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Clinical relevance of examiner position on the objective alternating cover test

Abstract

Background: Although the alternate cover test is a widely accepted test of ocular alignment, clinical ambiguity exists regarding the specific location of the examiner. This study was an attempt to replicate the findings of a previous study that compared two examiner positions and their effect on heterophoric measurement at 40cm.

Methods: Fifty-seven adult subjects (mean age, 24.0 +1-2.88 years) with healthy binocular systems were measured for heterophoric posture during the cover test while the examiner position was varied between midline and 30 degrees to the right of patient midline.

Results: A significant difference between midline and offset position of 1.3A was found ($P < 0.001$). The results show that a greater exophoric measurement was seen when the examiner performs the test in the offset position.

Discussion: A 1.3A difference in examiner positions demonstrates a statistically significant difference between examiner positions. This difference, it seems, is related to proximal awareness or prismatic measurement error. Given the small magnitude of the effect, its importance in clinical care is probably most relevant in patients with high phorias or intermittent strabismus. Examiner position may also contribute to variability in cover test measures between examiners or on test-retest.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Bradley Coffey

Keywords

objective alternating cover test, examiner position, heterophoria

Subject Categories

Optometry

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CLINICAL RELEVANCE OF EXAMINER POSITION ON THE
OBJECTIVE ALTERNATING COVER TEST

By

THOMAS EUGENE CLARE and WILLIAM REYNOLDS

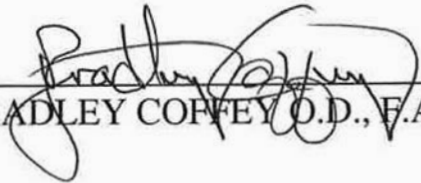
**A thesis Submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May 2001**

Advisor:

BRADLEY COFFEY O.D., F.A.A.O

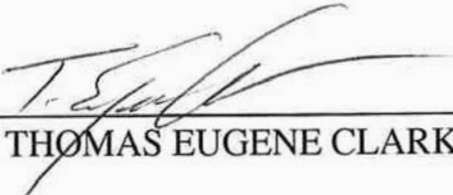
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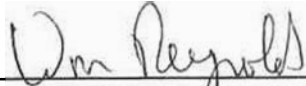


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BIOGRAPHIES

THOMAS EUGENE CLARK

Gene Clark attended the University of Mary in Bismarck, North Dakota where he received a Bachelor of Science degree in Medical Biology and Chemistry. Although not active in his graduate studies Gene was a student representative his last two years at the University of Mary including vice president of the Math Science Association. Gene plans on attending a Geriatric Residency after graduation in hopes to working with an ophthalmologist in the Midwest.

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William Reynolds attended Albertson College of Idaho and received his Bachelor of Science degree in Zoology. After completing the Doctorate of Optometry program at PUCO, he will return to the US Army to begin his professional career.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Bradley Coffey for his guidance, knowledge, and mentorship throughout this project. Thanks also to fellow students Nathan Heilman and Trent Thompson for their contributions to the data collection process. Finally we would like to thank Dr. Scott Cooper and Dr. Karl Citek for their assistance during the revision process.

ABSTRACT

Background: Although the alternate cover test is a widely accepted test of ocular alignment, clinical ambiguity exists regarding the specific location of the examiner. This study was an attempt to replicate the findings of a previous study that compared two examiner positions and their effect on heterophoric measurement at 40cm.

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Keywords: objective alternating cover test, examiner position, heterophoria

INTRODUCTION

The cover test is a venerable procedure which provides the practitioner valuable information by screening for binocular anomalies in the presence or absence of patient symptoms. The test is relatively simple to administer, while being versatile in its testing capacity. Both strabismus and heterophoria may be qualified and quantified, either subjectively, objectively, or both. Based on the optometric literature, the cover test is a valuable and dependable assessment tool for the practitioner that provides inter-examination repeatability and reliability.¹⁻⁵

Sparks has reviewed several studies related to cover test characteristics. He was specifically interested in the effect of varying examiner position on the measurement of horizontal heterophoric posture at near. Sparks wrote: "The positions under investigation were that of the clinician either to the side of or behind and directly in line with the accommodative target being observed by the patient during the measuring process."⁶

After reviewing a pre-publication draft of Spark's paper, the authors were intrigued with the findings of the paper, especially the discovery of an increase of 4.38 prism diopters (^Δ) of exophoria associated with an off-midline position of the examiner. While Sparks may have detected a potentially important variable in heterophoric measurement when utilizing the cover test at near, several aspects of his reported protocol were unclear. Therefore, the authors decided to replicate the study to verify Sparks' findings, while maintaining more stringent control of test variables.

After conducting a literature search related to examiner position during cover testing, we were unable to locate procedural instructions specifying a consistent examiner

position. One source defined the location from an observation standpoint. Carlson et al. reported, "...the examiner must be positioned to see the patient's eyes easily without interfering with the patient's view of the target."⁷

Other sources specified a midline position. Grosvenor stated, "The practitioner is seated opposite the patient, with his or her head positioned so that it does not block the patient's view of the chart....The test is repeated in a similar manner at 40cm...."⁸ Von Noorden proposed a midline position and even included a picture. He wrote, "...the examiner may fix a small (Snellen) card to the bridge of his glasses."⁹

An offset position was also implied in the literature. In *Clinical Refraction 2nd edition*, Borish wrote, "The operator must, however, assume a position which enables him to see the movement of the occluded eye, both behind the occluding card and after it is removed."¹⁰ In a subsequent edition of Borish's *Clinical Refraction*, Benjamin revised the previous instruction and stated, "The clinician is seated beside the patient, and in front of the patient by a short distance of perhaps 25 to 40cm....The movement of the occluded eye will not be visible to the clinician."¹¹

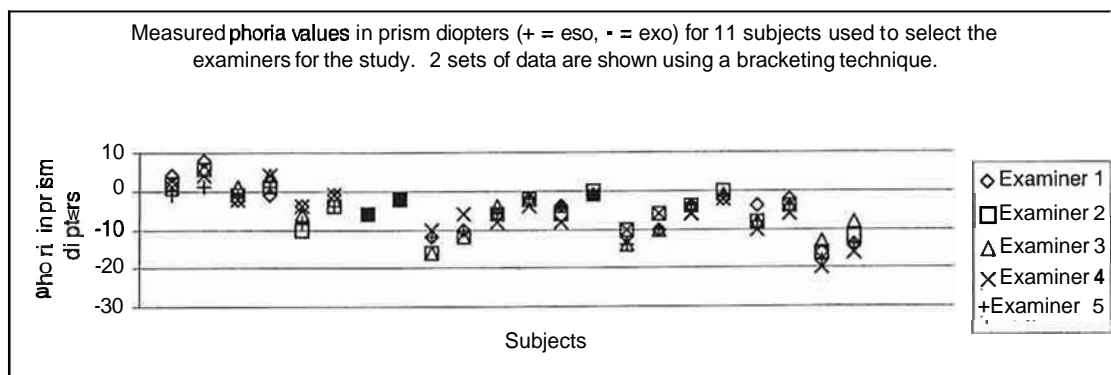
The literature contains much information about the cover test, such as origin, purpose, execution, interpretation, reliability, etc., and established it as a valuable screening tool. However, instructions for examiner position were neither consistent nor consistently specified.

The purpose of this study was to investigate the effect of examiner position on the phoria measurement when conducting the prism neutralized objective cover test at 40cm. Examiner positions at patient midline and 30 degrees right of patient (henceforth referred to as 30R) were analyzed to determine if a clinically significant difference existed.

METHODS

EXAMINERS

Five 3rd-year interns from Pacific University College of Optometry (PUCO) participated in a screening to assess inter-examiner accuracy and repeatability. Each examiner performed the 40cm alternating cover test objectively on eleven subjects using the same bracketing technique that was to be utilized in the actual study. The data collected were then analyzed using a scatter plot (Figure 1 shows each recording for the bracketing technique, thus two sets of data are plotted for each subject).



From the scatter plot, examiners #2, #3, and #5 were chosen based on the similarities of results for each cover test performed. Examiner #5 was then ruled out based on unwillingness to participate in the study.

SUBJECTS

Fifty-seven 1st-year optometry students at PUCO were selected for study participation. The students were tested during the second week of their first semester of optometry school and were naïve regarding the cover test procedure. The mean age of the sample was 24.0 ± 2.88 years, with ages ranging from 21 years to 33 years. The mean age of the 36 male subjects was 24.0 ± 2.75 years, while the mean age of the 21 female

participants was 24.0 f3.16. The subjects were screened prior to study participation for systemic, ocular, and refractive conditions that were excluded. All subjects met the following criteria:

- a. Visual acuity: best visual acuity of at least 20/25 in each eye.
- b. Binocular status: stereopsis of at least 200 seconds of arc at near, as measured with the Lang stereoacuity card.
- c. Refractive conditions: the spherical component of the refraction had to lie between the range of +5.00 diopters (D) to -5.00D, anisometropia of 1.00D or less, and the cylinder component less than -2.50D. These parameters were validated via submission of a current spectacle or contact lens prescription, or by verification of spectacle lenses with lensometry.
- d. Accommodative amplitude: all subjects had to exhibit at least 5.00D of accommodation, as determined with a modified Donders pushup. Subjects were presented with the 20/40 Snellen paragraph at 18 centimeters (cm) and asked to call out the words.

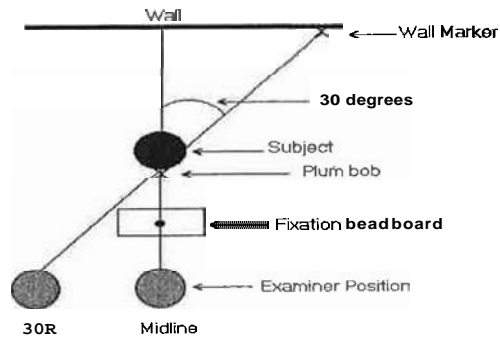
Of the original 84 possible subjects, 27 were eliminated due to failure to meet the inclusion criteria.

PROCEDURE

In order to fulfill the authors' mandate to keep the research clinically oriented, all screening and testing was conducted in two established clinic lanes at PUCO. Every effort was undertaken to make the environment extremely consistent with a normal exam environment.

The testing areas consisted of two similar 20-foot exam lanes, equipped with typical optometric equipment. A plumb bob (a weight attached to the end of a string) was hung from the ceiling in a position that approximately corresponded to the subject's corneal or spectacle plane. This device was the base reference point to which all angles and distances were measured. As most optometric lanes are configured such that the optometrist has only physical access to the area in front and to the right of the patient, the examiner test positions were

Figure 2: Over head view of procedural set-up.



chosen to be at patient midline and **30R** (30 degrees right). A row of vertical dots, spaced approximately 20cm apart, was marked on the wall behind the examination chair at a **30** degree left offset, as referenced to the plumb bob. This configuration allowed the examiner to sight through the string and maintain proper alignment when testing in the **30R** position. A Schematic of the set-up is shown in figure 2. To maintain accommodative control, the nearpoint target consisted of a bead with a 20/25 near Snellen 'E' printed on it. A holding device was constructed to ensure proper and consistent alignment of the near point target. A hole was drilled 90 degrees perpendicular to the grain of a small board (1"x12"x24"). An appropriately sized wooden dowel rod was placed in the hole and allowed to move freely in a vertical manner. The nearpoint target was attached to one end of the rod.

Subjects were individually seated in an exam lane. An independent screener, using proper exam techniques, verified each subject's eligibility. The screener either

prepared eligible subjects for horizontal phoria testing or dismissed non-eligible subjects. The subject was comfortably situated in the examination chair. All subjects were wearing proper refractive compensation, if necessary. Depending on the subject and their refractive status, either the corneal plane or the spectacle plane was aligned to the plane of the base reference point. The holding device was placed on the subject's lap and adjusted horizontally until the nearpoint target was at patient midline at a distance of 40cm. The dowel rod was then adjusted vertically until the near point target allowed alignment of the eyes in primary position. Minor adjustments were performed to ensure a 40cm working distance in primary gaze and proper alignment of all elements. When properly aligned, the base reference point acted as a pivot point to which all angles and distances could be referenced. Appropriate nearpoint lighting illuminated the target. The environment of the two rooms was substantially identical.

After proper subject positioning, Examiner #1 entered the room and the screener exited the room. Each examiner conducted one prism neutralized, objective, nearpoint, horizontal alternating cover test while located at either of the two examiner positions under investigation. The positions were defined as: 1) at the midline alignment of the subject and the nearpoint target, at approximately examiner's arms-length behind the target, and 2) at 30 degrees to the right of the subject, at approximately examiner's arms-length. For both examiner positions, the subject was instructed to maintain clear fixation on the nearpoint target located straight ahead on the subject's midline.

The two examiners implemented a counterbalanced technique, which rotated the two examiner positions (midline and 30R) among the examiners for every 10 subjects tested. Examiner #1 always entered the room prior to Examiner #2 for the duration of the

testing. For subjects 1 thru 10, Examiner #1 performed the cover test at the midline position and then exited the room. Examiner #2 then entered the room, alone, and performed the cover test at the 30R position. For subjects 11 thru 20, Examiner #1 executed the cover test at the 30R position, while Examiner #2 executed the cover test at the midline position. This rotating pattern was continued for the duration of testing. No communication was allowed between the two examiners during the entire testing regime.

A prism bar consisting of 2^{Δ} intervals was applied to objectively quantify each subject's horizontal phoric posture. A bracketing technique was used around each subject's neutral phoric position, such that the first esophoric movement and the first exophoric movement were recorded.

Each subject was classified into 1 of 3 categories of horizontal phoria using the midline position cover test. Subjects measuring between one diopter of base-out prism and one diopter of base-in prism for neutrality were classified as orthophoric, subjects measuring two diopters or more of base-out prism were classified as esophoric, and subjects measuring two diopters or more of base-in prism were classified as exophoric.

RESULTS

Data were entered into an Excel spreadsheet program and then submitted to statistical analysis using paired t-tests. The independent variable was examiner position with two conditions (midline and 30R). Dependent variables analyzed were the prism power in place to obtain first esophoric movement, prism power in place to obtain first exophoric movement, and the mean of these two prism values. The data are summarized in Table 1.

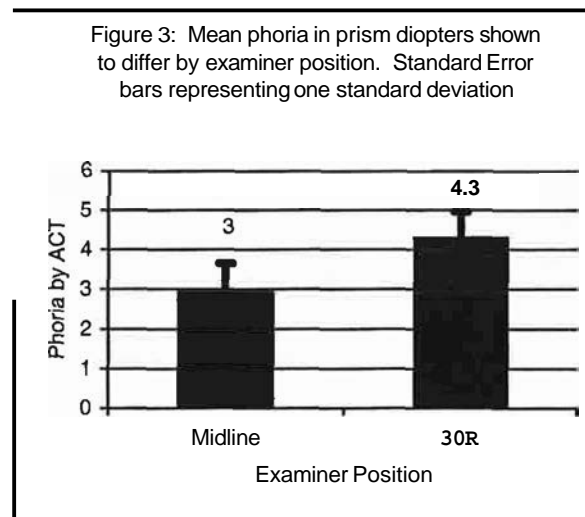
Table 1: Mean prism in place (A) change for first Eso, first Exo, and mean alternate cover test by examiner position.

	MID mean (s.d.)	30R mean (s.d.)	30R - MID mean (s.d.)
1st Eso	-4.79 (2.56)	-6.09 (3.19)	-1.30 (0.64)
1'' Exo	-1.21 (0.34)	-2.44 (3.15)	-1.23 (2.81)
Mean	-3.00 (2.67)	-4.26 (3.12)	-1.26 (0.46)

For the midline examiner position, the mean prism in place to measure the first esophoric movement was 4.8^Δ base-in. The mean prism in place when the first exophoric movement was noted was 1.2^Δ base-in. The resultant calculated phoria was 3.0^Δ exo for the midline condition. For the 30R examiner position, the mean prism in place to measure the first esophoric movement was 6.1^Δ base in. The mean prism in place to determine the first exophoric movement showed a mean of 2.4^Δ base-in. The resultant calculated phoria for this examiner position was 4.3^Δ exo. The first esophoric measure between conditions differed, showing a 1.3^Δ greater exophoric measurement in the 30R condition (df = 56, t = 4.585, p<0.0001).

A similar result was found for the first exophoric measure. It differed by 1.2^Δ more exophoria, again in the 30R condition (df = 56, t = 5.06, p < 0.0001). Based on the data in Table 1, Figure 3 shows the mean phoria was 1.3^Δ more exo when cover testing was performed

with the examiner at the 30R position (df = 56, t = 5.275, p < 0.0001). The subjects were grouped for comparison based upon the habitual phoria measured in the midline position.



The large number of exophoric subjects (n=49) compared to esophoric (n=5) and orthophoric (n=3) subjects prevented any inferential analysis, but descriptive data are shown (Table 2).

Table 2: Change in phoria (A) by examiner position based upon habitual phoria

	(n)	A phoria (30R - MID)
All subjects	57	-1.26
Exophoric subjects	49	-1.16
Esophoric subjects	5	-2.00
Orthophoric subjects	3	-1.67

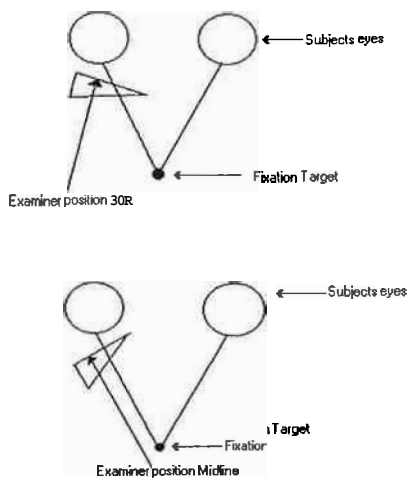
DISCUSSION

The results indicate that the 40cm alternating cover test measures differed between the two examiner positions. An average 1.3^Δ greater exophoria was detected when examiners performed the cover test in the 30R position for subjects in the study. While the sample population for orthophoric and esophoric subjects was too small to make definitive conclusions, the data in Table 2 suggest this effect might be slightly less for exophoric subjects versus subjects with habitual esophoria or orthophoria. The reason for the difference between examiner positions is not known, but proximal vergence effects may be a factor. Proximal effects on vergence refer to changes in vergence posture that occur associated with awareness of target distance. A common example of the proximal effect is the difference in gradient and far-to-near ACIA ratios, with the far-to-near calculated ACIA typically higher than the gradient. This difference is partly due to the presence of changes in target distance in the far-to-near method that induces proximal vergence changes not present in the gradient method. Based upon a review of several studies of proximal vergence, Hokoda and Ciuffreda¹² found an average proximal effect of 1.29^Δ per diopter. While the target distance did not change in the current study,

the proximal cues did with greater proximal awareness present when the examiner was in the midline position obstructing the subject's distance cues. Assuming that the examiner was slightly less than one meter away from the subject during measurement, the 1.3^Δ change toward eso in the midline condition compares favorably with the 1.29^Δ per diopter value mentioned above.

Another potential source of phoria difference by examiner position may be the influence of the prism-viewing angle. In this study plastic prism bars with a flat posterior surface were used for the measurement of subjects' heterophoria. The flat plastic prism bars are designed for correct measurement when the flat surface of the prism bar lies in the frontal plane i.e. the *frontal* position¹³. By rotating examiner positions, the angle at which the examiner views the eye becomes different between the two positions. It is known that rotating the measuring prism only four degrees can affect phoria

Figure 4: Prismatic angle at which examiner views subjects eye as compared to that of the frontal and Prentice's position.



measurements when prism powers are greater than about 7^Δ (see Appendix 1). Thompson and Guyton¹⁴ showed this difference occurs when comparing measurements with prism in the frontal vs. Prentice position. The Prentice position is achieved when the primary visual axis is perpendicular to the flat posterior part of the prism¹³ as represented by the midline measurements in this study (see Figure 4). The four degree difference between the frontal and Prentice positions is magnified in the current study since the measuring prism was rotated approximately 30 degrees in the 30R

condition to enable the examiner's view of the subject's eye. These conditions indicate that part of the effect found in this study is due to prismatic measurement differences associated with examiner position. Given this information those subjects with higher heterophoric postures would skew the data and possibly create a larger difference between the two examiner positions.

When comparing results for this study to those of Sparks,⁶ the data show conflicting information. Although both studies show an increase in exophoric measurements in the offset examiner position the magnitude of the effect is different. Sparks found a 4.4^Δ difference by examiner position whereas this study found only 1.3^Δ of difference. Sparks' 4.4^Δ difference by examiner position is with respect to exophoric subjects, which comprised 36.3% (n=113) of his sample population. In this study the sample population included 86.0% (n=57) exophoric subjects. Therefore, the sample size of exophoric subjects for both studies is nearly identical, approximately 50 subjects. Because the sample population size for exophoric subjects is primarily equal, the results between the two studies should be similar. However, Sparks' standard deviation for exophoric subjects was higher than this study by 3.0^Δ, twice the mean standard deviation of this study, suggesting greater variability (larger values) in exophoria measurements for Sparks' subjects. Because Sparks' subjects presented with larger exophoric deviations, the prismatic difference with viewing conditions mentioned above may be a contributing factor for the difference in these two studies.

The 1.3^Δ increase in exophoria associated with the 30R examiner position suggests a need for stricter procedural protocol for the alternating cover test. However, with only a 1.3^Δ difference between examiner positions, it may or may not be clinically

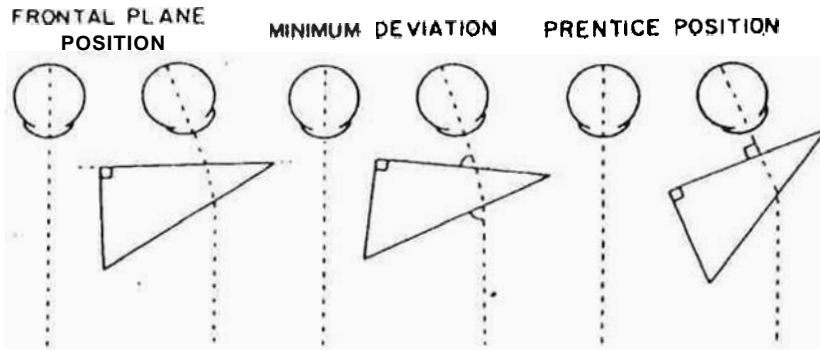
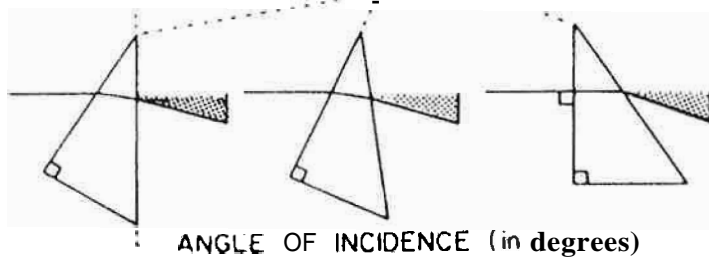
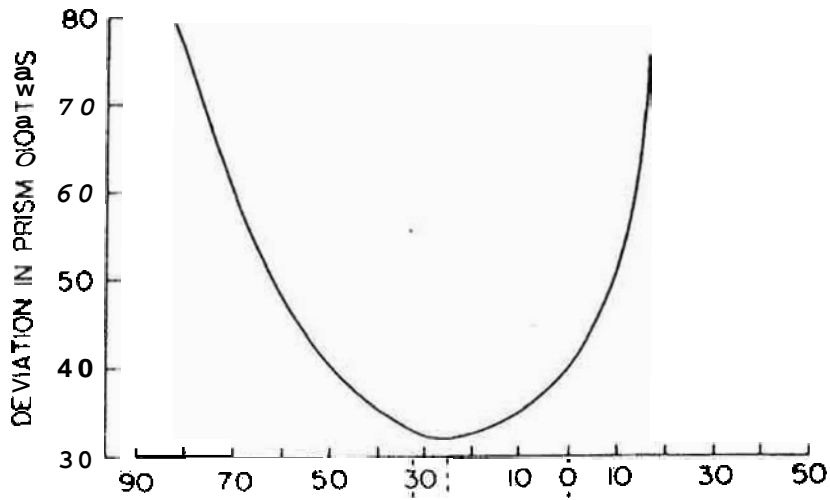
relevant in identifying possible binocular dysfunctions. Ludvigh reported difficulty in perceiving less than 2^{Δ} of fixation movement with the unaided eye.¹⁵ This would suggest the 1.3^{Δ} difference found in this study was statistically significant although clinically irrelevant and probably undetectable to even the most experienced examiner. The presence of this effect is probably most relevant in conditions such as convergence insufficiency intermittent exotropia in which maintenance of nearpoint fusion is tenuous. A reduction in proximal vergence cues or peripheral fusion cues may allow the intermittent strabismus to manifest. With borderline high heterophorias it may be prudent to evaluate the near cover test in the 30R examiner position to reveal the full magnitude of the phoria. In these patients a well-defined protocol for the alternating cover test could have clinical importance. Howarth et al. described two sources for variation in measuring horizontal heterophoria: 1) inter-examiner variations and 2) variations due to patients' varying phorias.¹⁶ If as clinicians we are able to reduce the inter-examiner variation then we can place the emphasis on patient variation resulting in a better and more reliable test.

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Appendix 1: Deviation in prism diopters vs. labeled value of plastic prisms held in Prentice and frontal positions (from Thompson and Guyton¹⁴).



This is a common way of holding prisms

This is how plastic prisms are calibrated

This is how glass prisms are calibrated