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A New Concept in Heterophoria Assessment: The Koslowe Monocular Straw Test and its Implications

Kenneth Koslowe, OD, MS, FCOVD-A; Dikla Miller, BOpt; Yarden Weinberger, BOpt; Einat Shneor BOpt, PhD

Hadassah Academic College Department of Optometry

ABSTRACT

One of the earliest concepts of Behavioral Optometry was that visual anomalies are expressions of the entire organism and personality and not merely ocular deviations. Vergence or in the Optometric Extension Program (OEP) vernacular, "centering", enables the individual to assess the difference between his internal visual space world and the actual physical world. One of the classic indicators of the functioning of this vergence mechanism is the phoria as tested by the cover test. The phoria is classically defined as a tendency towards a deviation between the visual axes of the two eyes. As such, esophoria and exophoria are often thought of as problems in the horizontal (X axis) meridian. The behavioral viewpoint on the other hand, felt that they indicated a positioning of the visual axes in space, on the Z axis. If this positioning in space or visual behavior is an expression of basic behavior patterns in the subject then it should be visible both in the binocular and monocular performance. The instrumentation we devised to test this hypothesis is the Monocular Straw/Pointer Test.

Methods: Forty-seven subjects were tested according to the following age groupings: 6-12, 13-21, and 21-30. The instrument used was a straw mounted vertically on a flat black panel 40 centimeters from the subject and a long wooden pointer was hand held by each subject. All subjects were wearing their normal compensatory lenses and had stereo-acuity of at least 40 seconds of arc. All those included in the experiment had near pre-testing consisting of the following: cover test, fusional range, and stereopsis. The non-dominant eye was occluded while the patient was instructed to thread the pointer into the straw using their dominant hand in one smooth motion with only one attempt allowed. The distance from the target, either in front or behind the straw was measured in one centimeter steps.

Results: A significant statistical relationship was found ($p<0.01$) between the phoria and the positioning of the pointer in reference to the straw. On average, esophoric subjects placed the pointer in front of the straw while exophoric subjects placed it behind the straw. Group statistical significance was as follows: 6-12 (n= 15) p=0.022, 13-21 (n=12) p=0.033, and 22-30 (n=20) p<0.01. A moderate correlation (r=0.381 for exophores and 0.32 for esophores) was shown between the amount of the phoria and the size of the positioning error. In addition we found that the positioning error was greater for esophores than for exophores.

Conclusions: A clear relationship was seen between the heterophoria and the individual's perceived positioning in space or spatial awareness even in the monocular state. This supports the hypothesis that the heterophoria is actually an expression of general perceptual relationships and not merely an ocular phenomenon.

Keywords: binocular vision, monocular, phoria, perception, spatial organization

Correspondence regarding this article can be emailed to Dr. Kenneth Koslowe at kenkoslowe@yahoo.com or sent to Dr. Ken Koslowe, 10 Ahimeir Street Petach Tikva, Israel, 972-3-933-2991.

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Introduction

Many years ago A.M. Skeffington explained visual disorders in terms of ocular manifestations of the individual's personality and behavior rather than as ocular defects in themselves.[1] Additionally, in the vernacular of the Optometric Extension Program (OEP) philosophy that he (and others) expressed, the vergence or centering mechanism gives a person the ability to compare and contrast their internal space world and the physical reality.[2] Leo Manas later elaborated on the concept of vision as a behavior pattern embodying an individual's relationship to their environment that included responses by nearly all of the body's muscular and glandular systems.[3] The operation of this system attempts to reach some form of equilibrium with the environment and its demands through adjustments that have both positive and negative aspects.

According to this philosophy, a tendency to overconverge (esophoria) is indicative of a more central visual perception of space with a concomitant lack of peripheral awareness. This shutting down of the periphery would tend to alter perception of space to make things appear closer. The opposite would be true of the exophoric person who would downplay the central aspects of visual space and be more attentive to peripheral stimuli. This would tend to expand their visual space and spatial judgements.[4,5]

In a recent article, Warshowsky maintained that the status of the heterophoria is a reflection of the subject's personality and a potential indicator of their visual status. This in no way belittles the other visual skills and attributes such as accommodation, pursuits and saccades which further define our visual state. When the eyes work together, the function of vergence is to provide specific information about our body and its relationship to our visual space. Therefore if this function exceeds the normal findings there should be a concomitant change in our evaluation of size and space.[6] The more classical definition of the phoria is the tendency of the two visual axes to be misaligned at the point of fixation due to a stimulus that is insufficient to allow fusion. Therefore, the active and passive positions of the axes do not intersect at the point of regard.[7,8]

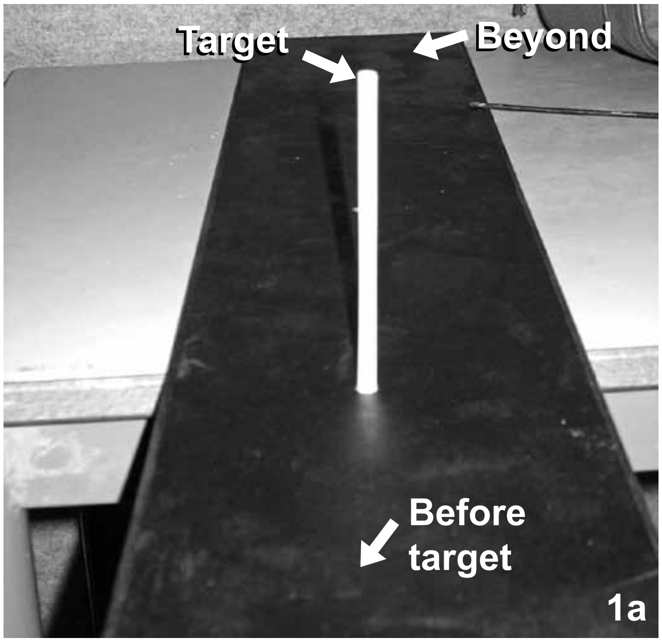
The purpose of this study was to determine if the influence of the phoria on spatial perception was so marked as to be evident even when tested in the monocular state. In other words, does the heterophoria visual spatial response "go away" or "remain apparent" even when the individual is in the monocular state? Does the esophoric person see the world as organized at a closer position on the z axis than the exophoric cohort?

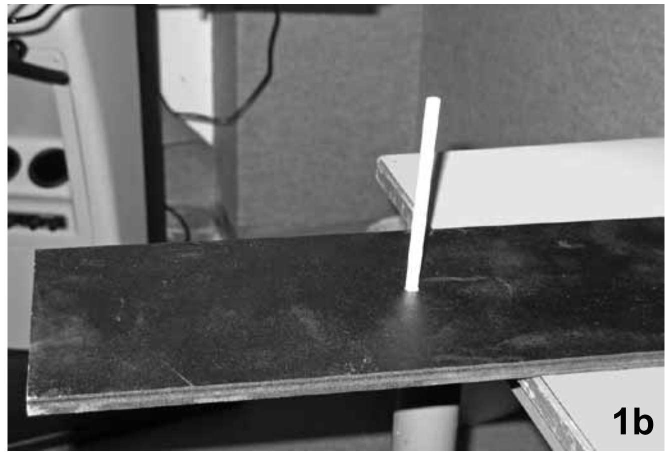
Methods

The total number of subjects tested (n=47) ranged in age from 6-30 (mean=18.11, SD= 7.32) and were divided into three age groups: 6-12 (n=15, mean=8.73, SD= 2.25), 13-21 (n=12, mean= 18.41, SD= 2.43) and 22-30 (n=20, mean= 24.95, SD= 1.96). The group consisted of 25 females and 22 males. Forty of the subjects were right hand dominant, seven were left hand dominant while 39 were right eye dominant and eight were left eye dominant. The examination was performed with our own original device, the Koslowe Monocular Straw Test (KMST), which will be described later. Each subject who participated in this study was wearing their appropriate glasses (as determined in the Hadassah Academic College Optometry Clinic) and achieved at least 40 seconds of arc of stereo-acuity. All were examined in the same clinic room under dim (2 foot-candles) illumination by the same two members of the research team (DM and YW). The subjects themselves were unaware of the purpose of the testing.

The pre-testing regimen consisted of the following:

1. Spectacles based on their current (within one year) refraction
2. Dominant eye was tested using the near point of convergence test (NPC) with the eye that maintained fixation determined as the dominant eye and the Dolman test for dominant eye. In case of conflicting results the NPC test was selected as this is performed at near as was the KMST.
3. Dominant hand was chosen as the hand that the subjects used for writing.
4. Alternate cover test was performed to determine the magnitude and direction of the heterophoria.
5. Fusional step vergence testing was performed with a prism bar while the subject viewed a vertical line of 6/9 (20/30) print at 40 centimeters. Divergence testing always preceded convergence testing and the prism bar was always introduced over the dominant eye. Normal findings were judged as such utilizing Sheard's Criteria which states that the opposing vergence should equal at least twice





Photos 1a and 1b: *The device viewed head on (left) and from the side (above).*

Photo 2: *Subject during testing.*

the phoria.[8] All of our subjects had normal fusional abilities by this criterion.

The testing session was performed using the KMST (Photos 1a, 1b and 2) which consisted of a rectangular (80 cm X 15 cm) board painted black (matte) with a hole 40 centimeters from the patient's eye in which a straw was mounted upright which had a diameter twice that of the pointer given to the subject. The KMST was mounted in a fixed position on a table throughout the experiment. The patient's non-dominant eye was then occluded and the subject was requested to thread the pointer through the straw (from above) in one smooth continuous rapid motion. The subjects were all instructed to grasp the pointer at its upper end. Each subject received only one opportunity to perform the task in order to eliminate any adaptive learning process. The "target" board was marked in increments of 1 centimeter in front of and behind the hole. After each test, the patient's performance was noted.

Table 1: Relationship between phoria and target error in entire sample

phoria	On target	Beyond	Before target	Total
EXO	5	21	3	29
ESO	0	1	17	18

Results

The statistical analysis test chosen was the Fisher exact test (a statistical significance test used in the analysis of contingency tables where sample sizes are small. It is an alternative to the Chi Square test).[9] This showed a strongly significant relationship ($p > 0.01$) between the type of phoria and the type of error made in attempting to correctly thread the pointer into the straw. The error consisted of esophores aiming too close and exophores aiming too far (see Table 1). Table 2 shows the actual results for each age group separately. The level of significance for each group varied and was as follows: 6-12 (N=15), $p=0.022$; 13-20 (N=12), $p= 0.033$;22-30 (N=20), $p> 0.01$.

Since children do not have the same physiologic maturity nor size as adults, it was felt necessary to give them a longer pointer. A control study of nine subjects

Table 2: Relationship between phoria and target error in specific age groups

Total	On target	Beyond target	Before target	phoria	Age
10	1	8	1	EXO	6-12
5	0	1	4	ESO	
6	2	3	1	EXO	13-21
6	0	0	6	ESO	
13	2	10	1	EXO	22-30
7	0	0	7	ESO	

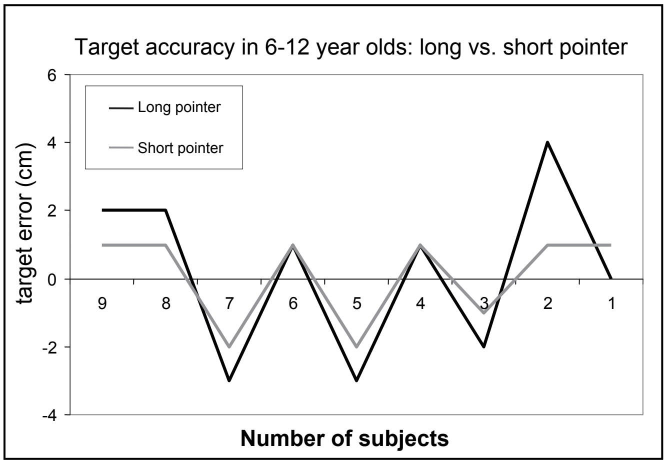


Figure 1: *Accuracy in the 6-12 year group, long as opposed to short pointer.*

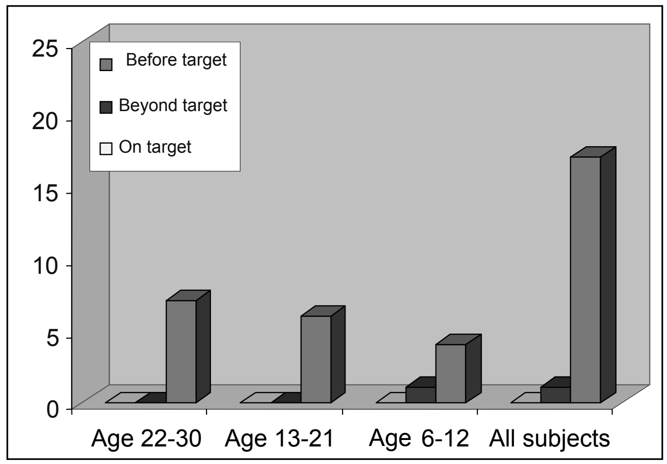
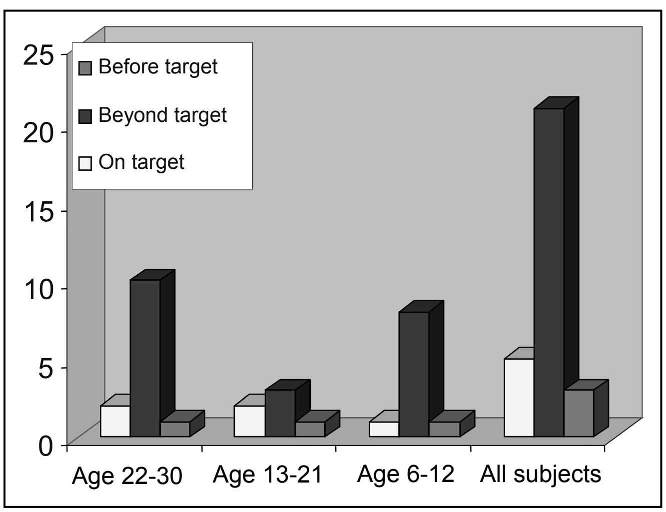


Figure 3: *Target accuracy in the various esophoric age groups.*



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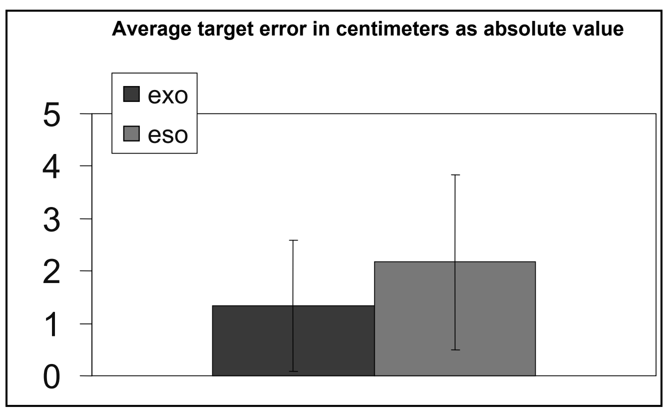

Figure 4: *Average target error in centimeters.*

was used to compare the results using the long and short pointer (Figure 1) and analysis of the correlation (Pearson r)[10] showed a very high level of correlation (r= 0.893). Therefore it was felt that analyzing all the age groups together was appropriate and legitimate.

In Figures 2 and 3, one can see the breakdown of accuracy of the different age groups according to the type of heterophoria present. Figure 4 shows the average error score in centimeters of each type of phoria.

Table 3: Amount of esophoria and target error in centimeters

4	2	2	1	2	4	12	3	1	2	8	6	2	4	2	4	2	10	Amount of eso
-2	-4	-2	-1	-2	-3	-3	-3	-1	-1	-1	-4	-2	-3	1	-3	-2	-3	Target error in cm

Table 4: Amount of exophoria and target error in centimeters

6	6	5	10	6	8	10	14	6	10	4	Amount of exo
2	-2	1	2	3	1	0	2	1	1	2	Target error in cm

An analysis was made (Tables 3 and 4) of the amount of error made by the esophoric and exophoric groups to see if the amounts were statistically equal. On average, esophoria (avg.=2.166, SD= 1.248) had a significantly greater effect (p>0.01) than exophoria (avg.= 1.344, SD=1.674) on target error. As can be seen in Tables 3 and 4 in the group of esophores (n=18, r-0.32) and exophores (N= 29, r-0.381) there was only a weak correlation between the amount of heterophoria and the amount of target error.

Discussion

In this study we have attempted to show whether the heterophoria is in fact a binocular and ocular phenomenon or alternatively, a visual manifestation of a behavior pattern or style of visual perceptual organization that is affected by and represents our personality traits. This would be shown by an esophoric individual attending more to central detail, closing in his visual space world and centering it closer on the z axis while the exophoric individual would do the opposite.[11]

Using our new testing device, the KMST, we have shown that such an interpretation may be supportable. A significant relationship was found between the phoria and the individual's perceived positioning in space even when tested in the monocular state. Our esophoric subjects did center their visual space world closer, while those who were exophoric did the opposite. In addition, the influence of esophoria on spatial perception had a greater effect than that of exophoria. This may support the supposition that the esophoric position is neither the norm nor the expected position. If this is true then it would be logical for this diversion from normalcy to be a reflection of a visual organization that is more at odds with the real world.

The KMST result can allow us to test the adaptive state of the patients' visual organization as is also reflected in the traditional heterophoria test. One would presume that the longer the time period that the patient has maintained their phoric position the greater the visual spatial adaptation may be. This will give us an additional tool to judge the embededness of the patients' condition. If the phoria and the KMST disagree, this might indicate a more fluid visual status on the one hand or a more perceptually conflicted patient on the other. This is speculative at this state as the device will need further testing in order to confirm such possibilities.

Three different age groups were tested in order to determine if this effect changes as a function of development. The highest correlation was found in the older group which might indicate that the process becomes more embedded with age.

One of the proponents of such a theory was Lawrence MacDonald who stated that individuals located in the same visual environment will develop their own separate interpretations of that environment based on their initial vergence state.[12] Elliot Forrest further expanded this approach and felt that the key to understanding a subject's visual behavior lies in the vergence status at the time of performing a task. He felt that the phoria status was the physiologic result of previous visual experience and interpretation which is imprinted on the individual and his extra-ocular muscles. The vergence behavior will predict how the subject will perform on various daily living tasks and affect the basic thought processes that determine his reactions to events and other individuals.[13] The previously stated article by Warshowsky suggested that convergence is one of the key elements in understanding visual behavior and as such deserves much more consideration in evaluating our patients.

For example, a patient diagnosed with convergence insufficiency is not merely showing a physiologic condition of defective vergence skills, but is expressing an inner need or drive the affects his positioning in space. An appreciation of this by the patient and the doctor can aid significantly to successful treatment.[14]

Conclusions

While one study does not necessarily validate a new testing device nor prove an entire theory of visual performance, this study did indicate that the KMST is a potentially valid new tool within the optometric testing battery and lends further possible evidence of the opinion by many behavioral optometrists as to the true meaning and value of heterophorias and vergence ranges.

As this has been the first study devoted to this monocular expression of a hitherto binocular concept, there is a need for further research utilizing this device. Some areas of research may include testing using the dominant hand and dominant eye, whether abnormal binocular vision, time of day when tested or refractive status might alter the outcomes noted here. The results of such studies will determine the true assessment value of this device. The KMST can remain a laboratory curiosity as a valuable teaching aid and an interesting method of demonstrating a school of optometric philosophy or it can become an important new diagnostic tool in the search to better understand our patients.

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