

The Relationship between the Heterophoria and Visual Organization in First and Second Grade Children on the Gesell Copy Form Test

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ABSTRACT

Behavioral Optometry as a school of thought views visual behavior and its various attributes as a reflection of general behavioral patterns and not as merely ocular phenomenon. As such, the heterophoria is not merely a position that the eyes assume when fusion is broken or a demand that must be overcome but an integral part of the person's organization of their visual space world. Therefore just as the heterophoria can be shown as an ocular phenomenon, it should also be present in tasks that demonstrate the individual's perception of space. As such, we have sought to find if there is a possible connection between a subject's heterophoria and their performance on a visual form copying test (Winterhaven/Gesell Copy Form Test (GCFT)) which also demonstrates the subject's visual organization level.

Methods: This study was carried out on 78 elementary school children in grades 1 and 2 in a public school. At the outset three different groups of near heterophoria testing results were determined in accordance with accepted norms. The subjects were

divided into three groups (Exophoria-XP, Esophoria-EP and Normal-N) utilizing a standard Cover Test (CT). The subjects were then administered the Winterhaven version of the GCFT and the results were analyzed according to two attributes: the area of the page that was utilized for the copying and the shortest spacing between the borders of adjacent figures. While all 7 figures were used in the testing phase, only those figures which were consistently reproduced with a level of accuracy that allowed analysis (Figures 1-3) were evaluated. The findings in each group were then analyzed using the student's t-test in order to determine if there was a relationship between the heterophoria and the spatial organization of the figures.

Results: A significant statistical relationship (at the $p < 0.02$ level) was found between the near heterophoria and the smallest difference between the borders of adjacent figures for the esophoric group as opposed to the exophoric subjects in the case of the cross and the square. No such correlation was found on any other adjacent figures

Conclusions: A relationship was found showing that esophoric subjects had a tendency to crowd their figures as opposed to the exophoric subjects. In the age group tested, it is possible that the cross and square are the most reliable indicators of the perceptual aspects of the subjects' heterophoria. The relationship that was found demonstrated an association with established thought in Behavioral Optometry as to the connection between heterophorias and the individual's spatial organization.

Keywords: behavioral optometry, heterophoria, visual spatial organization, Winterhaven/Gesell Copy Forms

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Introduction:

The concepts of Behavioral Optometry were first introduced to Optometry at large in the 1920's by A.M. Skeffington and E.B.Alexander through the Optometric Extension Program.¹ Among the basic tenets of this philosophy is the integration of visual behavior with the general systematic behavior of the organism. They viewed vision as a process that was afferent, integrative and efferent. In line with this definition came the concept that vision is output and all measurements of vision are measurements of output.² It has recently been suggested by Warshowsky that the entire classic understanding of the meaning of vergence needs to be reassessed. Vergence should not be viewed solely as an ocular phenomenon but may be indicative of the perceptual and visual-spatial behavior of an individual.³

In Behavioral Optometry, the heterophoria is not simply an ocular misalignment but an important attribute and indicator of the patient's personality and visual space world.⁴ The exophoric patient localizes his visual spatial concepts further away from his body on the z axis, and thus expands his visual space. The esophore, however, centers the space world closer to the body and thus contracts the available visual space.^{5,6} An accepted psychological method of determining visual spatial organization is by utilizing a copy form test.⁷ In Optometry a well accepted and often used variant of this type of testing is the Gesell Copy Form test (GCFT).^{8,9}

The GCFT consists of seven geometric shapes in ascending order of difficulty which are presented to the subject one at a time.¹⁰ The shapes can be found in Figure 1.

According to Suchoff, the GCFT tests visual spatial organization along with other factors such as form discrimination, bimanual integration and visual-motor hierarchy. The subjects' rendering of these images is never a true copy of the shape as would be the case in a tracing task. The child must first internalize and categorize the shape they have seen. The second stage of the task is the output or when the shape is reproduced as an expression of this internal processing. An example often seen in the GCFT is the reproduction of the divided rectangle. The internal detail of the divided rectangle may be reproduced with continuous oblique lines, or the child may see and reproduce this shape as a series of connected individual triangles.¹⁰ Since this test appears to represent this internal perceptual process,

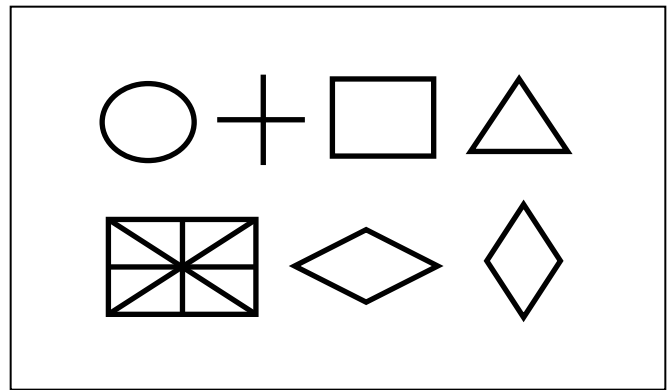


Figure 1: GCFT Geometric shapes.

Table 1: Determination of heterophoria status

1. Normal (N):	1-6 prism diopter exophoria
2. Exophoria (XP):	exophoria greater than 6 prism diopters
3. Esophoria (EP):	orthophoria or any amount of esophoria

it was felt that the GCFT might provide evidence of the spatial effects of the subject's heterophoria.

Methods

Seventy-eight first and second grade children from a public elementary school were examined (17 girls, 61 boys). The age range was from 6.1-8.9 (average age 7.3, SD= 1.12) and inclusion criteria were:

- stereopsis of 600 seconds of arc (Titmus Stereofly)
- no strabismus
- Near visual acuity of 20/20 (6/6) as measured by the Rosenbaum Pocket Screener Card.

All subjects were evaluated in an empty classroom with standard school desk and chair and normal full illumination. The subjects all wore their habitual refractive correction for near (if applicable). The two examiners were stationed in opposite corners of the room at two evaluation positions. None of the subjects evaluated were able to view the copy form results of the other child in the room. At one station the following tests were performed: near visual acuity, stereopsis, and cover test at near (both cover/uncover and alternate cover test). The amount of heterophoria was measured using the prism neutralization method with a prism bar.¹¹ All of the testing was performed at a distance of 40 centimeters. The children were assigned to one of the three following groups: Normal (n=42), Exophoria (n=13), and Esophoria (n=23) (Table 1)

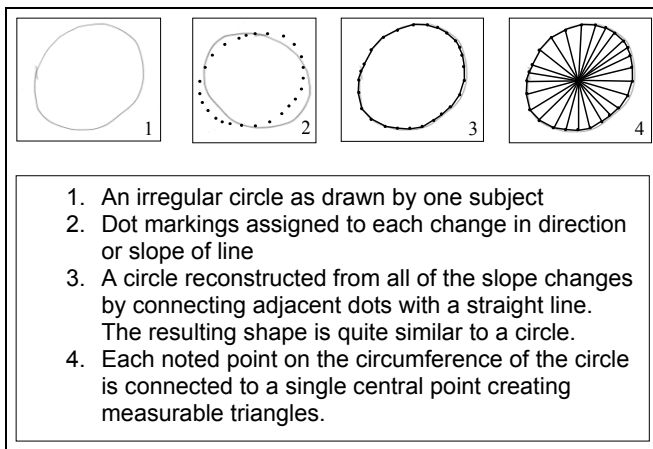


Figure 2: Calculating the area of a drawn circle.

At the second station the GCFT was administered in accordance with Suchoff¹⁰ and Lowry⁷. The child was presented with an A4 (the most common paper size) page placed in the horizontal orientation and was shown the various shapes in order one at a time. During this viewing segment the child was instructed to count the shapes out loud in order to amplify to the child the number of shapes involved in the process. It is thought that this is advantageous particularly when trying to judge visual spatial organization. At this point the child was once again shown the shapes one at a time and asked to “make each shape on the page in front of you.” This wording is considered less threatening than asking the child to draw or copy the shapes. The child used a #2 pencil with no eraser. While typically the test is evaluated on many levels, for the purpose of this study, the use and evaluation was restricted to the spacing of shapes on the page.

The first group (N) consisted of 42 children, the second group (XP) had 13 children, and the third group (EP) had 23 children. The copy form results of each group were then analyzed utilizing two criteria (see Figure 3): firstly, the area of the page used to draw all the figures and secondly, the shortest distance between the circumferences of two adjacent shapes. Since the drawings made by the children did not constitute regular geometric shapes there was no possibility to calculate the area used by their shapes with simple mathematical formulas. As drawn by the subjects, the shapes had differing radii. In order to calculate the result, a software program from MATLAB³ for calculating areas was used. In

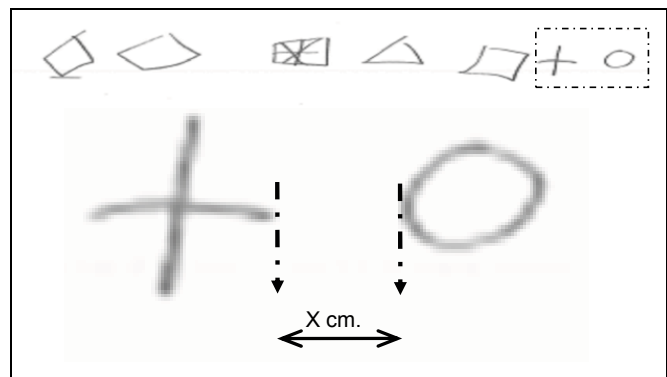


Figure 3: Measuring the distance between edge borders of two adjacent shapes.

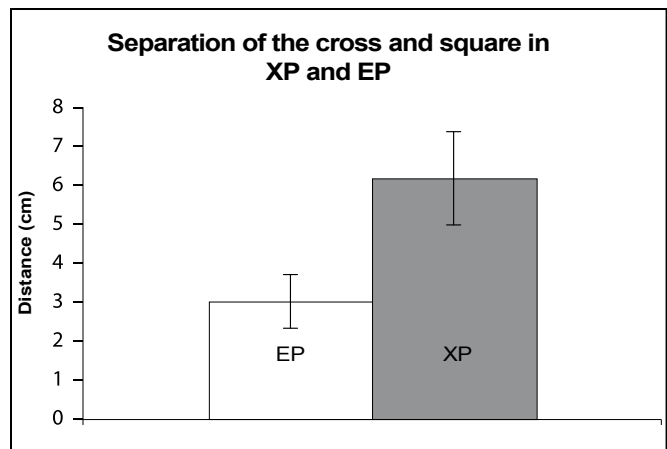


Figure 4

this program any change in curvature or slope of a figure is noted, thus allowing for maximum accuracy in measuring the area of the original shapes as drawn by the subjects. Each point is assigned a value of X or Y and the program automatically calculated the area enclosed by the shapes by dividing it into measurable triangles. The second criterion was measured with a centimeter ruler simply as the smallest distance between the edges of adjacent figures (see Figure 4). The examiner had no knowledge as to the group identity of the figures being measured.

Results

A two tailed t-test assuming equal variables of the area of each figure and the distance between the edge borders of adjacent figures was performed and the findings between each different group were compared. (Table 2) A strongly significant result ($p=0.018$) was found in the spacing between the cross and the square when comparing the esophoric group to the exophoric group. Additionally, the spacing between the circle and the cross when comparing the exophoric group to

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Table 2: t-test results

Type of deviation	Separation between plus and square ■ - +	Separation between circle and cross + - ●	Area of Square ■	Area of Cross +	Area of circle ●
EP-N	p= 0.227	p= 0.265	p= 0.15	p= 0.877	p= 0.616
XP-N	p= 0.227	p= 0.09	p= 0.69	p= 0.469	p= 0.247
EP-XP	p= 0.018	p= 0.51	p= 0.436	p= 0.539	p= 0.313

the normal group showed a somewhat weaker result (p=0.09).

The area of space taken up by each figure did not show statistically significant differences among the three groups. The only possible exceptions were the area of the circle drawn by the normal (mildly exophoric) group (p=0.247) and the area of the square drawn by the esophoric group (p=0.15). Other findings of mild statistical significance were the separation of both the circle from the cross (p=0.265) and the plus from the square (0.227) in the esophoric group.

The standard error of the means was 0.72 for the esophoric group and 1.16 for the exophoric group. These differences are an expression of the wide variation in copying shapes that one can find in children this age. Figure 4 illustrates the difference in form separation.

Discussion

A significant finding was found in the spacing of the cross and the square. In the age group tested, it is possible that the cross and square are the most reliable indicators of the perceptual aspects of the subjects' heterophoria. The circle might be too easy and therefore the ease or difficulty in performing the motor task might mask the phenomenon that we were searching for.

One of the difficulties faced in this research was a significant problem in assessing imperfect renditions of the figures. While initially it was planned to evaluate all seven figures, the performance of this relatively young population on Figures 4-7 did not allow for any valid analysis. As stated, for this reason the analysis was restricted to the first three figures. No mechanism or tool was found that was sophisticated enough to measure the relevant factors in the other shapes. It is possible that with a more sophisticated methodology this would be possible. One possibility would be to have the child electronically draw the

figures on a flat pad with the information fed to an appropriate computer program.

Another possibility analysis which will be considered in future studies of this phenomenon would be to represent the separation between figures as a percent of the total area occupied by the figures. In order to represent the total area, a rectangular outline inclusive of all of the shapes drawn could be used, but square to the edges of the page. If this spacing were to be viewed as a percent of the overall space over which the forms were written, it could increase the significance, not only of the significant result in this study, but perhaps of other findings as well. Such a method might effectively normalize the data, which would aid in solving the problem of significant variations among children's drawings. This relative spacing might also be more representative of the crowding phenomenon than the linear spacing.

In addition, the aforementioned difficulty in obtaining shapes reproduced accurately enough to allow measurements would indicate that it would be worthwhile repeating this study in an older population. In the current study it is important to note that while all subjects were tested to determine that they had binocular vision, there was no evaluation of the quality of their binocular vision. It is possible that conditions that might have affected performance such as convergence insufficiency or convergence excess went unnoticed. Another undetermined factor was the use of Ritalin. This could conceivably affect heterophoria and performance^{12,13} but within the confines of this study this information was unavailable.

Conclusions

A significant spacing difference was noted between the esophoric and exophoric children on the cross and the square. This supports the theory that the heterophoria is a spatial phenomenon (on the z axis) which can be demonstrated both through ocular

testing and perceptual testing. As has been predicted³ the esophoric subjects utilized less space between figures, they “crowded” their shapes, while the exophoric subjects “expanded” their visual perceptual space world. While this observation has been referred to by many of the references noted in this paper, our research may be the first to support this empirically.

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