	x	174	-1.75	-0.50	x	161	-2.00	-0.25	x	170		-2.75	-2.00		-2.13		0.25	-0.25	-9.00	9.00	0.13	
82	-5.00	-0.25	x	45	-4.75				-4.75	-0.25	x	45		-5.13	-4.75	-0.50	-4.88	-0.88	0.00	0.25	-45.00	0.00	0.13	-0.38

	-4.00	-0.25	x	90	-4.00	-0.50	x	84	-3.75	-0.50	x	85		-4.13	-4.25		-4.00		-0.25	0.00	-1.00	1.00	-0.25	
83	-4.75	-0.50	x	174	-1.50	-0.75	x	177	-1.75	-0.50	x	175		-5.00	-1.88	0.25	-2.00	0.50	0.25	-0.25	2.00	2.00	0.13	0.25
	-3.00	-0.75	x	10	-1.75	-0.75	x	180	-2.25	-0.50	x	7		-3.38	-2.13		-2.50		0.50	-0.25	173.00	7.00	0.38	
84*	-2.75	-0.50	x	174	-2.00	-0.50	x	170	-2.50	-0.50	x	175		-3.00	-2.25	0.00	-2.75	-0.25	0.50	0.00	-5.00	5.00	0.50	-0.25
	-2.25	-0.75	x	17	-2.00	-0.50	x	21	-2.25	-0.50	x	21		-2.63	-2.25		-2.50		0.25	0.00	0.00	0.00	0.25	
85	-4.75	-0.50	x	180	-2.75	-0.50	x	180	-3.00	-0.50	x	180		-5.00	-3.00	0.50	-3.25	0.63	0.25	0.00	0.00	0.00	0.25	0.13
	-6.75	-0.50	x	8	-3.25	-0.50	x	10	-3.75	-0.25	x	180		-7.00	-3.50		-3.88		0.50	-0.25	-170.00	10.00	0.38	
86	-3.25	-0.50	x	111	-2.00	-0.50	x	85	-2.25	-0.50	x	85		-3.50	-2.25	-0.13	-2.50	0.25	0.25	0.00	0.00	0.00	0.25	0.38
	-3.75	-0.50	x	69	-2.00	-0.25	x	85	-2.50	-0.50	x	80		-4.00	-2.13		-2.75		0.50	0.25	5.00	5.00	0.63	
87	-0.75	-0.25	x	45	-1.00				-1.25					-0.88	-1.00	0.13	-1.25	0.00	0.25	0.00	0.00	0.00	0.25	-0.13
	-1.00	-0.25	x	135	-1.00	-0.25	x	135	-1.25					-1.13	-1.13		-1.25		0.25	-0.25	135.00	0.00	0.13	
88	-2.50	-0.25	x	21	-2.25	-0.25	x	71	-1.75	-0.50	x	70		-2.63	-2.38	0.13	-2.00	0.25	-0.50	0.25	1.00	1.00	-0.38	0.13
	-2.00	-0.75	x	90	-2.00	-1.00	x	97	-1.75	-1.00	x	93		-2.38	-2.50		-2.25		-0.25	0.00	4.00	4.00	-0.25	
89	-4.25	-0.75	x	135	-3.50	-0.50	x	132	-3.75	-0.75	x	135		-4.63	-3.75	1.50	-4.13	1.63	0.25	0.25	-3.00	3.00	0.38	0.13
	-6.00	-0.50	x	55	-5.25				-5.50	-0.50	x	80		-6.25	-5.25		-5.75		0.25	0.50	-80.00	0.00	0.50	
90*	-0.75	-0.75	x	100	-0.50	-0.50	x	97	-1.00	-0.50	x	87		-1.13	-0.75	0.00	-1.25	0.25	0.50	0.00	10.00	10.00	0.50	0.25
	-1.00	-0.50	x	78	-0.50	-0.50	x	90	-1.25	-0.50	x	85		-1.25	-0.75		-1.50		0.75	0.00	5.00	5.00	0.75	
91*	-1.50	-0.50	x	105	-0.75	-0.75	x	90	-0.75	-0.50	x	94		-1.75	-1.13	0.13	-1.00	0.63	0.00	-0.25	-4.00	4.00	-0.13	0.50
	-1.25	-0.75	x	76	-1.00	-0.50	x	84	-1.25	-0.75	x	79		-1.63	-1.25		-1.63		0.25	0.25	5.00	5.00	0.38	
92*	-1.50	-2.00	x	2	-1.25	-1.75	x	180	-1.75	-1.75	x	180		-2.50	-2.13	0.00	-2.63	0.25	0.50	0.00	0.00	0.00	0.50	0.25
	-2.00	-1.75	x	176	-1.50	-1.25	x	167	-2.25	-1.25	x	170		-2.88	-2.13		-2.88		0.75	0.00	-3.00	3.00	0.75	
93*	-2.00	-0.25	x	180	-1.75	-0.25	x	80	-2.00					-2.13	-1.88	-0.50	-2.00	-0.38	0.25	-0.25	80.00	0.00	0.13	0.13
	-1.50	-1.00	x	45	-1.00	-0.75	x	60	-1.25	-0.75	x	51		-2.00	-1.38		-1.63		0.25	0.00	9.00	9.00	0.25	
94	-6.00	-0.50	x	21	-5.00				-5.50					-6.25	-5.00	0.00	-5.50	0.00	0.50	0.00	0.00	0.00	0.50	0.00
	-6.00	-0.50	x	180	-4.75	-0.50	x	143	-5.50					-6.25	-5.00		-5.50		0.75	-0.50	143.00	0.00	0.50	
95*	-1.25	-0.75	x	163	-1.25	-0.25	x	163	-1.50	-0.25	x	150		-1.63	-1.38	0.13	-1.63	0.38	0.25	0.00	13.00	13.00	0.25	0.25
	-1.50	-0.75	x	25	-1.50				-2.00					-1.88	-1.50		-2.00		0.50	0.00	0.00	0.00	0.50	
96	-0.25	-0.75	x	180	0.50	-0.25	x	171	0.50	-0.50	x	175		-0.63	0.38	-0.13	0.25	-0.13	0.00	0.25	-4.00	4.00	0.13	0.00
	-0.25	-0.75	x	180	0.75	-0.50	x	175	0.50	-0.25	x	131		-0.63	0.50		0.38		0.25	-0.25	44.00	44.00	0.13	
97	-2.50	-0.50	x	180	-2.25				-2.75	-0.25	x	160		-2.75	-2.25	0.25	-2.88	0.25	0.50	0.25	-160.00	0.00	0.63	0.00
	-2.75	-0.50	x	12	-2.50				-3.00	-0.25	x	39		-3.00	-2.50		-3.13		0.50	0.25	-39.00	0.00	0.63	
98*	-5.00	-2.25	x	4	-4.25	-1.50	x	180	-4.50	-2.25	x	5		-6.13	-5.00	0.50	-5.63	0.88	0.25	0.75	175.00	5.00	0.63	0.38
	-6.25	-2.25	x	173	-5.00	-1.00	x	4	-5.75	-1.50	x	1		-7.38	-5.50		-6.50		0.75	0.50	3.00	3.00	1.00	
99	-3.00	-0.25	x	135	-2.50				-2.50					-3.13	-2.50	-0.13	-2.50	-0.25	0.00	0.00	0.00	0.00	0.00	-0.13
	-2.75	-0.25	x	12	-2.25	-0.25	x	71	-2.25					-2.88	-2.38		-2.25		0.00	-0.25	71.00	0.00	-0.13	
100	-0.50	-0.50	x	165	-1.00	-0.25	x	155	-1.00	-0.25	x	170		-0.75	-1.13	0.13	-1.13	0.00	0.00	0.00	-15.00	15.00	0.00	-0.13
	-0.50	-0.75	x	5	-1.00	-0.50	x	180	-1.00	-0.25	x	5		-0.88	-1.25		-1.13		0.00	-0.25	175.00	5.00	-0.13	
101	-1.50				-1.25	-0.25	x	120	-1.50					-1.50	-1.38	0.13	-1.50	0.25	0.25	-0.25	120.00	0.00	0.13	0.13
	-1.75				-1.50				-1.75					-1.75	-1.50		-1.75		0.25	0.00	0.00	0.00	0.25	
102	-1.75	-0.25	x	90	-1.25	-0.25	x	94	-1.50	-0.25	x	90		-1.88	-1.38	0.25	-1.63	0.25	0.25	0.00	4.00	4.00	0.25	0.00
	-1.75	-0.25	x	45	-1.50	-0.25	x	83	-1.75	-0.25	x	80		-1.88	-1.63		-1.88		0.25	0.00	3.00	3.00	0.25	
103*	-2.25				-0.75				-1.00					-2.25	-0.75	0.00	-1.00	0.13	0.25	0.00	0.00	0.00	0.25	0.13
	-2.25	-0.25	x	120	-0.75				-1.00	-0.25	x	105		-2.38	-0.75		-1.13		0.25	0.25	-105.00	0.00	0.38	
104*	-0.75	-0.25	x	45	-0.50	-0.25	x	40	-0.75	-0.50	x	42		-0.88	-0.63	0.00	-1.00	0.00	0.25	0.25	-2.00	2.00	0.38	0.00
	-0.75	-0.25	x	60	-0.50	-0.25	x	74	-1.00					-0.88	-0.63		-1.00		0.50	-0.25	74.00	0.00	0.38	
105	-2.25	-2.00	x	21	-2.25	-1.50	x	24	-2.00	-1.75	x	20		-3.25	-3.00	-0.13	-2.88	-0.25	-0.25	0.25	4.00	4.00	-0.13	-0.13
	-2.00	-2.00	x	153	-2.00	-1.75	x	157	-1.75	-1.75	x	157		-3.00	-2.88		-2.63		-0.25	0.00	0.00	0.00	-0.25	
106*	-2.50	-0.75	x	17	-2.25	-0.50	x	16	-2.75	-0.75	x	15		-2.88	-2.50	-0.63	-3.13	-0.88	0.50	0.25	1.00	1.00	0.63	-0.25
	-2.00	-0.50	x	168	-1.75	-0.25	x	153	-2.00	-0.50	x	172		-2.25	-1.88		-2.25		0.25	0.25	-19.00	19.00	0.38	
107*	-0.75	-0.75	x	90	0.00	-1.25	x	83	-0.25	-1.25	x	89		-1.13	-0.63	0.75	-0.88	0.63	0.25	0.00	-6.00	6.00	0.25	-0.13
	-1.25	-0.75	x	73	-1.00	-0.75	x	88	-1.25	-0.50	x	81		-1.63	-1.38		-1.50		0.25	-0.25	7.00	7.00	0.13	
108	-3.50	-2.50	x	2	-3.25	-2.25	x	2	-3.50	-2.25	x	4		-4.75	-4.38	0.88	-4.63	1.00	0.25	0.00	-2.00	2.00	0.25	0.13
	-4.25	-3.00	x	1	-4.00	-2.50	x	179	-4.25	-2.75	x	180		-5.75	-5.25		-5.63		0.25	0.25	-1.00	1.00	0.38	
109*	-2.75	-0.50	x	165	-2.25				-2.50	-0.25	x	167		-3.00	-2.25	0.00	-2.63	0.13	0.25	0.25	-167.00	0.00	0.38	0.13
	-2.75	-0.50	x	174	-2.00	-0.50	x	170	-2.50	-0.50	x	175	.5 BU	-3.00	-2.25		-2.75		0.50	0.00	-5.00	5.00	0.50	

THESIS DATA ALL SUBJ

110*	-7.50	-0.50	x	15	-6.75	-0.50	x	45	-7.25	-0.50	x	27		-7.75	-7.00	0.25	-7.50	0.50	0.50	0.00	18.00	18.00	0.50	0.25
	-7.50	-0.75	x	12	-7.25				-7.75	-0.50	x	12		-7.88	-7.25		-8.00		0.50	0.50	-12.00	0.00	0.75	
111	-0.25	-0.50	x	6	1.00				0.25					-0.50	1.00	0.13	0.25	0.25	0.75	0.00	0.00	0.00	0.75	0.13
	0.25	-1.25	x	180	1.25	-0.75	x	166	0.25	-0.50	x	154		-0.38	0.88		0.00		1.00	-0.25	12.00	12.00	0.88	
112*	-2.75	-1.25	x	174	-2.00	-0.50	x	178	-2.00	-1.00	x	177		-3.38	-2.25	-1.25	-2.50	-1.38	0.00	0.50	1.00	1.00	0.25	-0.13
	-1.00	-0.25	x	45	-1.00				-1.00	-0.25	x	2		-1.13	-1.00		-1.13		0.00	0.25	-2.00	0.00	0.13	
113	-5.25	-1.00	x	168	-5.00	-0.75	x	160	-5.00	-0.50	x	160		-5.75	-5.38	-0.50	-5.25	-0.25	0.00	-0.25	0.00	0.00	-0.13	0.25
	-4.50	-1.25	x	177	-4.25	-1.25	x	10	-4.50	-1.00	x	9		-5.13	-4.88		-5.00		0.25	-0.25	1.00	1.00	0.13	
114	-0.50	-0.25	x	180	-0.50				-0.75					-0.63	-0.50	0.25	-0.75	0.00	0.25	0.00	0.00	0.00	0.25	-0.25
	-0.50				-0.75				-0.75					-0.50	-0.75		-0.75		0.00	0.00	0.00	0.00	0.00	
115	-4.25	-0.25	x	159	-3.50				-4.50					-4.38	-3.50	-0.38	-4.50	-0.25	1.00	0.00	0.00	0.00	1.00	0.13
	-4.00	-0.25	x	45	-3.00	-0.25	x	90	-4.00	-0.50	x	90		-4.13	-3.13		-4.25		1.00	0.25	0.00	0.00	1.13	
116	-3.25	-0.75	x	25	-2.50	-0.25	x	23	-3.50	-0.25	x	26		-3.63	-2.63	0.50	-3.63	0.13	1.00	0.00	-3.00	3.00	1.00	-0.38
	-3.25	-0.75	x	180	-3.00	-0.25	x	135	-3.50	-0.50	x	146		-3.63	-3.13		-3.75		0.50	0.25	-11.00	11.00	0.63	
117*	-3.00	-0.25	x	102	-0.75	-0.50	x	101	-1.50	-0.25	x	91		-3.13	-1.00	0.25	-1.63	0.50	0.75	-0.25	10.00	10.00	0.63	0.25
	-2.50	-0.50	x	45	-1.25				-2.00	-0.25	x	87		-2.75	-1.25		-2.13		0.75	0.25	-87.00	0.00	0.88	
118	-5.75	-0.75	x	180	-4.50				-5.25					-6.13	-4.50	-1.00	-5.25	-0.88	0.75	0.00	0.00	0.00	0.75	0.13
	-4.75	-0.25	x	180	-3.50				-4.25	-0.25	x	136		-4.88	-3.50		-4.38		0.75	0.25	-136.00	0.00	0.88	
119	-2.50	-1.00	x	169	-2.00	-0.75	x	168	-2.00	-0.75	x	169		-3.00	-2.38	0.13	-2.38	0.13	0.00	0.00	-1.00	1.00	0.00	0.00
	-2.75	-1.00	x	12	-2.25	-0.50	x	16	-2.25	-0.50	x	29		-3.25	-2.50		-2.50		0.00	0.00	-13.00	13.00	0.00	
120	-0.75	-0.25	x	111	-0.50	-0.50	x	111	-0.75	-0.25	x	111		-0.88	-0.75	-0.25	-0.88	-0.13	0.25	-0.25	0.00	0.00	0.13	0.13
	-1.00	-0.25	x	69	-0.25	-0.50	x	73	-0.50	-0.50	x	74		-1.13	-0.50		-0.75		0.25	0.00	-1.00	1.00	0.25	
121	-0.75	-0.25	x	150	-1.25				-1.25	-0.25	x	130		-0.88	-1.25	-0.38	-1.38	-0.38	0.00	0.25	-130.00	0.00	0.13	0.00
	-0.50	-0.25	x	168	-0.75	-0.25	x	180	-1.00					-0.63	-0.88		-1.00		0.25	-0.25	180.00	0.00	0.13	
122	0.00	-0.25	x	159	0.00	-0.25	x	120	0.00					-0.13	-0.13	0.00	0.00	0.25	0.00	-0.25	120.00	0.00	-0.13	0.25
	0.25	-0.50	x	8	0.00	-0.25	x	30	-0.25					0.00	-0.13		-0.25		0.25	-0.25	30.00	0.00	0.13	
123	-3.00	-0.25	x	90	-1.25	-0.75	x	86	-3.00					-3.13	-1.63	0.50	-3.00	0.25	1.75	-0.75	86.00	0.00	1.38	-0.25
	-3.00	-0.25	x	69	-2.00	-0.25	x	90	-3.25					-3.13	-2.13		-3.25		1.25	-0.25	90.00	0.00	1.13	
124*	-4.25	-0.75	x	5	-2.75				-3.25					-4.63	-2.75	0.25	-3.25	0.25	0.50	0.00	0.00	0.00	0.50	0.00
	-5.50	-0.75	x	180	-3.00				-3.25	-0.50	x	17		-5.88	-3.00		-3.50		0.25	0.50	-17.00	0.00	0.50	
125*	-4.50	-0.75	x	180	-2.50	-0.50	x	1	-3.25	-0.25	x	180		-4.88	-2.75	0.38	-3.38	0.25	0.75	-0.25	-179.00	1.00	0.63	-0.13
	-4.75	-1.00	x	180	-3.00	-0.25	x	3	-3.50	-0.25	x	4		-5.25	-3.13		-3.63		0.50	0.00	-1.00	1.00	0.50	
126*	1.25	-2.50	x	166	1.25	-2.00	x	165	1.25	-2.50	x	164		0.00	0.25	0.25	0.00	0.38	0.00	0.50	1.00	1.00	0.25	0.13
	1.25	-4.25	x	13	1.75	-3.50	x	10	1.75	-4.25	x	12		-0.88	0.00		-0.38		0.00	0.75	-2.00	2.00	0.38	
127	-3.25	-1.75	x	9	-3.00	-1.00	x	5	-3.25	-1.00	x	10		-4.13	-3.50	-0.25	-3.75	-0.25	0.25	0.00	-5.00	5.00	0.25	0.00
	-2.75	-1.50	x	175	-2.75	-1.00	x	174	-3.00	-1.00	x	176	.75 BD	-3.50	-3.25		-3.50		0.25	0.00	-2.00	2.00	0.25	
128	0.00	-0.50	x	98	0.25	-0.50	x	91	-0.25	-0.50	x	91		-0.25	0.00	0.13	-0.50	0.50	0.50	0.00	0.00	0.00	0.50	0.38
	-0.50	-0.25	x	180	0.00	-0.25	x	180	-1.00					-0.63	-0.13		-1.00		1.00	-0.25	180.00	0.00	0.88	
129	-4.00	-0.50	x	174	-3.25	-0.25	x	173	-4.00	-0.25	x	176		-4.25	-3.38	0.25	-4.13	0.25	0.75	0.00	-3.00	3.00	0.75	0.00
	-4.25	-0.25	x	180	-3.50	-0.25	x	180	-4.25	-0.25	x	159		-4.38	-3.63		-4.38		0.75	0.00	21.00	21.00	0.75	
130	-5.75	-1.75	x	14	-4.50	-1.50	x	16	-4.75	-1.50	x	15		-6.63	-5.25	0.25	-5.50	0.25	0.25	0.00	1.00	1.00	0.25	0.00
	-6.50	-1.00	x	176	-5.25	-0.50	x	165	-5.50	-0.50	x	177		-7.00	-5.50		-5.75		0.25	0.00	-12.00	12.00	0.25	
*= SUBJECT PARTICIPATING IN LENS WEAR STAGE																								

Appendix F

SUBJECT #	2	5	19	23	25	26	36	39	45	47	50	52	57	60	64	66	71	75	77
TRADITIONAL REFRACTION (T)**																			
Acuity	6.00	7.00	5.00	7.00	7.00	7.00	6.00	4.00	4.00	7.00	7.00	6.00	3.00	7.00	7.00	7.00	6.00	4.00	6.00
Tension	5.00	7.00	4.00	7.00	7.00	2.00	6.00	7.00	7.00	7.00	7.00	5.00	3.00	7.00	5.00	7.00	7.00	0.00	7.00
Headaches	7.00	7.00	4.00	7.00	7.00	3.00	6.00	7.00	7.00	7.00	7.00	7.00	4.00	7.00	7.00	7.00	7.00	1.00	7.00
Unnaturalness	6.00	7.00	2.00	7.00	7.00	2.00	4.00	7.00	7.00	7.00	7.00	5.00	4.00	6.00	6.00	7.00	7.00	1.00	6.00
Pulling	7.00	7.00	4.00	7.00	7.00	2.00	7.00	7.00	7.00	7.00	7.00	4.00	3.00	7.00	7.00	7.00	7.00	1.00	7.00
Diplopia	7.00	7.00	7.00	7.00	7.00	7.00	7.00	2.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	5.00	7.00
Burning	7.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Sens. to light	3.00	7.00	7.00	7.00	7.00	4.00	6.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00	3.00	7.00	7.00	4.00	7.00
Glare	7.00	7.00	7.00	7.00	7.00	7.00	4.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	2.00	6.00	7.00	3.00	6.00
Dizziness	7.00	7.00	7.00	7.00	7.00	3.00	3.00	7.00	7.00	7.00	7.00	5.00	3.00	7.00	7.00	7.00	7.00	2.00	7.00
Eye strain	6.00	7.00	2.00	7.00	7.00	2.00	6.00	7.00	2.00	6.00	7.00	5.00	2.00	7.00	5.00	7.00	7.00	1.00	7.00
Tired eyes	6.00	7.00	2.00	7.00	7.00	2.00	6.00	7.00	3.00	6.00	7.00	5.00	2.00	7.00	6.00	7.00	7.00	2.00	7.00
Itching	7.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00	7.00	3.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Comfort	6.00	7.00	4.00	7.00	7.00	3.00	6.00	3.00	4.00	7.00	7.00	5.00	3.00	7.00	5.00	7.00	7.00	2.00	6.00
AVERAGE	6.21	7.00	4.93	7.00	7.00	4.14	5.64	6.14	5.93	6.57	7.00	5.86	4.36	6.93	5.79	6.93	6.93	2.86	6.71
BINOCULAR REFRACTION (B)**																			
Acuity	0.00	7.00	5.00	6.00	6.00	7.00	7.00	6.00	6.00	7.00	7.00	7.00	2.00	6.00	7.00	4.00	7.00	6.00	6.00
Tension	0.00	7.00	5.00	6.00	6.00	7.00	2.00	5.00	3.00	7.00	7.00	7.00	0.00	7.00	7.00	6.00	7.00	3.00	5.00
Headaches	4.00	7.00	5.00	6.00	7.00	7.00	0.00	4.00	4.00	6.00	7.00	7.00	0.00	7.00	7.00	1.00	7.00	3.00	6.00
Unnaturalness	0.00	7.00	5.00	7.00	3.00	7.00	2.00	4.00	4.00	3.00	7.00	7.00	0.00	6.00	6.00	5.00	5.00	4.00	3.00
Pulling	0.00	7.00	7.00	7.00	7.00	7.00	0.00	4.00	7.00	6.00	7.00	7.00	0.00	7.00	6.00	6.00	7.00	1.00	2.00
Diplopia	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00
Burning	2.00	7.00	7.00	7.00	7.00	7.00	2.00	4.00	7.00	7.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	7.00
Sens. to light	3.00	7.00	7.00	6.00	7.00	6.00	3.00	7.00	7.00	2.00	7.00	7.00	6.00	7.00	3.00	7.00	7.00	5.00	7.00
Glare	6.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	6.00	6.00	7.00	7.00	6.00	7.00	4.00	7.00	7.00	5.00	6.00
Dizziness	3.00	7.00	7.00	7.00	7.00	7.00	4.00	7.00	2.00	6.00	7.00	7.00	0.00	7.00	7.00	6.00	5.00	5.00	7.00
Eye strain	0.00	7.00	6.00	7.00	6.00	7.00	1.00	4.00	6.00	6.00	7.00	7.00	0.00	6.00	6.00	3.00	7.00	3.00	2.00
Tired eyes	0.00	7.00	5.00	7.00	6.00	7.00	1.00	4.00	7.00	5.00	6.00	7.00	0.00	7.00	6.00	5.00	7.00	4.00	4.00
Itching	5.00	7.00	7.00	7.00	6.00	7.00	5.00	7.00	7.00	5.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Comfort	0.00	7.00	5.00	7.00	6.00	7.00	2.00	6.00	6.00	6.00	7.00	7.00	0.00	6.00	6.00	2.00	6.00	4.00	4.00
AVERAGE	2.14	7.00	6.07	6.64	6.29	6.93	3.07	5.43	5.64	5.64	6.93	7.00	2.43	6.71	6.14	5.21	6.64	4.50	5.21
SUBJECT'S Rx PREFERENCE	2.00	5.00	6.00	4.00	4.00	7.00	1.00	7.00	6.00	1.00	4.00	7.00	2.00	3.00	6.00	1.00	4.00	7.00	2.00
Rx WORN 1st	T	B	B	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
AVG. WEARING TIME (hrs)																			
TRADITIONAL	15.0	8.0	4.5	14.0	8.0	14.0	5.0	14.0	12.0	14.0	13.5	14.0	2.5	15.0	10.0	16	5.0	16.0	7.0
BINOCULAR	2.0	6.0	4.5	14.0	10.0	14.0	2.0	14.0	12.0	14.0	13.5	14.0	0.5	15.0	10.0	8.5	5.0	16.0	5.0

SUBJECT #	78	84	90	91	92	93	95	98	103	104	106	107	109	110	112	117	124	125	126	AVG
TRADITIONAL REFRACTION (T)**																				
Acuity	2.00	2.00	2.00	6.00	6.00	6.00	5.00	3.00	5.00	5.00	6.00	5.00	6.00	6.00	5.00	7.00	6.00	4.50	5.50	5.42
Tension	2.00	6.00	3.00	7.00	6.00	5.00	6.00	3.00	7.00	5.00	7.00	6.00	4.00	6.00	7.00	7.00	7.00	4.00	5.00	5.53
Headaches	4.00	7.00	7.00	7.00	7.00	7.00	6.00	3.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00	7.00	7.00	5.00	6.00	6.11
Unnaturalness	0.00	2.00	7.00	7.00	6.00	7.00	5.00	4.00	7.00	4.00	6.00	7.00	3.00	6.00	7.00	7.00	6.00	3.00	5.00	5.37
Pulling	2.00	3.00	7.00	7.00	6.00	6.00	7.00	3.00	7.00	5.00	7.00	7.00	2.00	7.00	7.00	7.00	7.00	4.00	6.00	5.76
Diplopia	4.00	7.00	7.00	7.00	7.00	7.00	7.00	5.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	4.00	6.61
Burning	7.00	7.00	7.00	7.00	7.00	7.00	7.00	3.00	7.00	6.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	6.00	7.00	6.79
Sens. to light	7.00	7.00	7.00	7.00	7.00	5.00	7.00	3.00	7.00	5.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00	6.32
Glare	7.00	7.00	7.00	7.00	6.00	7.00	4.00	4.00	7.00	5.00	7.00	6.00	5.00	6.00	7.00	7.00	7.00	6.00	6.00	6.24
Dizziness	4.00	6.00	7.00	7.00	6.00	7.00	7.00	3.00	7.00	6.00	7.00	7.00	5.00	5.00	7.00	6.00	7.00	5.00	6.00	6.03
Eye strain	3.00	3.00	3.00	7.00	7.00	5.00	5.00	2.00	7.00	5.00	7.00	6.00	4.00	4.00	7.00	7.00	7.00	4.00	5.00	5.21
Tired eyes	6.00	5.00	4.00	7.00	7.00	5.00	4.00	3.00	7.00	4.00	7.00	5.00	7.00	6.00	7.00	7.00	7.00	4.00	6.00	5.55
Itching	7.00	7.00	7.00	7.00	7.00	7.00	7.00	5.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.79
Comfort	4.00	3.00	3.00	7.00	6.00	6.00	4.00	4.00	7.00	5.00	7.00	6.00	4.00	6.00	7.00	7.00	7.00	4.50	5.00	5.41
AVERAGE	4.21	5.14	5.57	6.93	6.50	6.21	5.79	3.43	6.86	5.21	6.86	6.21	5.29	6.07	6.86	6.93	6.86	5.00	5.75	5.94
BINOCULAR REFRACTION (B)**																				
Acuity	6.00	6.00	5.00	6.00	5.00	7.00	6.00	0.00	7.00	7.00	7.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	6.00	5.92
Tension	5.00	7.00	5.00	5.00	6.00	7.00	6.00	0.00	7.00	1.00	1.00	2.00	5.00	6.00	6.00	5.00	5.00	6.50	6.00	4.96
Headaches	5.00	7.00	4.00	7.00	5.00	7.00	7.00	0.00	7.00	1.00	6.00	3.00	7.00	5.00	6.00	6.00	6.00	6.50	7.00	5.20
Unnaturalness	6.00	7.00	3.00	4.00	3.00	7.00	6.00	0.00	7.00	2.00	2.00	3.00	7.00	5.00	4.00	2.00	5.00	7.00	6.00	4.50
Pulling	5.00	5.00	2.00	5.00	3.00	7.00	6.00	0.00	7.00	0.00	2.00	2.00	7.00	7.00	4.00	7.00	6.00	7.00	7.00	4.84
Diplopia	7.00	7.00	7.00	7.00	6.00	7.00	7.00	2.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.00	6.76
Burning	7.00	7.00	7.00	7.00	7.00	7.00	7.00	1.00	7.00	1.00	7.00	7.00	7.00	6.00	7.00	7.00	7.00	7.00	7.00	6.29
Sens. to light	7.00	7.00	7.00	7.00	7.00	5.00	6.00	1.00	7.00	3.00	7.00	5.00	7.00	7.00	7.00	7.00	7.00	6.00	6.00	5.97
Glare	7.00	7.00	7.00	7.00	6.00	7.00	5.00	1.00	7.00	5.00	6.00	7.00	5.00	6.00	7.00	7.00	7.00	6.00	6.00	6.26
Dizziness	6.00	7.00	3.00	7.00	2.00	7.00	7.00	0.00	7.00	1.00	6.00	5.00	7.00	4.00	2.00	2.00	7.00	7.00	7.00	5.32
Eye strain	6.00	6.00	6.00	4.00	5.00	7.00	6.00	0.00	7.00	0.00	2.00	3.00	7.00	4.00	7.00	5.00	5.00	6.00	6.00	4.82
Tired eyes	6.00	7.00	6.00	6.00	6.00	6.00	7.00	0.00	7.00	1.00	1.00	3.00	7.00	7.00	7.00	7.00	6.00	5.50	7.00	5.20
Itching	7.00	7.00	7.00	7.00	7.00	7.00	7.00	3.00	7.00	2.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.56
Comfort	6.00	6.00	5.00	4.00	4.00	7.00	6.00	0.00	7.00	2.00	2.00	3.00	6.00	5.00	3.00	2.00	5.00	7.00	6.50	4.75
AVERAGE	6.14	6.64	5.29	5.93	5.14	6.79	6.36	0.57	7.00	2.29	4.50	4.57	6.64	5.86	5.79	5.57	6.21	6.61	6.46	5.53
SUBJECT'S Rx PREFERENCE	7.00	7.00	7.00	1.00	2.00	5.00	6.00	3.00	5.00	1.00	2.00	6.00	6.00	3.00	1.00	1.00	2.00	7.00	7.00	4.16
Rx WORN 1st	B	T	B	B	B	T	T	B	B	B	T	B	T	B	B	B	T	T	T	
AVG. WEARING TIME (hrs)																				
TRADITIONAL	11.0	16.0	14.0	10.0	5.5	16.0	8.0	4.5	8.0	10.0	10.0	12.0	15.0	4.0	6.0	7.0	16.0	16.0	10.0	10.7
BINOCULAR	11.0	16.0	14.0	9.0	5.5	16.0	8.0	2.5	8.0	3.5	10.0	7.5	15.0	4.0	6.0	6.0	16.0	16.0	10.0	9.6

** SYMPTOM GRADING SCALE		Rx PREFERENCE	GRADING #
severe problem	0.00	strongly traditional	1.00
no problem	7.00	moderately traditional	2.00
		slightly traditional	3.00
		equal	4.00
		slight binocular	5.00
		moderately binocular	6.00
		strongly binocular	7.00