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Dynamic retinoscopies: Are they reliable?

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Abstract

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ARE THEY RELIABLE?

By

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AUTOBIOGRAPHIES

Christina Smith

Christina Smith was born in Washington, D.C. in the last year of the decade of the Woodstock generation. Named after Queen Christina of Sweden, where she lived her first three years, she informed her parents at age one that her name was actually "Kiki." The spawn of low myopes, her genetics and myopic tendencies led her to develop a whopping seven diopters before stabilizing. After a relatively uneventful suburban upbringing, she became a fifth generation Cornellian, then went on to Pacific University College of Optometry. Here she achieved her two biggest accomplishments to date: the paper you have before you, and the ability to cross one eye at will.

Herman Shen

Born on March 21, 1970 in Taipei, Taiwan, Herman did not speak a word of English until he was 11 when he immigrated to Canada. Despite the disadvantage, he went to University of Alberta at age 18 for 3 years before being accepted by Pacific University College of Optometry. He will graduate as an honor student in May 1995 with an O.D. degree. His immediate plan is to obtain an associateship position in the Northwest and eventually own an optometric practice.

Frank Lam

From many family stories and government documents, I was born in Kowloon, Hong Kong. Then, at the age of 3 months, I found myself in Phoenix, Arizona. Education and extracurricular activities were all from the Valley of the Sun. Higher education was from two outstanding PAC-10 institutions, Arizona State and the University of Arizona. Hobbies are sports, world history and T.V. Interest in optometry came from my father, who owned an optical shop in Kowloon and my brother, an optometry student at that very important time of my life. My future looks like a private practice in Phoenix and interests in local community activities.

ABSTRACT

The goal of this project was to establish the intraexaminer and interexaminer reliability of MEM, Book, Bell and Stresspoint retinoscopies, and secondly to compare findings of the different techniques to each other and to near autorefractor measurements. The four retinoscopies were performed on thirty-one children three times each by four retinoscopists. Identity of the children and the power of all lenses used in the study were concealed from the retinoscopists. Results indicate good intrarater reliability of all four techniques and poorer interrater reliability. Bell retinoscopy was statistically the most reliable of the four. The four techniques produced statistically different, though strongly correlated, results. None were well correlated with near autorefractor measurements.

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INTRODUCTION

Optometry as a profession has recognized the abundance of vision problems caused by extended near work, and has been concerned with their treatment and prevention. The root of many of these problems seems to stem from the incompatibility of our biology with the demands placed on our visual system by today's society. Evolutionarily, we are not equipped to spend large amounts of time sitting still with our focus directed at less than arm's length. The necessity of our doing so has led to what has been termed "near-point stress."[1] The visual system shows many individualized adaptations to near-point stress, including refractive, vergence and accommodative disorders.

Dynamic retinoscopies are useful in diagnosis and treatment of accommodative problems related to near point stress, such as the tendency to either over or underaccommodate. They are unique procedures in that they allow the examiner to directly observe and objectively evaluate the function of the accommodative system while it is in use. The positioning of accommodation can be evaluated through the distance refraction or through potential nearpoint lenses. Information gained during these procedures is often used to establish the most effective lens to reduce near-point stress. A variety of dynamic retinoscopies have been developed throughout the 1900s.

Sheard[2], Nott[3], Tait[4], Gesell[5], Getman[6], Apell[7], Bieber[8], Haynes[9],and Kraskin[10] have published material regarding the clinical importance of these techniques, especially in children. However, little research has been done on the intra and interexaminer reliability. Of them all, MEM has received the most quantitative study. Rouse and colleagues[11] demonstrated that MEM is a valid test of accommodative response since their measurements obtained by MEM and a haploscopic instrument were extremely well correlated. McKee[12] reported high interexaminer reliability of MEM.

Locke and Somers[13] found in their comparison study of dynamic retinoscopies that MEM, Nott and Cross retinoscopy are virtually interchangeable for providing comparable assessments of the accommodation lag. Bell retinoscopy results were significantly different from the other three techniques. However, this was not a double masked experiment, and retinoscopy measurements for each procedure were taken sequentially, which may have affected the results. In addition, subjects in this study were all adults, although clinically these techniques are most often used with children.

In another study Jackson and Goss[14] also demonstrated a high correlation between MEM, Nott, and low neutral (performed by adding plus in 0.25 D steps to the distance refraction until the first neutral was obtained) dynamic retinoscopies. But again, it was not a double masked study and the results may be tainted.

Streff and Clausen[15] found high intraexaminer and low interexaminer reliability of Bell retinoscopy between two examiners who neutralized different areas of the pupillary reflex. When one of the examiners repeated his measurements on three of the subjects using the other examiner's method of motion assessment in the center of the pupil, reliability improved drastically. The researchers suggested that the technique differences were in large part responsible for low interexaminer reliability.

The relationships between MEM, Book and Stresspoint, and between Bell, Book, and Stresspoint have never been explored. No research has been carried out which shows the intraexaminer reliability of Bell retinoscopy, nor have any reliability studies of Book and Stresspoint been documented.

The scarcity of literature regarding dynamic retinoscopy is unfortunate in light of the clinical importance of these techniques. The authors believe these procedures are underused by clinicians, in part due to skepticism concerning their reliability.

It was therefore the goal of this research project to establish the *intra* and *inter*examiner reliability of MEM, Bell, Book and Stresspoint dynamic retinoscopies. Secondly, the relationships among these techniques, as well as between autorefractor measurements and dynamic retinoscopy findings, were explored.

METHODS

Subjects, Retinoscopists, and Assistants

Thirty-one Caucasian, Asian-American and African-American children, eighteen males and thirteen females between the ages of six and thirteen years (mean age of 8.6 years), were selected for participation in this study. Subjects were screened (see Appendix A) to assure near and far visual acuities of 20/20 OD, OS, and OU. Retinoscopy was performed, through habitual lenses if they were worn, and those with residual hyperopia, astigmatism and/or anisometropia of greater than 1.50 D were excluded. If habitual lenses were required to meet the criteria, these lenses were worn during data collection. Subjects were compensated $6 for their time, and sent a certificate for a complimentary vision exam at the Pacific University Family Vision Center.

Four retinoscopists participated in this study. Two were relative novices, an optometry student who received thesis credit for participation, and a recent graduate. The other two were optometrists with clinical experience in dynamic retinoscopy. These two skilled retinoscopists were compensated for their time at $200 per day for the two days of data collection.

Four assistants aided in data collection each day. Two of the assistants obtained thesis credit for their participation. The others were compensated $50 per day for their time. Three of the assistants participated during both days of data collection. Two assistants participated one day each. The assistants and retinoscopists were given written instruction sets (see Appendix B) and participated in training sessions prior to the weekend of data collection to assure consistency.

Procedures/Instrumentation

Eight data collecting sessions were held, four on Saturday, June 18th and four on Sunday, June 19th. Four subjects attended each session (except for the 11:30 am session on Sunday, where we had only three subjects). During each session, the experimental protocol was identical.

Before each session, the four retinoscopists went into a holding room so that they never saw the subjects. Each retinoscopist was given a nametag with a number on it, one through four.

The assistants greeted each subject, had a parent sign an informed consent form (see Appendix C), and put a nametag on each stating the child's name, subject number, their Harmon distance (the distance from the tip of the elbow to the middle knuckle of the clenched fist measured on the outside of the arm) in inches, and the grade level the child had just completed. Then, assistants took three autorefractor measurements at far while the subjects were instructed to fixate a doorknob about twenty yards away; then three measurements were taken while subjects fixated a starburst pattern at 30 cm. A Canon R-1 Autorefractometer was used for these measurements.

Next each of the subjects was taken to one of four numbered identical examination rooms. Each subject was seated comfortably in an exam chair, completely covered behind a drape except for a slit which revealed their eyes (see Figure 1). The subject's forehead was placed against the bottom of the phoropter to control distance, with his or her nose touching a piece of cardboard attached to the back of the drape to stabilize it. The assistant told each subject "This will take about five minutes. A doctor will come in and tell you what to do. It's important that the doctor does not recognize you so you need to stay behind the sheet and talk only when asked while the doctor is in the room. Hold your nose against the cardboard but don't push it forward. If you do everything just as the doctor asks you, you will get fifty cents each time."

Once the subjects and assistants were prepared, the retinoscopists each picked a card from a shuffled pile. Each of the twenty-four cards outlined a different sequence of performance of the four types of dynamic retinoscopies; for example, one card gave the following order:

1. MEM
2. Book
3. Bell
4. Stresspoint

Once a card was picked, each retinoscopist entered the room corresponding to the number on their nametags. They greeted the subject, performed the four retinoscopies (protocol described later), gave the subject two quarters, then returned to the holding room. They placed their sequence card in a specified discard pile. When all four retinoscopists had returned to the holding room, each picked another sequence card and entered the room next in order. This continued until each retinoscopist had visited each of the four rooms once.

At this point, the subjects were given a break, during which they were offered food, drink, and a bathroom. After the break, the subjects were randomly rearranged in the four rooms according to a plan designed in advance of the study (see Appendix D). Once reseated, the retinoscopists proceeded exactly as before until all four rooms had again been visited. The subjects were given another break, rearranged again, then revisited for the last time by all four retinoscopists.

The session was now completed. Each subject had been visited by each retinoscopist three times. During each visit four dynamic retinoscopy measurements had been taken. Thus, a total of forty-eight retinoscopy measurements had been recorded for each subject.

Figure 1. Sample setup for Book retinoscopy

Protocol for the dynamic retinoscopies

Spot retinoscopes were used in plano mode for all measurements. Retinoscopies were performed using horizontal sweep motion on right eyes only. Dioptric values of all lenses used were concealed with stickers before being handed to the retinoscopist. The assistants' procedure insured that a "low neutral" type finding was recorded for each retinoscopy; the least plus lens to achieve the endpoint for MEM, Book, and Stresspoint, and the farthest distance at which "neutral" was seen for Bell. A sample assistant's recording sheet can be found in Appendix E.

MEM

To guide the retinoscopist to the proper working distance, the assistant placed a yellow card hanging from the near point rod at the Harmon distance of the child. The appropriate grade level Pierce MEM card[a] was attached to the retinoscope. The retinoscopist said to the child "I want you to look at this card for me. Are the words clear and single? I want you to read those words out loud for me, keeping them clear."

As the child read, the retinoscopist swept the beam across the pupil and made an estimate of the lens power required to neutralize the motion. The assistant chose a trial lens of equal or less plus (more minus) power, and handed it to the retinoscopist. The retinoscopist then quickly placed this lens in front of the right eye of the subject and reassessed the retinoscopic reflex. If "with" motion was seen with this lens, the power of the next lens handed to the retinoscopist was 0.25 D more plus. Plus was increased in quarter diopter steps until "neutral" or "against" motion was reported. The lens which gave the first "neutral" or last "with" (if no "neutral" reported) was the lens value recorded by the assistant. If "against" motion was seen with the first sweep, the assistant chose a lens of equal or more minus power estimated by the retinoscopist. If "with" motion was achieved with this lens, the assistant proceeded as above. If "against" motion was still seen, plus power was decreased (minus power increased) in 0.25 D steps until "with" motion was achieved. The assistant recorded the last "neutral" or first "with" if no "neutral". See Figure 2 for a flowchart describing the protocol of MEM performance.

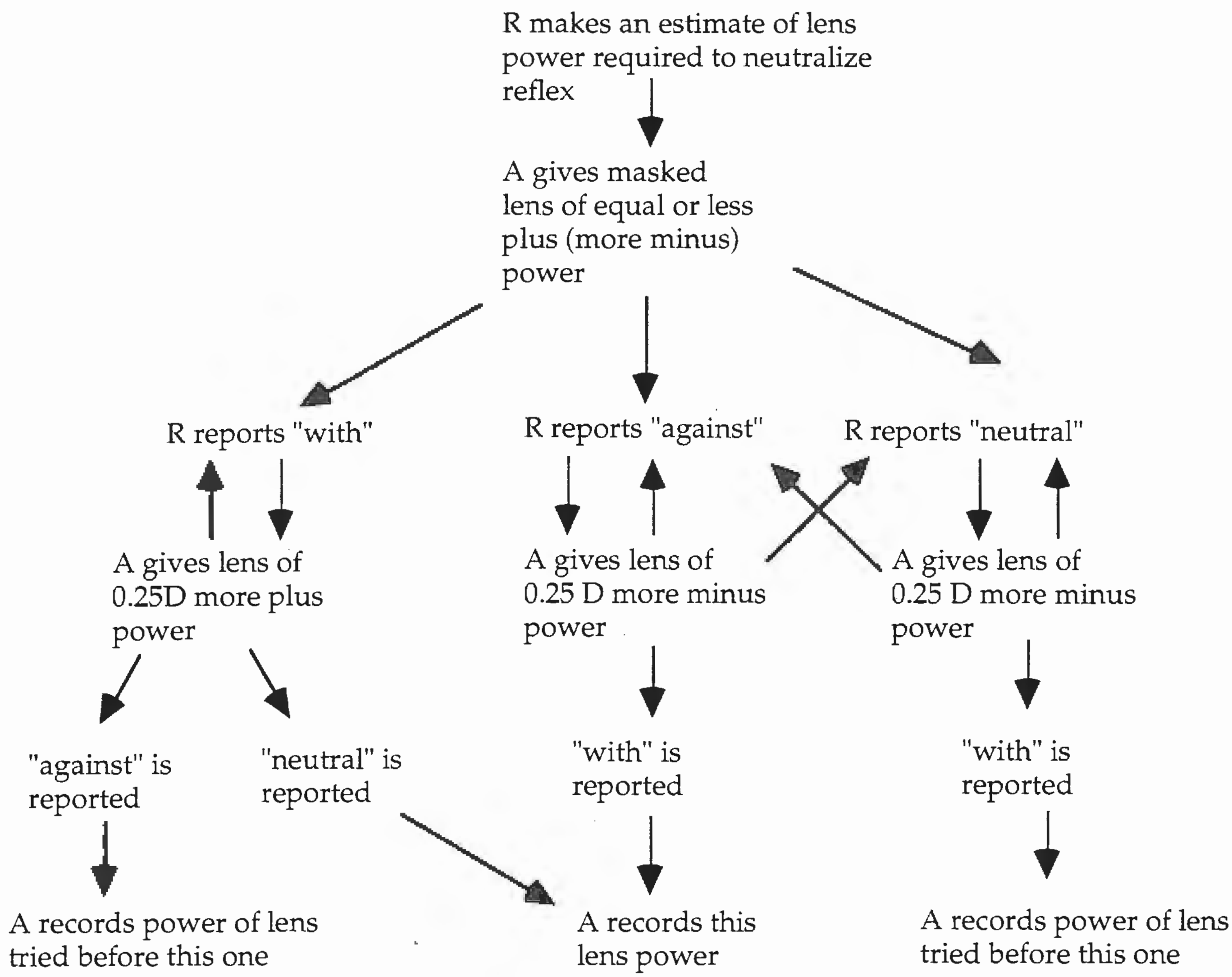


Figure 2. MEM protocol flowchart
"R" = Retinoscopist, "A" = Assistant

Book

Again the yellow distance-controlling card hanging from the near point rod was placed at the child's Harmon distance. Reading test paragraphs of the appropriate grade level (see Appendix F) were held at this distance, as was the retinoscope. The retinoscopist said to the child, "I want you to look at this card for me. Are the words clear and single? I want you to read this out loud for me, keeping it clear."

The protocol now was identical to that of MEM, except lens flippers were used instead of trial lenses, and were held by the child in front of both eyes for as long as the retinoscopist desired while assessing reflex motion.

Bell

The assistant placed the yellow distance-controlling card at 50 cm. A cartoon face was attached to the drape so that the reflected face could be seen on the surface of the chrome ball. Both the retinoscope and a chrome ball were held at 50 cm. The retinoscopist said to the child, "I want you to look at this round ball. Can you find the small reflection of a face? Keep looking at it. Keep it clear. I am moving it closer to you." The child was constantly reinforced to keep his attention on the chrome ball throughout the procedure.

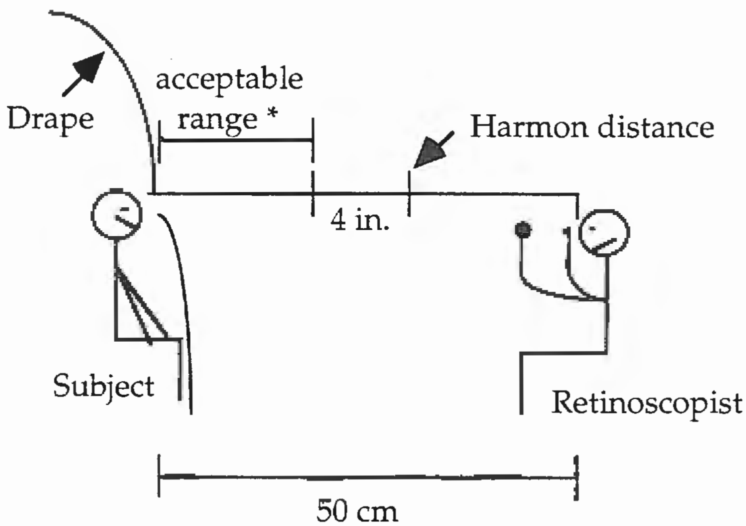
The retinoscopist then moved the ball towards the subject in such a way that it was co-axial with the line of sight of both the subject's right eye and the peephole of the retinoscope, all the while sweeping the beam horizontally across the pupil. As soon as neutrality was observed the retinoscopist stopped moving the ball and said "now." The assistant recorded the distance of the ball from the subject in inches. If "against" motion was seen while the ball was at 50 cm, instead of moving it towards the subject, the retinoscopist moved it further away until "with" was observed, then moved it back towards the subject until the first "neutral" was seen. This distance was recorded by the assistant.

Stresspoint

The yellow distance-controlling card was placed at 50 cm. The retinoscope and chrome ball were held at 50 cm. The retinoscopist gave the child the same instruction set as with Bell.

The retinoscopist held the retinoscope beam stationary on the subject's pupil and moved the chrome ball towards the subject such that it was co-axial with the line of sight of both the subject's right eye and the retinoscope peephole. When the stresspoint of the subject was observed, the examiner said "now" and stopped moving the ball. The stresspoint is the distance at which a brief brightening, followed by a dulling, followed by a return to the previous level of brightness is observed in the retinoscopic reflex[10].

If the stresspoint was reported to be closer than four inches inside the child's Harmon distance (Kraskin's criterion for children), the assistant recorded the distance of the ball to the child. If it was reported at or outside this distance, the assistant chose flipper lenses and had the child hold them over both eyes. The retinoscopist performed the procedure again. When lenses were found that brought the stresspoint to an acceptable distance by Kraskin's criterion, the assistant then decreased plus power of flippers given to the child by 0.25 D increments until the stresspoint moved outside the required distance. The lens value of the last flippers that kept the stresspoint within four inches inside the Harmon distance was recorded by the assistant (see Figure 3).



* the lens value recorded was the least plus lens which brought the stresspoint into this area

Figure 3. Diagram of Stresspoint retinoscopy performance

Data analysis

Statistical analysis of the data was carried out using one factor ANOVAs, correlations, and scatterplots. Mean measurements were determined, as were mean ranges of measurements.

RESULTS

Figures 4-7 chart the mean measurement and mean range for each retinoscopy type versus doctor. The mean range is the average dioptric value of a doctor's highest measurement minus the lowest measurement for a subject. Table 1 contains the means of each retinoscopy type performed by each of the doctors for each of the subjects. Tables 2-5 contain the descriptive data for each retinoscopy type (doctors 1 and 2 are the more experienced retinoscopists). Displayed are the mean measurement (for all 31 subjects) by each doctor for each of the three measurements, each doctor's mean measurement and mean range, and the probability values in the case of significant differences between the three measurements. Also included are probability values where there are significant differences between the four doctors' mean measurements. The highest and lowest correlations between an individual doctor's three measurements are included, as are the highest and lowest correlations between the four doctors' mean measurements.

Differences in the three measurements for a given retinoscopist are not statistically significant, with the exceptions of doctors 1 and 4 for Book, and doctor 1 for MEM. Between doctors, of all the retinoscopies, only Bell mean measurements do not have statistically significant differences. Mean ranges between doctors are significantly different for all the retinoscopies.

Analysis of Scheffe F-tests between doctors reveals that there is no evidence of any difference in reliability related to experience; overall, the novices and the more experienced retinoscopists were equally reliable. Intraexaminer and interexaminer correlations are high, with the exception of Stresspoint findings. Correlations within any one doctor's measurements tend to be stronger than correlations between different doctors' mean measurements.

The descriptive Stresspoint data are suspect because there were few subjects who required a lens at every visit from the same doctor, and even fewer who required a lens at every visit from every doctor. Thus the number of Stresspoint lens data points or Stresspoint distance data points for a given subject could vary from 0 to 12. Not only was the number of data points available for statistical analysis inconsistent, but in some cases was so low it is questionable whether any conclusions can be accurately drawn.

Although each of the retinoscopy techniques produced measurements that are significantly different from each other, at a probability value of 0.0001, Table 6 shows strong, significant correlations between the techniques. This implies that the four techniques produce findings that tend to differ by the same amount for any subject and doctor combination. For example, if doctor #1 found subject #1 to have a short lag on MEM, compared to the rest of the subjects, doctor #1 will tend to find subject #1 to have a short lag on all the techniques, compared to the rest of the subjects.

All of the retinoscopies produced findings which are both significantly different from the near autorefractor findings and are weakly correlated to them. Correlations between each of the techniques and the autorefractor measurements can be found in Table 6.

A scatterplot for each retinoscopy type can be found in Figures 8-12, plotting the overall mean retinoscopy finding for each subject against each doctor's mean finding for that subject. Scatter of the points shows a close grouping around the unity line, indicating good interrater reliability when three measurements are taken by a doctor and averaged.

Subject #	Auto FAR	Auto NEAR	GRADE	DR1 MEMmn	DR2 MEMmn	DR3 MEMmn	DR4 MEMmn	ALL MEMmn
1	0	-2.25	3	0.17	-0.58	-0.08	-0.33	-0.21
2	0	-2.87	2	0	-0.25	-0.08	-0.42	-0.19
3	0.25	-2.87	1	0.67	0.25	0.5	-0.08	0.33
4	0.25	-2.25	1	0.58	0.25	0.5	0.5	0.46
5	-0.37	-3	5	-0.33	-0.58	-0.25	-0.42	-0.4
6	0.25	-1.87	3	0.25	0.08	0.42	0.33	0.27
7	-0.62	-3	3	0	0	0.08	0.08	0.04
8	0.12	-2.37	3	-0.17	-0.33	0.08	-0.42	-0.21
9	-0.67	-2.87	7	0.42	0.25	0.25	0.25	0.29
10	-1.5	-3.12	5	0.92	0.75	1.08	0.75	0.88
11	-0.12	-2.5	4	0.42	-0.08	0.33	0.25	0.23
12	-0.75	-2.62	3	0.58	0.33	0.67	0.33	0.48
13	-0.25	-3.25	6	0.58	0.33	0.25	0.42	0.4
14	0.5	-2.62	1	0.25	0.58	-0.17	-0.25	0.1
15	0.25	-2.75	2	0.17	0.08	0.17	0	0.1
16	-0.25	-2.75	6	0	0.08	-0.08	0	0
17	0	-2.87	6	0.75	0.5	0.75	0.25	0.56
18	0	-1.75	6	0.67	0.67	0.83	0.75	0.73
19	-0.37	-2.62	2	0.25	0.42	0.42	-0.33	0.19
20	0	-2.62	1	0.42	0.33	0.25	0.33	0.33
21	-1.25	-3	1	0	0	-0.08	-0.08	-0.04
22	-0.37	-2.87	6	0.33	0.42	0.17	-0.58	0.08
23	-0.87	-2.5	2	0.5	0.42	1	0.67	0.65
24	-0.5	-2.5	2	0.58	0.58	0.92	0.83	0.73
25	-0.5	-2.87	3	0.42	0.58	0.5	0.33	0.46
26	-0.5	-2.12	4	0.92	1.25	1.17	1	1.08
27	-0.25	-2.87	6	0.67	0.75	0	-0.33	0.27
28	0.12	-3	5	-0.58	-0.17	0.33	-0.42	-0.21
29	-1	-3	8	-0.25	-0.17	-0.17	-0.58	-0.29
30	-0.5	-2.12	2	0.17	0.33	0.33	0.25	0.27
31	-0.5	-2	2	0.42	0.25	0.08	-0.17	0.15
Mean	-0.3	-2.63	3.58	0.31	0.24	0.33	0.09	0.24
s.d.	0.47	0.38	2.05	0.36	0.4	0.39	0.44	0.36

Table 1. Means of each retinoscopy by Doctor and Far and Near Autorefractor results for each subject

Subject #	DR1 BOOKmn	DR2 BOOKmn	DR3 BOOKmn	DR4 BOOKmn	ALL BOOKmn	DR1 BELLmnD	DR2 BELLmnD
1	-1.33	-1.42	-1	-1.42	-1.29	0.7	0.45
2	-0.08	-0.25	-0.25	-0.33	-0.23	0.56	0.27
3	0.5	0.17	0.17	-0.67	0.04	0.94	1.42
4	0.5	-0.5	0.5	-0.25	0.06	1.41	1.17
5	-2.83	-1.5	-2.25	-1.92	-2.13	0.2	0.37
6	-0.42	-0.33	-0.08	-0.08	-0.23	0.37	0.46
7	-1	-0.92	-1.17	-1	-1.02	0.52	0.45
8	0	-0.25	-0.42	-0.92	-0.4	0.47	0.97
9	0.17	0.08	0.08	0.5	0.21	0.38	0.04
10	0.92	0.92	1.67	1.17	1.17	1.23	0.93
11	0	-0.17	-0.75	-0.83	-0.44	0.57	0.88
12	-0.17	0.33	0.25	-0.08	0.08	0.44	0.64
13	0.08	0.33	-0.33	-0.08	0	0.92	1.09
14	-1.17	0	-0.08	-0.58	-0.46	0.67	0.86
15	-0.75	-0.08	-0.58	-0.5	-0.48	0.62	0.73
16	-1.5	-0.83	-1.5	-0.75	-1.15	0.15	0.19
17	-0.33	0.92	0.08	0.17	0.21	0.71	0.86
18	0.83	1.67	1.5	1.75	1.44	1.14	1.07
19	-0.58	0.92	-0.75	-0.33	-0.19	0.51	0.41
20	-0.25	1	0.08	0.33	0.29	2.53	0.73
21	-1.08	-0.42	-1.25	-0.42	-0.79	0.56	0.76
22	-0.33	0.92	0.17	-0.75	0	0.57	0.65
23	0.33	1	1.5	1.75	1.15	0.87	1.01
24	0.25	1	0.83	1.08	0.79	0.69	0.64
25	0.08	0.75	0	-0.08	0.19	0.64	0.57
26	0.83	1.17	1	1	1	1.29	1.63
27	-0.25	0.58	-0.58	-0.5	-0.19	0.6	0.67
28	-0.08	-1.08	-1	-1.25	-0.85	0.11	0.32
29	-1.75	-0.42	-0.92	-1.25	-1.08	-0.69	-0.17
30	-0.67	0.67	0.17	-0.25	-0.02	0.32	0.75
31	0.75	0.75	-0.25	-0.08	0.29	0.76	0.78
Mean	-0.3	0.16	-0.17	-0.21	-0.13	0.67	0.7
s.d.	0.84	0.81	0.89	0.87	0.78	0.52	0.38

Table 1. Continued

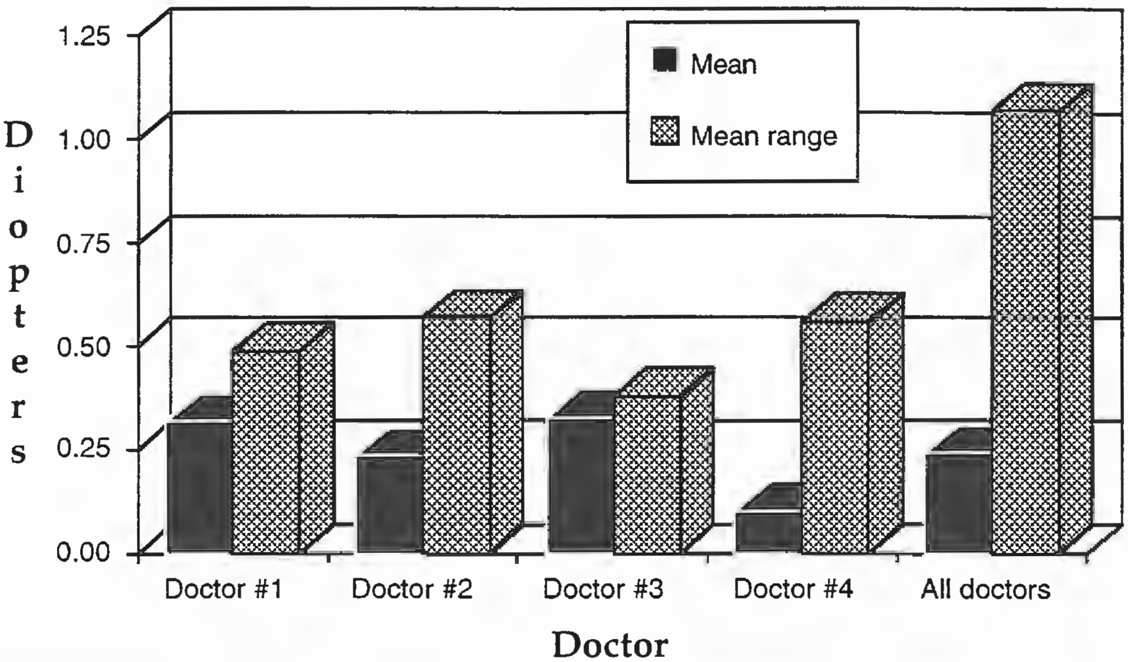
Subject #	DR3 BELLmnD	DR4 BELLmnD	ALL BELLmnD	DR1STRDISmn	DR2STRDISmn	DR3STRDISmn	DR4STRDISmn
1	0.81	0.5	0.61		6.88		7.25
2	0.45	0.28	0.39	7.25	7	7.5	
3	1.09	1.11	1.14				
4	1.42	1.13	1.28				
5	0.58	0.58	0.44	7.75	7.42	7.75	7.75
6	0.55	0.58	0.49		7.33		7.5
7	0.5	0.72	0.55	8	7.08	8	7.88
8	0.75	0.68	0.72		6.75	6.92	6.75
9	0.24	0.6	0.31	8.25	7.5	7.92	7.67
10	1.55	1.24	1.24	8	7.67	8.13	7.58
11	0.57	0.85	0.72		8		7.75
12	0.76	0.68	0.63	9	7.13	7.88	7.88
13	0.72	0.75	0.87	8	8	8	
14	0.9	0.99	0.86		6.25		
15	0.75	0.4	0.62	8	7.58	7.75	7.38
16	0	0.5	0.21	7.08	7.5	7.33	8.5
17	0.8	0.46	0.71	8.25	7.42	8.5	8.25
18	1.19	1.19	1.15	8.25	7.5	7.75	7.75
19	0.54	0.62	0.52		6.75	7	
20	1.72	0.86	1.46		6		
21	0.53	0.8	0.66				
22	0.51	0.34	0.52		6.5		
23	1.3	1.13	1.08	6.75	7.25	7.5	7
24	0.73	0.54	0.65	7.5	7.17	6.75	
25	0.57	0.6	0.59		7	6.5	7
26	1.47	1.26	1.41		6		
27	0.47	0.19	0.48	10	9.25	9.5	9.33
28	0.54	0.49	0.36	8.58	8.33	8.83	8.67
29	-0.13	-0.58	-0.39	7.75	8.42	9	7.92
30	0.76	0.53	0.59	6.5	6.25		
31	0.68	1.13	0.84				
Mean	0.75	0.68	0.7	7.94	7.26	7.82	7.77
s.d.	0.42	0.38	0.38	0.83	0.75	0.77	0.63

Table 1. Continued

Subject #	ALLSTRDISmn	DR1STRLENSmn	DR2STRLENSmn	DR3STRLENSmn	DR4STRLENSmn	ALLSTRLENSmn
1	7.06	-0.58	0.08	0.75	0.5	0.19
2	7.25	-0.25	0.13	0.25	0.5	0.16
3		0.25	1.88	2.17	2	1.57
4		0.25	1.38	1.75	1.75	1.28
5	7.67	-0.58	0	0.33	0.17	-0.02
6	7.42	0.08	0	0.67	0.08	0.21
7	7.74	0	0	0.17	0.08	0.06
8	6.81	-0.33	0.08	0	0.25	0
9	7.83	0.25	0	0	0	0.06
10	7.84	0.75	0	0.33	0	0.27
11	7.88	-0.08	0.08	0.33	0.33	0.17
12	7.97	0.33	0	0	0.08	0.1
13	8	0.33	0	0	0.17	0.13
14	6.25	0.58	0.92	1.88	1.25	1.16
15	7.68	0.08	0	0.17	0.08	0.08
16	7.6	0.08	0	0	0	0.02
17	8.1	0.5	0	0.25	0.17	0.23
18	7.81	0.67	0	0.25	0.08	0.25
19	6.88	0.42	0.08	0.67	1.13	0.57
20	6	0.33	0.33		1.5	0.72
21		0	0.5	0.75	0.5	0.44
22	6.5	0.42	0.5	0.67	2	0.9
23	7.13	0.42	0.25	0.25	0.17	0.27
24	7.14	0.58	0	0.25	0.5	0.33
25	6.83	0.58	0.25	0.5	0.42	0.44
26	6	1.25	0.42	0.58	0.42	0.67
27	9.52	0.75	0	0	0	0.19
28	8.6	-0.17	0	0	0	-0.04
29	8.27	-0.17	0	0	0	-0.04
30	6.38	0.33	0.5	1		0.42
31		0.25	1.08	2.25	1	1.15
Mean	7.41	0.24	0.27	0.54		0.37
s.d.	0.82	0.4	0.46	0.65		0.44

Table 1. Continued

Figure 4. MEM mean and mean range vs. doctor

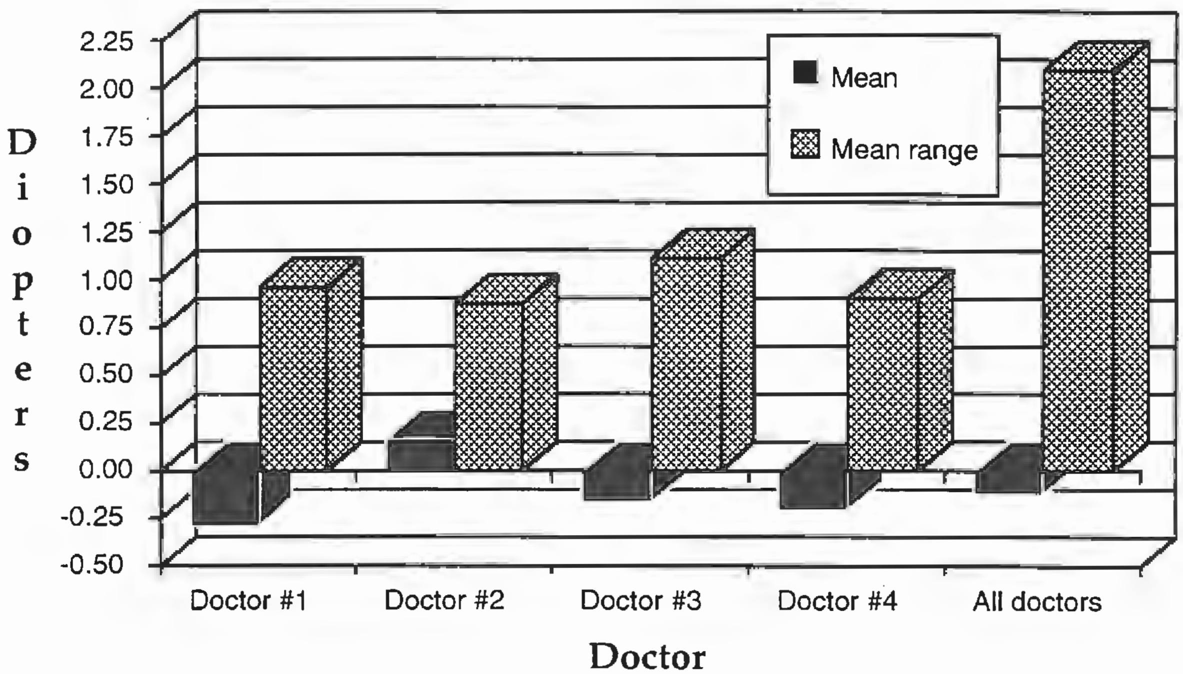


	Mean measurement in diopters for all subjects				mean	
	first	second	third	all	range	Probability
Doctor #1	0.39	0.20	0.36	0.32	0.49	<0.01
Doctor #2	0.26	0.20	0.27	0.24	0.57	NS
Doctor #3	0.34	0.36	0.29	0.33	0.38	NS
Doctor #4	0.12	0.07	0.13	0.10	0.56	NS
All doctors	0.28	0.21	0.26	0.24	1.07	NS
	Interexaminer probability			<0.001	<0.001	
	Intraexaminer measurement correlations ranged from .82 to .93					
	Interexaminer measurement correlations ranged from .63 to .83					

Table 2. MEM Descriptive Data

The "first," "second," and "third" columns show the mean measurement in diopters for all subjects by each doctor and by all the doctors. The "all" column shows the mean of the three measurements in diopters for all subjects by each doctor and by all the doctors. The "mean range" column shows the average highest measurement - lowest measurement for a subject by doctor and between all doctors. The "probability" column shows the probability that the three intraexaminer measurements are not significantly different for each doctor ("NS" = not significant). The "interexaminer probability" row near the bottom of the table gives the probability that the four doctors' mean measurements and mean ranges are not significantly different. The box at the bottom of the table shows the highest and lowest intraexaminer correlations (correlations between the three measurements taken by any one doctor) and interexaminer correlations (correlations between the four doctors' mean measurements).

Figure 5. Book mean and mean range vs. doctor

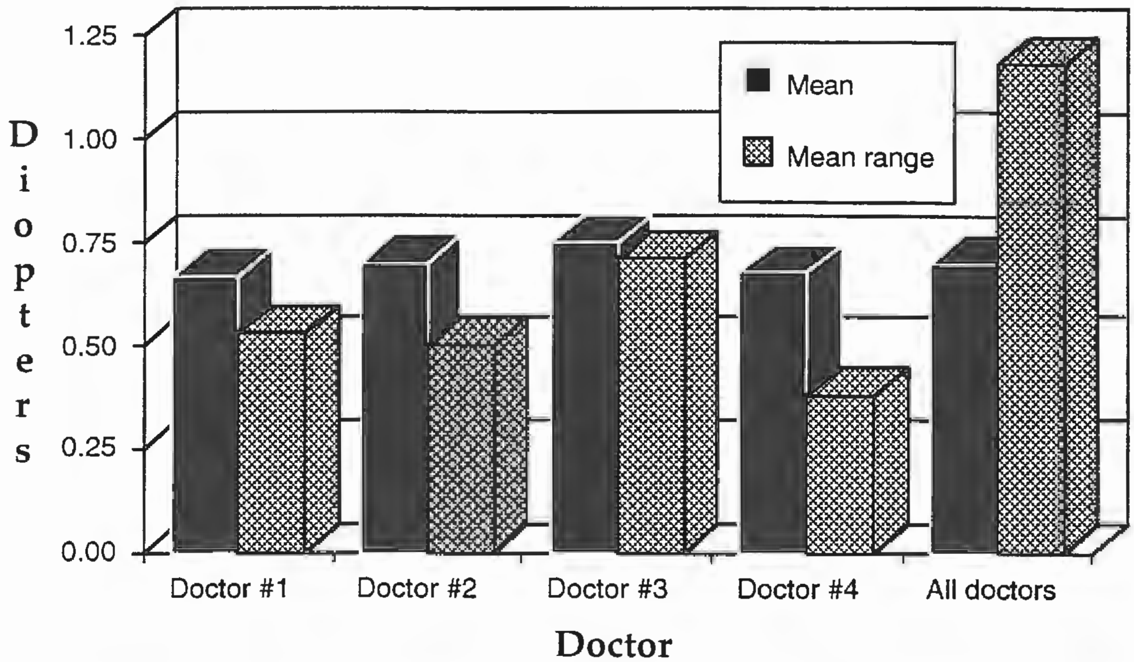


	Mean measurement in diopters for all subjects				mean	
	first	second	third	all	range	Probability
Doctor #1	-0.13	-0.60	-0.18	-0.30	0.96	<0.01
Doctor #2	0.26	0.12	0.11	0.16	0.88	NS
Doctor #3	-0.06	-0.23	-0.22	-0.17	1.11	NS
Doctor #4	0.05	-0.32	-0.37	-0.21	0.90	0.01
All doctors	0.03	-0.25	-0.17	-0.13	2.10	NS
	Interexaminer probability			<0.001	<0.001	
	Intraexaminer correlations ranged from .74 to .93 Interexaminer correlations ranged from .66 to .88					

Table 3. Book Descriptive Data

The "first," "second," and "third" columns show the mean measurement in diopters for all subjects by each doctor and by all the doctors. The "all" column shows the mean of the three measurements in diopters for all subjects by each doctor and by all the doctors. The "mean range" column shows the average highest measurement - lowest measurement for a subject by doctor and between all doctors. The "probability" column shows the probability that the three intraexaminer measurements are not significantly different for each doctor ("NS" = not significant). The "interexaminer probability" row near the bottom of the table gives the probability that the four doctors' mean measurements and mean ranges are not significantly different. The box at the bottom of the table shows the highest and lowest intraexaminer correlations (correlations between the three measurements taken by any one doctor) and interexaminer correlations (correlations between the four doctors' mean measurements).

Figure 6. Bell mean and mean range vs. doctor

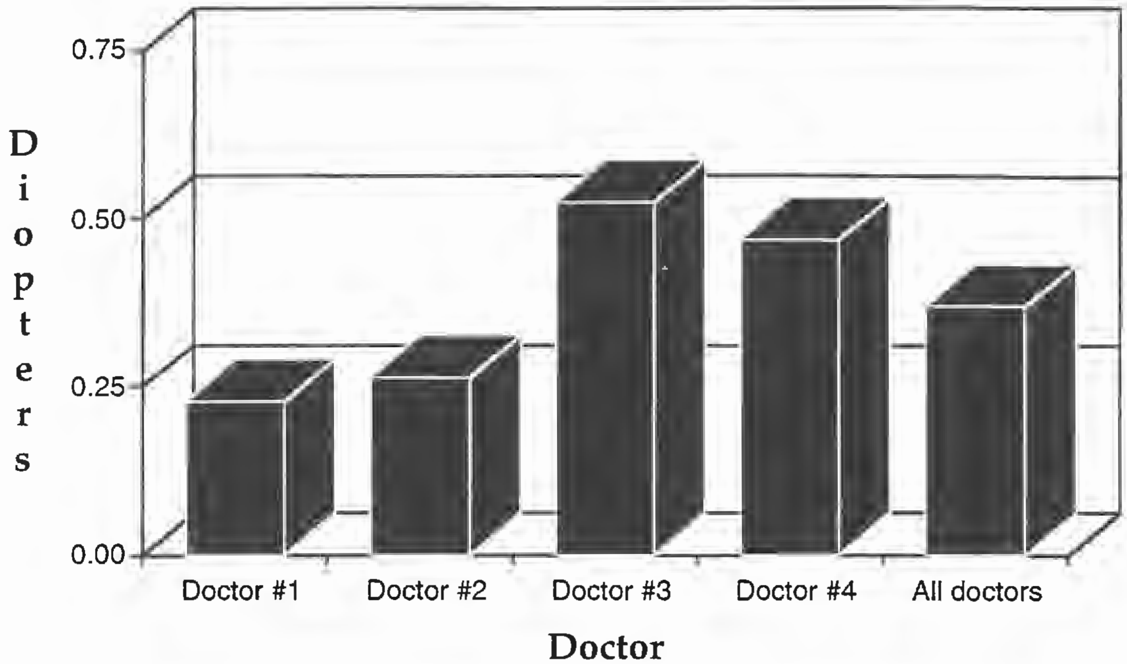


	Mean measurement in diopters for all subjects				mean	
	first	second	third	all	range	Probability
Doctor #1	0.60	0.62	0.79	0.67	0.53	NS
Doctor #2	0.73	0.83	0.60	0.70	0.50	NS
Doctor #3	1.08	0.76	0.67	0.75	0.71	NS
Doctor #4	0.78	0.69	0.62	0.68	0.38	NS
All doctors	0.80	0.72	0.67	0.70	1.18	NS
	Interexaminer probability			NS	<0.001	
	Intraexaminer correlations ranged from .80 to .94 Interexaminer correlations ranged from .75 to .88					

Table 4. Bell Descriptive Data

The "first," "second," and "third" columns show the mean lag measurement in diopters for all subjects by each doctor and by all the doctors. The "all" column shows the mean of the three measurements in diopters for all subjects by each doctor and by all the doctors. The "mean range" column shows the average highest measurement - lowest measurement for a subject by doctor and between all doctors. The "probability" column shows the probability that the three intraexaminer measurements are not significantly different for each doctor ("NS" = not significant). The "interexaminer probability" row near the bottom of the table gives the probability that the four doctors' mean measurements and mean ranges are not significantly different. The box at the bottom of the table shows the highest and lowest intraexaminer correlations (correlations between the three measurements taken by any one doctor) and interexaminer correlations (correlations between the four doctors' mean measurements).

Figure 7. Stresspoint mean lens value vs. doctor



	Mean measurement in diopters for all subjects				distance	
	first	second	third	all	(in inches)	Probability
Doctor #1	0.43	0.34	0.37	0.23	7.63	NS
Doctor #2	0.13	0.25	0.13	0.26	7.20	NS
Doctor #3	0.23	0.37	0.39	0.53	7.63	NS
Doctor #4	0.25	0.21	0.25	0.47	7.46	NS
All doctors	0.26	0.29	0.28	0.37	7.48	NS
	Interexaminer probability			<0.01	<0.01	
	Intraexaminer correlations ranged from .19 to .99 Interexaminer correlations ranged from -.08 to .98					

Table 5. Descriptive Stresspoint Data

The "first," "second," and "third" columns show the mean measurement in diopters for all subjects for which lens data were available by each doctor and by all the doctors. The "all" column shows the mean of the three measurements (where available) in diopters for all subjects by each doctor and by all the doctors. Reliable range data for Stresspoint are not available due to too few subjects requiring a lens for all measurements. The "distance " column shows the mean distance where the stresspoint was found for all the subjects for which it was available by doctor and by all the doctors. Reliable means are not available for each of the three distance measurements due to too few subjects. The "probability" column shows the probability that the three intraexaminer lens measurements are not significantly different for each doctor ("NS" = not significant). The "interexaminer probability" row near the bottom of the table gives the probability that the four doctors' mean measurements are not significantly different. The box at the bottom of the table shows the highest and lowest intraexaminer correlations (correlations between the three measurements taken by any one doctor) and interexaminer correlations (correlations between the four doctors' mean measurements).

Technique	Mean MEM	Mean Book	Mean Bell	Mean Stresspoint
Mean MEM	1			
Mean Book	.90	1		
Mean Bell	.77	.74	1	
Mean Stresspoint	.86	.87	.83	1
Mean Autorefractor	.46	.55	.45	.44

Table 6. Correlations between the mean measurements of the techniques

Figure 8. Overall MEM mean vs. Individual Doctor's mean by Subject

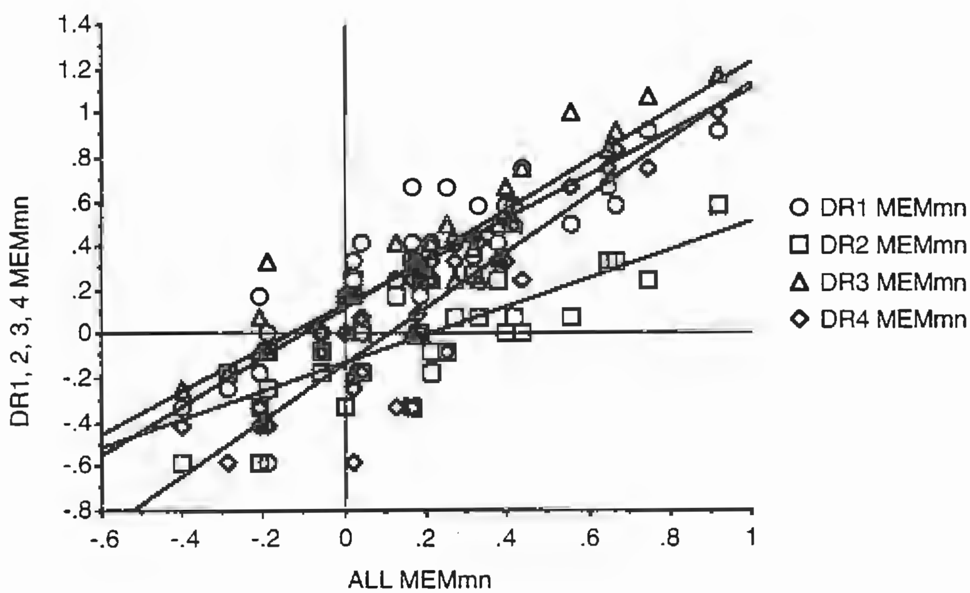


Figure 9. Overall Book mean vs. Individual Doctor's mean by Subject

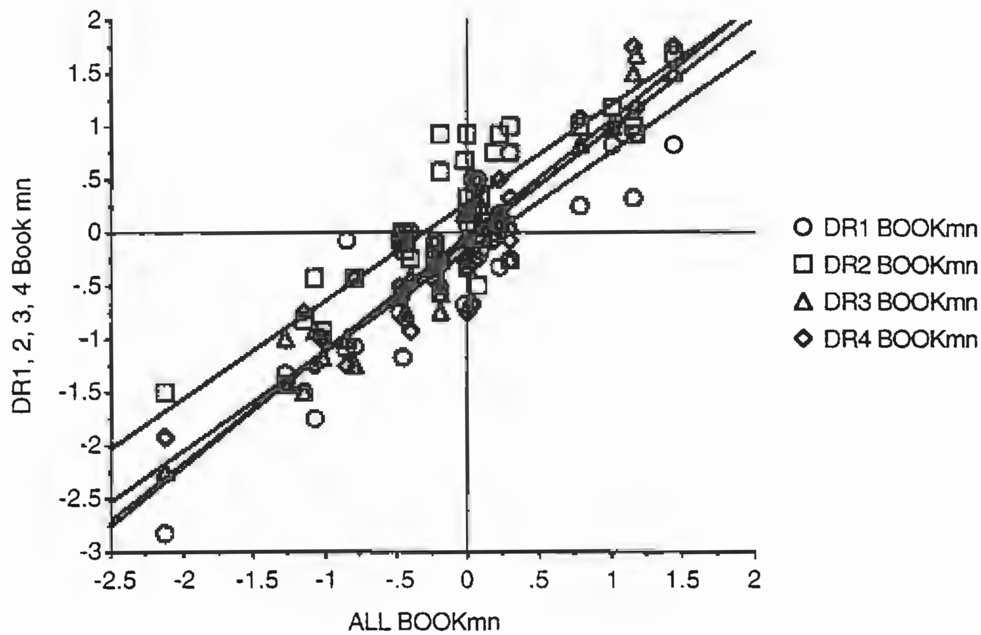


Figure 10. Overall Bell mean vs. Individual Doctor's mean by Subject

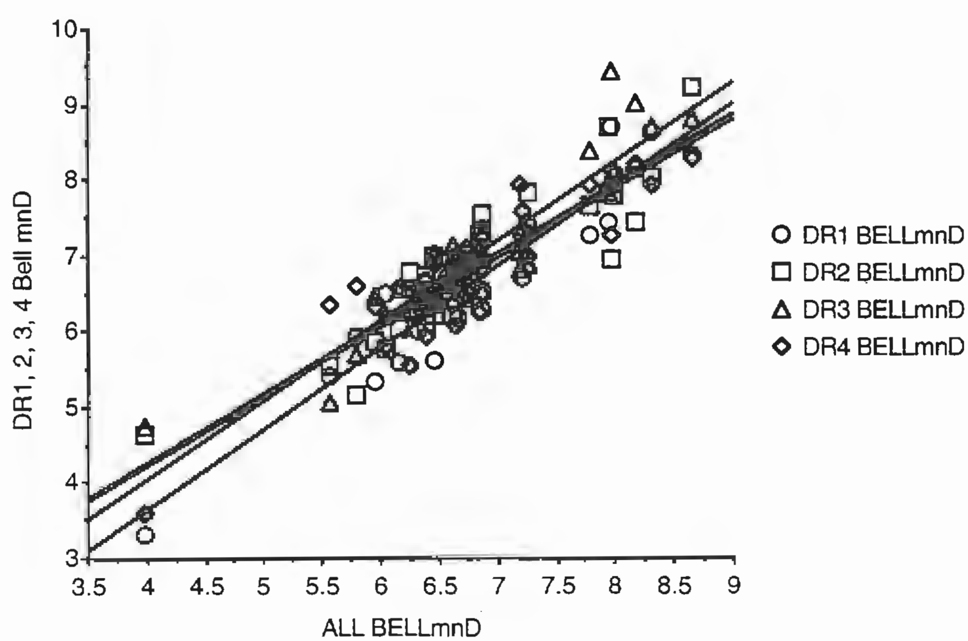


Figure 11. Overall Stresspoint Distance mean vs. Individual Doctor's mean by Subject

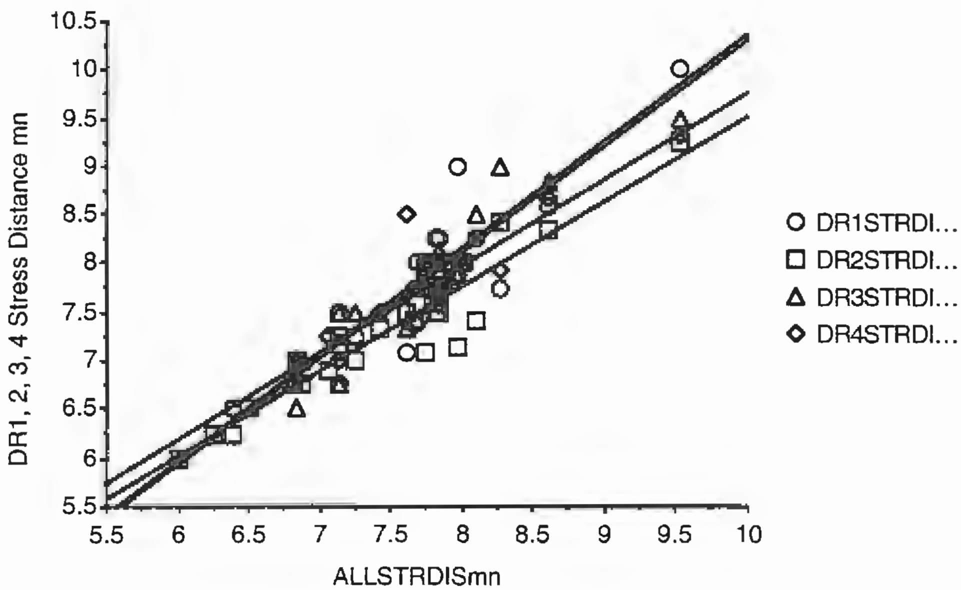
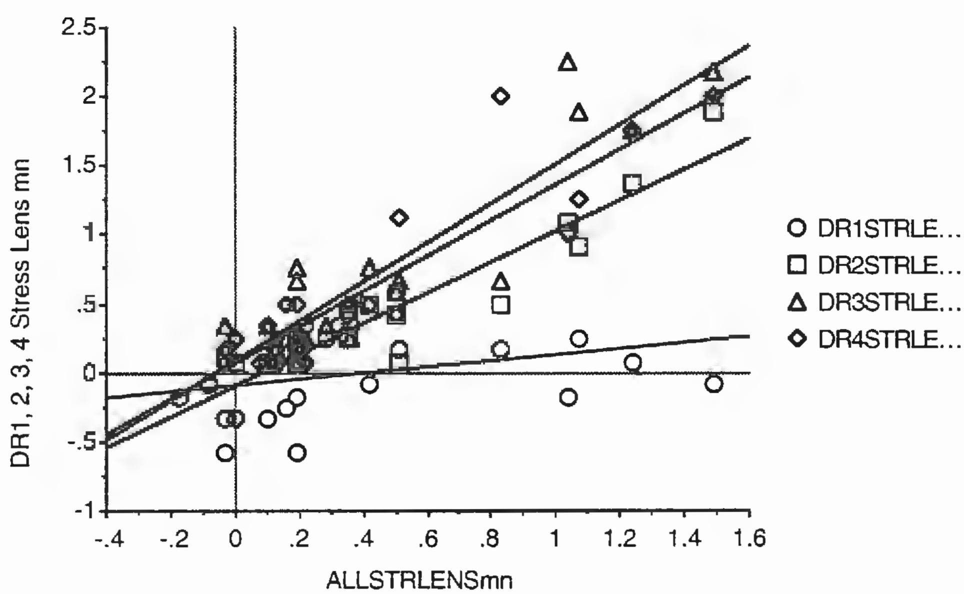


Figure 12. Overall Stresspoint Lens mean vs. Individual Doctor's mean by Subject



DISCUSSION

Most of our statistical evidence reveals that all four retinoscopies show good reliability for a given examiner, and poorer, though still acceptable, reliability between examiners. Doctors 1 and 4 for Book and Doctor 1 for MEM had means for their three measurements within 0.50 D, although they came out as statistically different. Clinically, this maximum mean difference of 0.50 D is of questionable importance. Mean range data also support the good intraexaminer reliability in these statistically unfortunate situations. Doctor 1 had a mean range of 0.49 D for MEM; this means that on average, any measurement deviates less than 0.25 D from the mean measurement. Doctor 1's Book range is 0.96 D, and Doctor 4's is 0.90, indicating any measurement will on average be no more than 0.43 D and 0.40 D from the mean measurement, respectively.

Statistically, only Bell retinoscopy was found to be reliable between the examiners, with a difference between the examiners' means of 0.08 D. However, differences between examiners' means were 0.23 D for MEM, 0.46 D for Book, and 0.30 D for Stresspoint, again differences of questionable clinical importance. Interexaminer mean ranges tell a different story, showing a considerable spread of the twelve data points obtained for a given subject. Mean ranges were 1.07 D for MEM and 1.18 D for Bell, indicating that measurements taken by any doctor will on average be no more than 0.54 D from the mean for MEM and 0.59 D from the mean for Bell. The authors find these deviations to be borderline acceptable clinically. The mean range for Book is more troublesome -- at 2.10 D, a retinoscopist will on average be no more than 1.05 D from the mean, possibly demonstrating considerable variation. Mean range information was not available for Stresspoint due to the incomplete data set.

Scatterplots of the means for each doctor versus overall mean for a technique showed close spread of the data. Scatterplot analysis is important because it allows readers to impose their own standards of clinical significance. The ANOVA test does not discern clinically acceptable differences; it recognizes that 0.25 D and 0.50 D are different, but cannot make a judgment as to whether this is a clinically important difference. The strong correlations both within a given examiner's measurements and between examiners' mean measurements provide more evidence of the good reliability of these techniques. Stresspoint was the exception, with correlations varying from excellent to very poor. In addition to problems with the data set discussed in the results section, Stresspoint was reported to be the most difficult technically for the retinoscopists. None of the retinoscopists had any clinical experience with the technique prior to participating in the study. The reflex end point was unfamiliar, involving brightness changes rather than the motion change the examiners had experience identifying.

High correlations between the four retinoscopies imply that they are measuring related phenomena. Near autorefractor measurements appear to be a measure of something else, as they were poorly correlated to all four techniques. It is likely that the near autorefractor is an unreliable method of measuring accommodative posture, but its reliability was beyond the scope of this study.

Theoretically, MEM is the purest measure of what is meant by the term "accommodation posture." It is taken through the habitual near lens at the distance the individual should be reading (Harmon distance) while the patient is performing a cognitive task, and is ideally uncontaminated by any lens application. Scoping "on-axis" is easy with the Pierce MEM cards. The challenge in performing MEM is in accurately judging motion in less than a fifth of a second (the average reaction time to an accommodative stimulus). Also, is that fraction of a second representative of the lag during everyday reading, or did it occur at a particularly easy or challenging word? The retinoscopists agreed that performing MEM was more difficult than they imagined with masked lenses. In a typical clinical setting, the lens is used only to verify an estimate, and the retinoscopist expects to see "neutral" motion with it. In our study the retinoscopist did not know what power lens they had been given, and thus couldn't have a mental preset as to what type of motion to expect.

Assuming we have a reliable MEM finding, how valuable is this information? We now know the patient's accommodative posture, but this doesn't tell us how a patient will react to a lens prescribed for near (unless MEM is performed over a potential near lens). This concern is addressed by Book and Stresspoint retinoscopies.

Book retinoscopy is the most natural situation of all the retinoscopies; the patient reads grade level material at the Harmon distance through prospective near lenses, allowing the retinoscopist to judge the response to the lenses. The classical method of Book retinoscopy performance involves a reflex quality and color judgment by the retinoscopist, which was not included in our study. Our retinoscopists agreed that the most challenging part of Book performance was scoping off-axis as the subject read across (pointing their eyes left and right of the scope) and down (pointing their eyes beneath the scope). The result was a darker, poorer quality reflex which made motion evaluation more difficult. It is well known that the curvature of the cornea and lens changes in an unpredictable manner as one moves away from their axes. This might explain in part why the Book findings were in most cases less reliable than the other retinoscopies, and were more "minus" than expected. Perhaps Book findings would have been found to be more reliable if we had used reading material spanning a shorter distance on the page, instead of reading test paragraphs modeled after the Gray Oral Book Retinoscopy cards[b] (see Appendix F). Also, Book performance may have been simpler if retinoscopists could have scoped both eyes, and thus could go back and forth between eyes depending on which eye was more on-axis at the moment.

Stresspoint retinoscopy is another method which evaluates the effectiveness of potential near lenses. It is unique in that it makes no claim of evaluating what is thought of as accommodation posture. Instead, its intent is to discover the point at which a physiological, whole-body stress response to near fixation suddenly occurs. It defines the place in space where "near-point stress" becomes a problem for an individual, then aids in determining a lens which moves this stressful zone close enough to the patient so that they are buffered during most near activities.

In theory, the principles behind prescribing by Stresspoint are the most noble of all the retinoscopies. The problem is twofold. First, the reflex changes as described by Kraskin differed from what our retinoscopists experienced. Kraskin describes a "brief brightening, followed by a dulling, followed by a return to the previous level of brightness."[10] Our retinoscopists saw a gradual dulling as they began moving the chrome ball towards the subject, then observed a point at which a more dramatic dulling occurred, corresponding with a noticeable decrease in pupil diameter. This was the point at which they would say "now." The initial brief brightening and the return to brightness were not observed by our retinoscopists, although it must be kept in mind that our study was their first experience with Stresspoint.

The second problem is the lack of acceptance in the optometric community of the premise of Stresspoint -- that the reflex brightness changes correspond to a physiological "stress point." The optical explanation for the gradual dulling of the reflex observed by our retinoscopists is simple; the increasing distance between the conjugate focus of the eye and the apparent source of the retinoscope will cause the light coming back to the retinoscopist to be more diffuse, and thus less bright, as the chrome ball is moved towards the subject. However, no mechanism for the other brightness changes has been scientifically validated, except possibly by Kruger[16]. His 1977 research shows that detectable luminance changes in the reflex occur with accommodation changes of 0.50D or more or with pupil diameter changes of 10% or more, especially if these changes are fast. The dramatic dulling observed corresponding with the noticeable (probably at least 10%) pupil size decrease reported by our retinoscopists is consistent with Kruger's finding. So now the question is, "what is causing the dramatic pupil size reduction at this assumed 'stresspoint?'" Kraskin claims there will be signs of physiological stress at the same moment, in particular a pulse pressure flattening and an increase in muscular tension in the lower back. Clearly, more research needs to be published to support this theory.

Also, the designation of "four inches inside the Harmon distance for children and within eight or nine inches from the face for adults" is arbitrary. If the "stresspoint" exists as described, more research is needed to determine how large a buffer is required to yield comfortable, efficient function. If, as described by Kraskin, the stresspoint will move back away from the patient as too much plus is used, then perhaps the most desirable lens for anybody would be that which moves the stresspoint closest in. Why not get the largest buffer possible?

Of all four retinoscopies, Bell fared the best statistically. This study's retinoscopists reported it to be an easy technique: looking for motion, under no time pressure, and on-axis. The only difficulty was when a subject exhibited a "lead" in accommodation at 50 cm. In these cases the chrome ball had to be moved further away from the subject to achieve neutrality. To stay on-axis, it would have to be moved through the retinoscopist's head. Our retinoscopists being hard-headed, they had to scope off-axis, yielding results of questionable value. Another problem with Bell retinoscopy is that there is no standard distance to which the calculated lag can be attributed, since the distance associated with the lag depends on the lag itself (remembering the endpoint of Bell being when neutral is observed by the retinoscopist at 50 cm as they move a target towards the subject). Thus, a subject with a short lag will often have their Bell-measured lag associated with a distance further than their actual reading distance, and a subject with a long lag will often have their Bell-measured lag associated with a distance closer than their actual reading distance. A lag measurement at either subject's actual reading distance might be considerably different from the the Bell-measured lag. Also, does the unusual task of looking at a chrome ball produce an accommodative posture comparable to a more common nearpoint task, e.g. reading? And again, in classical performance no evaluation is made of the effectiveness of a potential near lens.

Perhaps we can apply the unique aspect of Bell (neutralization by changing the retinoscopist's position rather than lenses) to a more natural situation. Nott[3] describes a hole card with printed material held stationary at the patient's reading distance, with the retinoscopist moving their scope away from the patient until neutrality is observed. The dioptric equivalent of the retinoscopist's end distance would be subtracted from the dioptric equivalent of the reading distance. This procedure can be performed in phoropter, through the distance refraction or through a tentative nearpoint prescription. One drawback to this procedure is that it is impossible to quantify a lead in accommodation. Any further research dealing with dynamic retinoscopy should examine this procedure, as our results suggest it may have superior reliability.

In retrospect, our study contained a few design flaws. Subject distance was controlled well by the bottom of the phoropter during trial sessions using adults , but when children were used during data gathering, their smaller heads sometimes slipped under the phoropter, and the assistants had to be vigilant to control distance. Book retinoscopy reading paragraphs should have been designed for easier on-axis scoping. Initial Stresspoint distance should have been recorded, even if a near lens was later applied. If it had been, we could have had at least one complete Stresspoint data set, and could analyze reliability of the initial Stresspoint distance. Retinoscopists should have been required to practice the techniques (especially Stresspoint retinoscopy) for more than one session to improve pre-data collecting competency.

Despite these flaws, some valuable conclusions can be drawn from the results of this study. Bell and MEM retinoscopies are highly reliable techniques, both within an examiner and between examiners. Book retinoscopy is somewhat less reliable, especially between examiners, though it is speculated that increased reliability might be obtained with smaller reading paragraphs. It is difficult to make any valid conclusions regarding Stresspoint due to problems with the data set. All of the techniques produce findings that are highly correlated with each other, supporting the idea that they are measuring related phenomena. Apparently the near autorefractor is not measuring anything related to what the retinoscopies measure, as those findings were poorly correlated. Experience did not appear to affect reliability of a retinoscopist, suggesting that all clinicians should be able to employ these valuable techniques with confidence, regardless of their level of expertise.

REFERENCES

1. Birnbaum MH (1984). Nearpoint visual stress: a physiological model. J Am Optom Assoc 55(11): 825-835.

2. Sheard C (1920). *Dynamic skiametry.* Chicago Cleveland Press.

3. Nott, IS (1925). Dynamic skiametry, accommodation and convergence. Am J Phy Opt 6(4): 490-503.

4. Tait EF (1928). A quantitative system of dynamic skiametry. Am J Opt 6(12): 669-693.

5. Gesell A, Ilg FL, Bullis GE, Getman GN, Ilg V (1949). *Vision: its development in infant and child.* Paul Hoeber, Inc.

6. Getman GN, Kephart NC (1958). Book retinoscopy. Optometric Extension Program Papers, Series 2(10-11).

7. Apell RJ (1975). Clinical application of bell retinoscopy. J Am Opt Assoc 46(10): 1023-1027.

8. Bieber JC (1974). Why nearpoint retinoscopy with children. Optom Wkly 65(54-7): 78-82.

9. Haynes HM (1960). Clinical observations with dynamic retinoscopy. Optom Wkly 51: 2243-46, 2306-9.

10. Kraskin RA (1965). Stress-point retinoscopy. J Am Opt Assoc 36: 416-9.

11. Rouse MW, London R, Alleen DC (1982). An evaluation of the monocular estimate method of dynamic retinoscopy. Am J Optom Physiol Opt 59(3): 234-9.

12. McKee GW (1981). Reliability of monocular estimate method retinoscopy. Optom Monthly 72: 30-1.

13. Locke LS, Somers WA (1989). A comparison study of dynamic retinoscopy techniques. Optom Vis Sci 66: 540-4.

14. Jackson TW, Goss DA (1991). Variation and correlation of clinical tests of accommodative function in a sample of school-age children. J Am Opto Assoc 62(11): 857-64.

15. Streff JW, Claussen VE (11971). Retinoscopy measurement differences as a variable of technique. Am J Optom Physiol Opt 48: 671-76.

16. Kruger PB (1975). Luminance changes of the fundus reflex. Am J Optom Physiol Opt 52: 847-61.

a Pierce MEM cards can be obtained from Dr. Edward Warren, 15 Pasture Lane, West Lebanon, N.H. 03784

b Gray Oral Reading Paragraphs can be obtained from Mast-Keystone, 4673 Aircenter Circle, Reno, NV, 89502

Appendix A
Sample screening form

Date: June 17, 1994

Thesis Screening

Name: [redacted] DOB: [redacted] Age: [redacted]
Address: [redacted] Phone: [redacted]
Parents Name: [redacted]

Visual Acuities

Distance	Near
O.D. 20/20	O.D. 20/20
O.S. 20/20	O.S. 20/20
O.U. 20/20	O.U. 20/20

Retinoscopy
O.D. +.25
O.S. +.25

— Myopia
— Astigmatism > 1.50D
— Hyperopia >1.50D
— Aniso > diff. than 1.50D

Thank you for participating in our screening. We will inform you if you have been selected as a participant in our thesis project. If you are chosen, you will be compensated for your time.

The thesis will be conducted in mid-June. If you would like further information, please contact Frank Lam at 357-6168 or Herman Shen at 359-0422. Thank you again for participating.

Appendix B
Instructions given to retinoscopists and assistants

INSTRUCTION SET FOR THE RETINOSCOPISTS

MEM: SAY: "I want you to look at this card for me. Are the words clear and single? I want you to read those words out loud for me, keeping them clear."

BOOK: SAY: "I want you to look at this card for me. Are the words clear and single? I want you to read this out loud for me, keeping it clear."

BELL: SAY: "I want you to look at this round ball. Can you find the small reflection of a face? Keep looking at it. Keep it clear. I am moving it closer to you" Keep reinforcing the patient to keep his attention on the chrome ball.

STRESSPOINT: SAY: "I want you to look at this round ball. Can you find the small reflection of a face? Keep looking at it. Keep it clear. I am moving it closer to you" Keep reinforcing the patient to keep his attention on the chrome ball.

RESPONSIBILITIES OF THE ASSISTANTS:

1) Set up patient behind phoropter. Make sure he is completely covered and comfortable. Prepare the Book retinoscopy card and MEM card appropriate for his grade level. Instruct patient to follow the instructions, not to talk unless asked directly, and to keep their nose touching the cardboard without pushing forward.

2) Make sure that the patient and the retinoscopist keep their proper distance during the measurements.

3) Hand to the retinoscopists the appropriate lenses and cards.
a) For MEM and Book the retinoscopists will make an estimate of which lens is needed to reach neutrality and the assistant will choose lenses of equal of or less plus power, will mask them and hand them to the patient for Book or to the retinoscopist for MEM. After the first lens chosen, if with motion is still seen, increase the power of the lenses ALWAYS IN QUARTER STEPS and record THE FIRST NEUTRAL OR LAST WITH.

IF against motion is seen, the retinoscopist will estimate how much minus is needed to reach neutrality. The assistant chooses a lens of equal or more minus power and hands it to the retinoscopist. If with motion is now achieved, proceed as above.
IF against motion is seen with the first lens given to the retinoscopist, decrease plus power in quarter steps until with motion is perceived. At this point, the assistant should record the power of the last lens which resulted in neutral before the with motion is perceived. If neutrality was never achieved, record the lens which gives the first with motion.
b) For Bell retinoscopy, record the distance when the retinoscopist says "now" in inches.
c) For Stresspoint retinoscopy, note the distance at which the retinoscopist finds the stresspoint. If it is already within the ideal distance (Harmon distance minus four inches) just record the distance. If it is at or outside this distance, choose lenses of your choice, hand them to the patient, and have the retinoscopist perform the procedure again. If the stresspoint is still outside the required distance, increase the lens power in quarter steps and record the first lens which puts the stresspoint within this distance. If the first lens puts the stresspoint within the required distance, decrease the plus power in quarter steps until the last lens is found which will still keep the stresspoint inside the required distance.

ASSISTANTS MUST TELL SUBJECTS AT ONSET:
"This will take about five minutes. A doctor will come in and tell you what to do. It's important that the doctor does not recognize you so you need to stay behind the sheet and talk only when asked while the doctor is in the room. Hold your nose against the cardboard but don't push it forward. If you do everything just as the doctor asks you, you will get fifty cents each time."

Appendix C
Informed consent form

Informed Consent Form

Institution

A. Title of project:	Dynamic Retinoscopies: Are they reliable?
B. Principal investigator:	Barbara Briscoe O.D.
Co-investigators:	Christina Smith Herman Shen Frank Lam
C. Advisor:	Richard Septon O.D.
D. Location:	Pacific University College of Optometry Forest Grove, OR
E. Date:	March-June1994

1. Description of project

This research project is designed to assess the reliability of dynamic retinoscopies in children. Dynamic retinoscopies are valuable objective clinical techniques for measurement of accommodative response. These procedures involve shining a light in the eye while the subject is asked to read or to look at their reflection in a chrome ball.

2. Description of risks

1) No unusual or invasive techniques will be used during all the near retinoscopy tests. However, some individuals may experience mild headache and/or glare or after images during or after the retinoscopy tests.

2) Since all the tests are at close proximity with movement of materials near the eyes, there is a possibility of subjects receiving trauma to the eye(s) and/or face from the lenses, near cards, rulers, retinoscopes, etc.

3) During the testing, different lenses will be introduced to the patient which may lead to temporary dizziness, mild nausea, blurred vision and a "swimming" or distortion of the visual field.

3. Description of benefits

This study will serve to increase the knowledge base about dynamic retinoscopy and may serve to increase its use clinically.

4. Alternatives advantageous to subjects

Not applicable

5. Records of this project will be maintained in a confidential manner and no name-identifiable information will be released.

6. Compensation and medical care

If you are injured in this experiment it is possible that you will not receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the experiment. All responsible care will be used to prevent injury.

7. Offer to answer any inquiries

The experimenters will be happy to answer any questions that you may have at any time during the course of the study. If you are not satisfied with the answers you receive, please call Dr. James Peterson at 357-0442. During your participation in the project you are not a Pacific University clinic patient or client for the purposes of the research and all questions should be directed to the researchers and/or the faculty advisor who will be solely responsible for any treatment (except for an emergency). You will not be receiving complete eye, vision or health care as a result of participation in the project; therefore, you will need to maintain your regular program of eye, vision, and health care.

8. Freedom to withdraw

You are free to withdraw your consent and to discontinue your child's participation in this project or activity at any time without prejudice to you or your child.

I have read and understand the above. I am the parent or guardian of the participant.

Print name____

Signed_______________________________Date_______________

Address______________________________Phone______________

City_________________________________State/Zip__________

Name and address of a person not living with you who will always know your address.

____

Appendix D
Sample randomization table for subject rotation

Subj. position #1	**subject #1**	**subject #2**	**subject #3**	**subject #4**
	doctor #1	doctor #2	doctor #3	doctor #4
	doctor #4	doctor #1	doctor #2	doctor #3
	doctor #3	doctor #4	doctor #1	doctor #2
	doctor #2	doctor #3	doctor #4	doctor #1
Subj. position #2	**subject #3**	**subject #1**	**subject #4**	**subject #2**
	doctor #1	doctor #2	doctor #3	doctor #4
	doctor #4	doctor #1	doctor #2	doctor #3
	doctor #3	doctor #4	doctor #1	doctor #2
	doctor #2	doctor #3	doctor #4	doctor #1
Subj. position #3	**subject #2**	**subject #4**	**subject #1**	**subject #3**
	doctor #1	doctor #2	doctor #3	doctor #4
	doctor #4	doctor #1	doctor #2	doctor #3
	doctor #3	doctor #4	doctor #1	doctor #2
	doctor #2	doctor #3	doctor #4	doctor #1

Appendix E
Sample data recording form

Subject's name and number
"C," "B," or "A" for subject's race
Subject's Harmon distance
Grade subject had just completed

Assistant's name
Date and time

Subject #4

examiner #1
MEM
Book
Bell
Stressp.

examiner #4
MEM
Book
Bell
Stressp.

examiner #3
MEM
Book
Bell
Stressp.

examiner #2
MEM
Book
Bell
Stressp.

Appendix F
Sample Book Retinoscopy Card

3 After they finished eating they watched the fire until it was time to go to sleep. When Dick and Father had gone to sleep something made a terribly loud noise and woke them up. Dick was afraid but Father laughed because it was only an airplane flying over them.