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## Determining whether peripheral directional localization and peripheral sensitivity can be enhanced by training

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# Determining whether peripheral directional localization and peripheral sensitivity can be enhanced by training

## Abstract

A visual enhancement training program utilizing the Eyespan was evaluated for its effect on peripheral directional localization and peripheral visual sensitivity abilities. These two abilities were evaluated on 48 subjects under identical conditions before and after a training program consisting of at least 16 training sessions. Twenty-four experimental subjects participated in the training sessions while the other 24 subjects served as a control group. The results were analyzed, and although the experimental group did show improvement on both peripheral directional localization and peripheral visual sensitivity, these improvements were not statistically significant.

## Degree Type

Thesis

## Degree Name

Master of Science in Vision Science

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## Keywords

Eyespan, peripheral directional localization, peripheral visual sensitivity

## Subject Categories

Optometry

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**DETERMINING WHETHER PERIPHERAL DIRECTIONAL  
LOCALIZATION AND PERIPHERAL SENSITIVITY CAN  
BE ENHANCED BY TRAINING**

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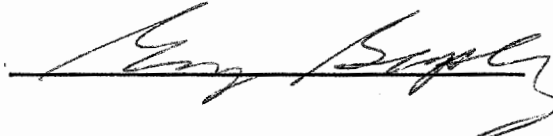
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SUBMITTED TO THE FACULTY OF PACIFIC UNIVERSITY,  
COLLEGE OF OPTOMETRY IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF  
OPTOMETRY

SPRING, 1987

**SIGNATURES**


Greg Brophy

A handwritten signature in cursive script, appearing to read "Greg Brophy", written over a horizontal line.

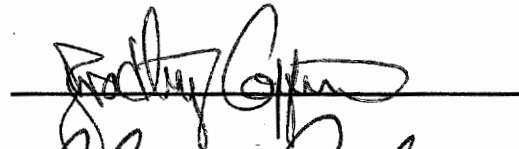
Morgan R. Leach

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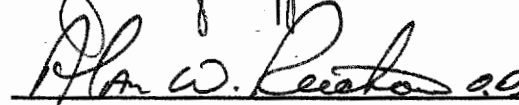
Robert Sheets

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Bradley Coffey

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Alan W. Reichow

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## **ABSTRACT**

A visual enhancement training program utilizing the Eyespan was evaluated for its effect on peripheral directional localization and peripheral visual sensitivity abilities. These two abilities were evaluated on 48 subjects under identical conditions before and after a training program consisting of at least 16 training sessions. Twenty-four experimental subjects participated in the training sessions while the other 24 subjects served as a control group. The results were analyzed, and although the experimental group did show improvement on both peripheral directional localization and peripheral visual sensitivity, these improvements were not statistically significant.

**Key Words:** Eyespan, peripheral directional localization, peripheral visual sensitivity

## INTRODUCTION

Peripheral vision is an important ability for an athlete. Greenwald (1984) stated that such mundane acts as crossing a street, parking a car, walking down a corridor or climbing the stairs would be "virtually impossible" without peripheral visual input. If these basic tasks would be difficult without peripheral awareness then sports that require a high level of peripheral visual ability such as football, basketball, baseball, tennis, etc., would be impossible to perform. Graybiel et al (1955) blocked the peripheral vision of javelin and discus throwers. This caused the movements of the athletes during the throws to become clumsy and irregular. In addition, the distance of the throws dropped dramatically. Ridini (1968) compared the size of the peripheral visual field between athletes and nonathletes and found that athletes had significantly larger peripheral fields. These experiments suggest that keen peripheral awareness is one of the visual skills necessary to fulfill the demands placed on an athlete.

Studies have been performed to determine the accuracy of directional localization. Directional localization can be defined as the ability to accurately determine the position of an object located in the periphery. It has been shown that when a brief flash in the visual periphery is presented in the dark there are errors made in determining the spatial direction of the flash. As the flash becomes increasingly peripheral there is a greater error in estimating the physical location of the flash (Osaka, 1977). The localization accuracy of a stimulus, providing the stimulus is seen, is independent of luminance and duration of the stimulus (the



luminance values in this experiment ranged from .01 to 5.12 millilamberts and the duration of the stimulus ranged from .01 to .64 seconds). The accuracy, however, varies with the radial position of the stimulus. The localization error is smallest in the horizontal meridian, next smallest in the vertical meridian, and greatest in the oblique meridians (Leibowitz, Meyers, and Grant, 1955). When directionally localizing an object using peripheral vision, there tends to be an underestimation of its actual position by approximately 10%; that is, a peripheral flash near a fixed reference point is judged to be 10% closer to the reference point than it really is (O'Regan, 1984). Mateeff (1983) provided a visible frame of reference (a continuously illuminated scale with numbered or lettered divisions) and then had subjects localize a brief light stimulus presented peripherally. It was concluded that, despite the visible background, subjects tended to base their decision on the "perceived egocentric direction" of the stimulus even though it did not coincide with the physical location of the stimulus. In other words, the subjects did not base their decision on where they saw the flash on the screen, but where they perceived the flash to be located with respect to their own sense of direction.

Other studies of interest concerning peripheral localization include the ability to localize a brief stimulus near the instant a saccade takes place. It is known that a person will mislocate a peripheral object near or during a saccade. Such mislocation effects have been studied by L. Matin and Pearce (1965), Bischof and Kramer (1968), L. Matin, E. Matin, and Pearce (1969), L. Matin, E. Matin, and Pola (1970), Monahan (1972), Mateeff

(1983), and O'Regan (1984).

If the various visual tasks necessary during a sporting activity are considered, the importance of the ability to accurately localize an object in the periphery will be evident. For example, when a basketball player is dribbling the ball up the court and wants to pass to one of his/her teammates it is of ultimate importance that the person dribbling the ball does not "telegraph" the pass. Precise peripheral localization in this situation would allow the dribbler to make an accurate pass without the defense knowing where the pass is going to be thrown. Indeed, the abilities which distinguish NBA assist leaders like Magic Johnson and Isaiah Thomas may be their exceptional peripheral localization abilities.

Another example can be applied to a football quarterback. The quarterback, who is watching his primary receiver must be able to accurately localize his secondary receiver peripherally in case the primary receiver is being closely guarded. Additional examples could easily be drawn from sports such as tennis, soccer, baseball, and others.

Extensive research is available on peripheral visual acuity. However, we chose to use peripheral sensitivity as our measurable variable in the second phase of our experiment. This allowed us to use a constant acuity demand for stimuli as they were brought in from an unrecognizable peripheral location toward the binocular fixation point. We tested only along the horizontal axis for peripheral sensitivity since previous experimenters( Egly and Homa, 1984) have determined this to be the most sensitive and consistent meridian.

Most of the visual field sensitivity experiments have been

within the central three degrees of the fixation point and deal with attentional cueing factors (Egly and Homa, 1984, Hardyck, Dronkers, Chiarello, and Simpson, 1985). We felt that in order to test visual fields comparable to the peripheral visual tasks utilized in most sporting events, we should design an experiment that measures these peripheral abilities. Consequently, we tested at least 50 degrees on each side of a central fixation point.

Attentional presets (auditory as well as visual) have been shown to affect peripheral sensitivity (Eriksen and Yeh, 1985; Eriksen and St. James, 1986). These were reduced to a negligible level by carefully monitoring room illumination and noise levels.

The purpose of this study is to assess two particular aspects of peripheral vision and determine if they are trainable. The first ability to be assessed is how accurately an individual can localize an object's position in the periphery. The second ability to be assessed is peripheral visual sensitivity (field size) as measured on a modified arc perimeter.

## **METHODS AND PROCEDURES**

### **SUBJECTS**

The subjects used in our experiments were 48 volunteers, primarily first-year optometry students. Of these, 36 were males and 12 were females; the mean age was 24 years and the ages ranged from 22 to 32 years. All subjects were paid a nominal sum (\$25.00) for their participation. All subjects had a minimum of

20/20 visual acuity at 6 meters.

## PERIPHERAL DIRECTIONAL LOCALIZATION PROCEDURES AND INSTRUMENTATION

Pre- and post-testing performance of peripheral stimulus localization was measured utilizing a constant-illumination tachistoscopic projection system (Model # 42011) by Lafayette Instrument Company. The tachistoscope presented a round, black, peripheral stimulus to subjects seated 1.675 meters away from a standard projector screen. The 1.3 cm diameter stimulus was flashed on a white projector screen distinctly outlined by a black border 4 cm. in width. The tachistoscopic stimulus was presented for .05 seconds, with both projectors set to high illumination. Room illumination was controlled at 18 candelas. For complete dimensions of the setup, see Figure 1.

Once the subject had entered the room and was comfortably seated, the instruction set was read. The subject was instructed to maintain fixation on a central fixation dot 1.0 cm. in diameter. Two practice slides were presented after which the 20 actual trials were performed. The examiner preset each tachistoscopic presentation by saying the words "ready" and then "set". A 1.5 second interval was given between the two words and between the second word and the actual presentation of the stimulus. After the stimulus was presented, the subject used a long pointed dowel to touch the screen at the point where s/he localized the center of the peripheral stimulus. The subject was allowed to look away from the central fixation dot to do this. The examiner then used a

small pointer to mark the subjective response location on the screen. The subject was instructed to remove the pointer and to close his/her eyes. The peripheral stimulus was then re-projected on the screen using the tachistoscope alignment mode. The examiner measured (to the nearest millimeter) the distance from the small pointer to the nearest edge of the actual stimulus. The value was then recorded. The next slide was advanced but not flashed, and the subject was instructed to again open his/her eyes. Once the subject was ready, the next peripheral stimulus was flashed. This sequence was repeated until data from the 20 trials was recorded.

If the subject failed to see the flashed stimulus (because of a blink or for whatever reason) the stimulus was flashed again. After collecting all of the subjects' data, .65 cm (one half of the peripheral stimulus diameter) was added to all of the scores. Therefore, if the subjective localization point was within the circumference of the actual peripheral stimulus, a negative value was recorded. Peripheral stimuli locations were randomly selected. The distances between the central fixation dot and the peripheral stimuli ranged from a visual angle of 3 degrees to 19 degrees. These measurements were taken from the outside edge of the peripheral stimulus to the inside edge of the central fixation dot.

## PERIPHERAL VISUAL SENSITIVITY PROCEDURES AND INSTRUMENTATION

This experiment was designed to assess the subjects' ability

to accurately identify various peripheral stimuli as they were slowly brought in from the far periphery on a standard arc perimeter. The stimuli used were a modified form of a Landolt C (subtending 5.83 degrees of visual angle). Stimuli were brought in on each side of the arc perimeter simultaneously. One stimulus was completely closed and acted as the control (Figure 2a) . The other stimulus was one of three possible variations. It was exactly the same as the control stimulus except it was either open on the top (Figure 2b), the bottom (Figure 2c), or both top and bottom (Figure 2d). These stimuli were mounted on wooden supports (painted to match the color of the surrounding apparatus) which were fastened magnetically to the carriers for the track system on the arc perimeter. This allowed rapid interchangeability of the stimuli. For complete stimulus dimensions, see Figure 2.

To facilitate subject comprehension, the various stimuli were displayed to the subject in the hallway prior to entering the experimental room. The subjects were shown what stimuli s/he could expect to see and were told how to respond. The subject then entered the experimental room and was seated in an adjustable chair for comfort. The subject placed his/her chin in the chin rest and was asked to close his/her eyes. The proper stimuli were placed on the arc perimeter and oriented correctly in the far periphery. The subject was then asked to open his/her eyes and maintain fixation on a centrally located cross-hair target.

The two stimuli were then simultaneously moved at a constant rate (approximately five degrees per second) toward the subject's central fixation. This was achieved using monofilament nylon line attached to the stimulus carriers and routed through a

pulley system. The two sides were yoked together and operated manually by an experimental aide. The only illumination used was that of the arc perimeter itself (25 watt standard bulb). The subject said "stop" when s/he felt that s/he could correctly identify the stimulus. S/He then identified the proper side as "right" or "left", (the control stimulus is on the other side), and then identified the proper orientation as "up", "down", or "both". If the subject's response was correct, the experimenter removed the two stimuli, moved the carriers back to the far periphery, asked the subject to again close his/her eyes, and placed the next stimulus sequence on the carriers. A total of 18 trials were run in this same manner in a consistent semirandom sequence. In this sequence, the stimulus was on the left 9 times and on the right 9 times. Of the 9 trials on each side, the stimulus was open on the top 3 times, open on the bottom 3 times, and open on both top and bottom 3 times. Subjects were unaware of this pattern.

Throughout the trials, the examiner stressed central fixation. The examiner also monitored the subject's fixation (via the corneal light reflex) and recorded which trials, if any, were invalid due to fixation losses. These invalid trials were then repeated after the last trial in the regular sequence was run. If the subject failed to give the correct response on any of the trials, the subject was asked to "try again" and the stimulus movement toward the fixation point was resumed at the standard speed. The subject was then allowed to respond again in the usual manner.

## EYESPAN PROCEDURES AND INSTRUMENTATION

The training took place on the Eyespan Model 2064 by Monark America (see Figure 3). The Eyespan is an instrument commercially available which is designed for eye-hand coordination training. It is a 122 cm square, wall mounted instrument. On its face are 64 radially arranged stimulus lights which also function as response buttons. In mode "A" a light stimulus is presented and the subject pushes the lit button to respond. The stimulus will remain lit until the correct response is made, whereupon another stimulus button will randomly light. The cycle continues for a preset amount of time (one minute sessions were used in this project). The instrument then stops and displays the number of correct responses. In mode "B" the Eyespan presents a stimulus for a preset amount of time. It then presents the next random stimulus whether the subject responds correctly or not. This continues for one minute, and again the correct number of responses is displayed. Both of these modes were used in the training sessions.

All subjects were pre-tested on the Eyespan using Mode A for two 60 second trials. Based on their score achieved on the pre-test, subjects were divided into two groups. The subjects were ordered from top score on the Eyespan to bottom score. The top score and every other subject thereafter was placed in the control group, the alternating subjects were placed in the experimental group. In addition to the initial testing on the Eyespan, all subjects were pre-tested with two distinct experimental setups to determine baseline values of peripheral



directional localization and peripheral visual sensitivity abilities.

The 24 experimental subjects participated in a 16 day training program consisting of daily training sessions of approximately 5 minutes each (a minimum of 16 training sessions were required). The training schedule consisted of two periods as follows:

Training period 1 (days 1-6):

Mode A- two trials using full hand.

- one trial using only the index finger.

Mode B- two trials at the .75 second interval using full hand.

Training period 2 (days 7-16):

Mode A- two trials using full hand.

- one trial using only the index finger.

Mode B- two trials at the .50 second interval using full hand.

The subjects were required to record their own scores in a ledger kept in the training room. Experimenters reviewed the ledger daily to insure subject compliance with the training program.

### POST-TESTING

At the end of the 16 day training period all subjects were retested to reveal any changes in peripheral visual abilities. The subjects were retested on the Eyespan using both modes "A" and "B". Subjects were again tested using the tachistoscope and the arc perimeter in exactly the same manner as before. Slides were presented in the same order in the tachistoscopic presentation to

determine directional localization ability. Similarly, the stimuli were displayed in the same order on the arc perimeter apparatus to determine peripheral visual sensitivity.

## RESULTS

All data compiled in pre- and post-testing were analyzed using matched sample t-tests for within group analyses and unmatched sample t-tests for between group analyses . Analysis of the changes in pre- to post-test scores in Modes "A" and "B" of the Eyespan was completed for both groups (see Table 1a and 1b). Experimental subjects showed much greater ( $p < .001$ ) improvements in scores than did control subjects. The magnitude of improvement was, however, less than that found by Blades and Young (1986; See figure 6).

The comparison between the experimental and control groups on the pre-test for both the peripheral visual sensitivity and the peripheral visual direction showed no significant differences (see Tables 1b and 1c). This allowed a valid comparison between pre- and post-data. Peripheral visual field size, the experimental measure of peripheral visual sensitivity was calculated by summing the data from the left and right field. Peripheral visual sensitivity for both the control and experimental group increased upon post testing with the experimental group showing greater improvement. The field size for the experimental group increased from approximately 39 degrees in the pre-testing data to approximately 45 degrees in the post-testing data. The field size

for the control group increased from 36.2 degrees to 39.6 degrees (See Figure 4). The greater improvement in the field size for the experimental group was not statistically significant.

The peripheral directional localization data showed no significant difference in either within or between groups analysis.

## DISCUSSION

The analysis of the Eyespan data revealed that the experimental subjects showed much greater improvements ( $p < .001$ ) in scores than did control subjects.

The results indicate that the experimental group did not improve a statistically significant amount for both the peripheral visual sensitivity and peripheral directional localization experiments. These results do not support our hypothesis that a person's peripheral visual sensitivity and peripheral directional localization abilities can be enhanced through training with the Eyespan.

There are several improvements that could be made in the experimental design. We feel these improvements would increase the precision in measuring the variables being assessed.

A problem with both the peripheral visual sensitivity and the peripheral directional localization experiment may be a result of a practice effect. The experiments utilized 18 or 20 trials on both the pre- and post-testing. This large number of trials may have been a factor in the improvement seen among the experimental and control groups in both experiments. This could be remediated by

decreasing the number of trials during the pre- and post-testing.

The peripheral directional localization experiment had most of the extraneous variables controlled. Two ways possible to improve upon the present experimental method would be to: (1) use some other device instead of a light-weight dowel as a pointer; the dowel may produce some variability due to an inability of the subject to accurately place the dowel upon the screen, and (2) have the subjects read the instructions prior to entering the room; we found that there was some confusion with the instructions among the subjects as they were explained by the experimental assistant. Another recommendation for future studies would be to make the experimental stimulus locations more peripheral. The tachistoscopic presentation of the peripheral stimulus during the pre- and post-testing ranged from a visual angle of 3 degrees to 19 degrees. Our training device, the Eyespan, has radially oriented peripheral stimuli ranging from a visual angle of approximately 3 degrees to 50 degrees (the visual angle of the peripheral stimuli is dependent upon how far the subject stands from the instrument). It is quite evident that the training procedure utilized more peripheral stimuli as compared to the tachistoscopic testing procedure. The enhancement of peripheral directional localization ability may well be a function of the peripheral retina (i.e. greater than a 19 degree visual angle ) and not of the central retina. If this is so, then future studies using a more peripheral stimulus must be conducted to measure this ability.

The improvements in the Eyespan scores from pre- to post-testing, although statistically significant, were not as great as expected. If the Eyespan results are compared to the Eyespan

results from the Blades and Young (1986) study, it will be noted that there is a more dramatic improvement in the 1986 study (See Figure 6). The explanation for this difference in improvement may be due to: (1) a motivational factor, (2) a difference between the subject population in the 1986 study and the present study, or (3) a difference in the training protocol between the 1986 study and the present study; the 1986 study emphasized speed (training using full hand) whereas the present study focused on both accuracy (training using only the index finger) and speed.

## **CONCLUSION**

In conclusion, the data obtained from the two experiments showed trends of improvement for both the peripheral directional localization and the peripheral visual sensitivity. Although these improvements were not statistically significant, we feel that this type of a training program has the potential to improve one's peripheral visual abilities. Several factors contributed to high variability in the data and improvements could be made in the experimental design to better measure the subtle changes that may be produced by training.

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FIGURE 1

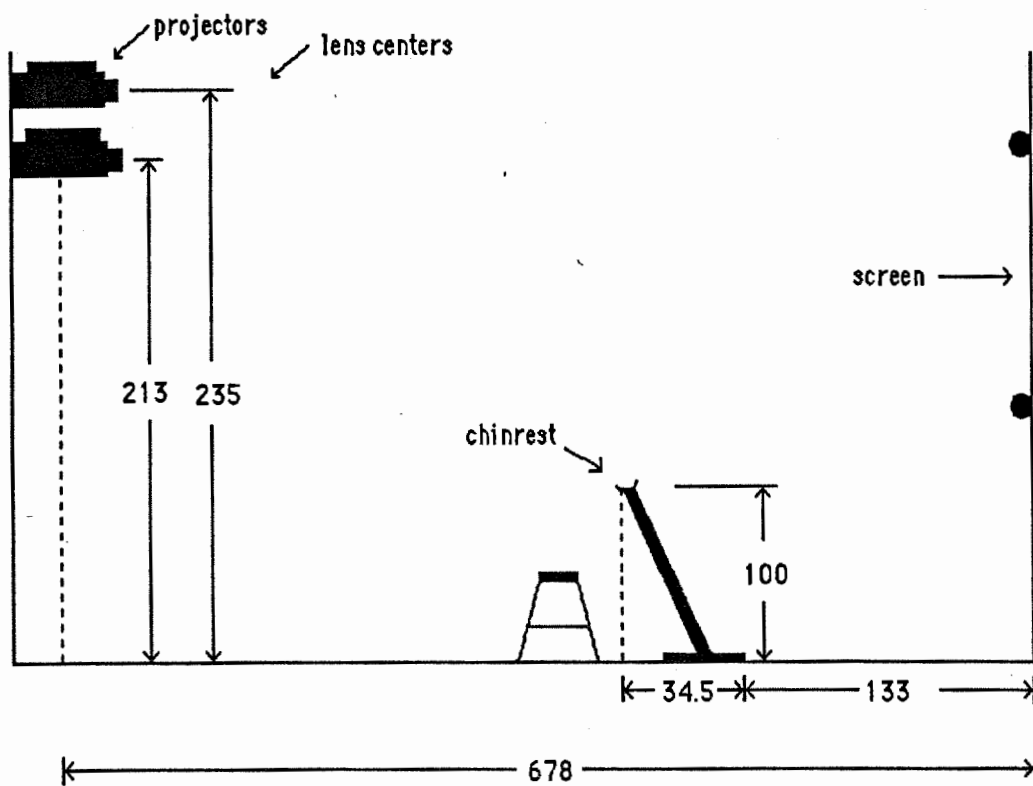


Fig. 1 Dimensions (cm) of the peripheral directional localization experiment.

FIGURE 2

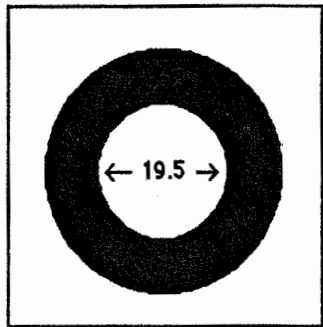


Fig. 2a

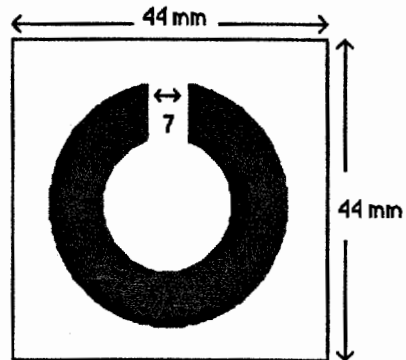


Fig. 2b

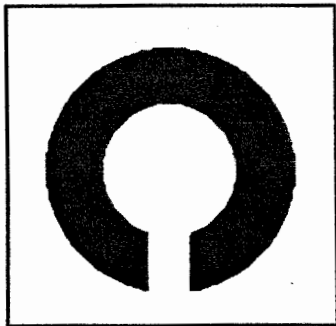


Fig. 2c

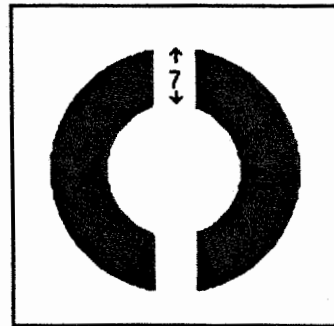


Fig. 2d

Fig. 2 Dimensions (mm) of the stimuli used in the peripheral visual sensitivity experiment.

FIGURE 3

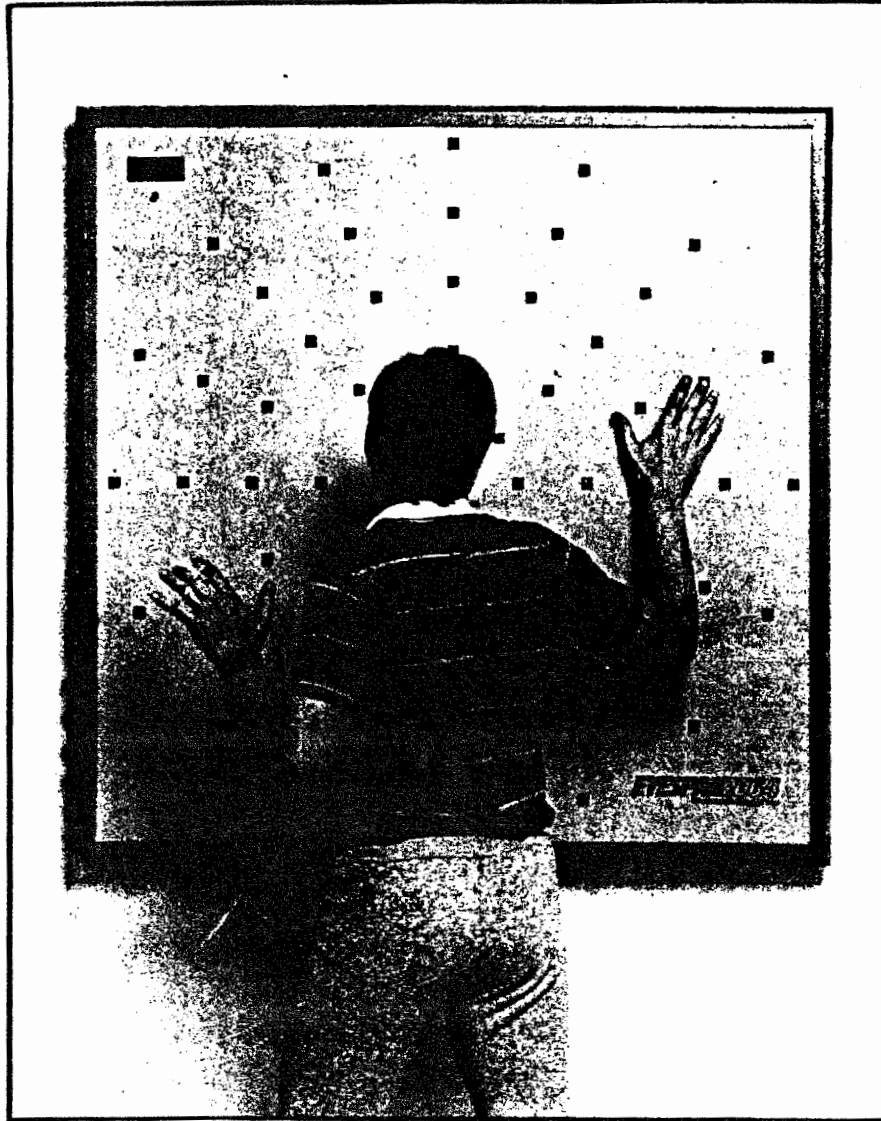


Fig. 3 The Eyespan was utilized as the training device by the experimental group. All subjects were tested on this instrument before and after the training period.

**FIGURE 4**

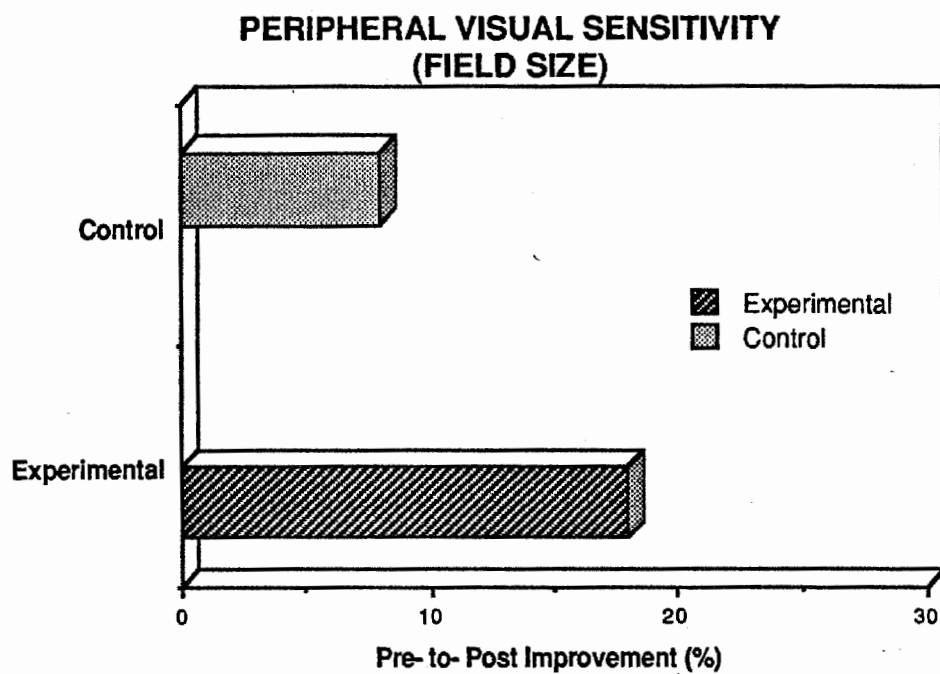


Fig. 4 The peripheral visual sensitivity differences (degrees) expressed as percentage change.

**FIGURE 5**

**EYESPAN  
MODES A & B**

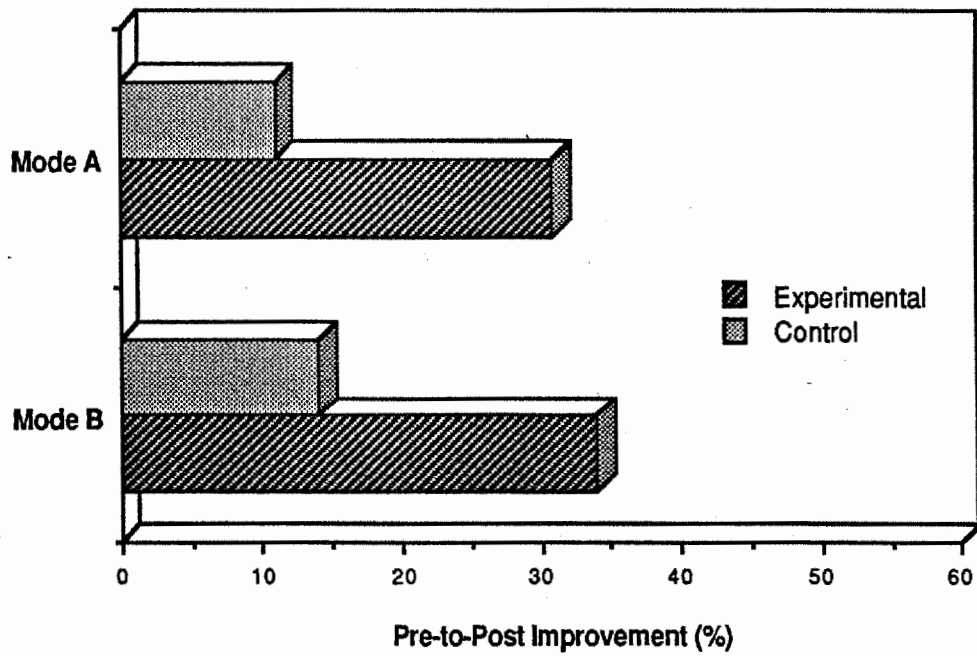


Fig. 5 The Eyespan score differences expressed as percentage change.

**FIGURE 6**

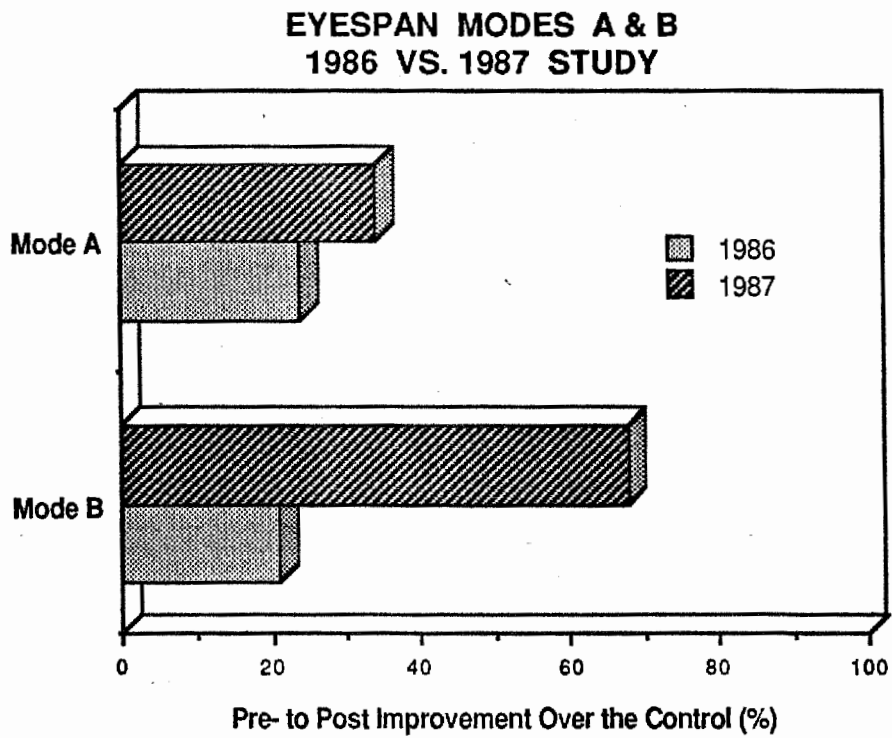


Fig. 6 Comparison between the 1986 and 1987 study with regard to the amount of improvement in the experimental over the control group.

**TABLE 1**

	<u>PRE-TEST</u>		<u>POST-TEST</u>		<u>DIFF(PRE-POST)</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.

**EYESPAN MODE "A"**

Experimental	88.5	10.6	117.3	10.4	28.8	8.9
Control	91.7	8.9	101.1	9.7	9.4	5.6

Table 1a. Results of the Eyespan mode "A" scores (# of correct responses).

**EYESPAN MODE "B"**

Experimental	73.9	16.4	109.4	15.8	35.5	10.6
Control	77.7	15.3	89.6	13.9	11.8	7.5

Table 1b. Results of the Eyespan mode "B" scores (# of correct responses).

**PERIPHERAL VISUAL SENSITIVITY**

Experimental	38.9	6.7	44.9	6.2	5.9	5.3
Control	36.2	6.0	39.6	9.0	3.4	6.8

Table 1c. Results of the peripheral visual sensitivity experiment (degrees).

**PERIPHERAL DIRECTIONAL LOCALIZATION**

Experimental	3.4	1.1	3.3	.8	.1	.9
Control	3.3	1.0	3.1	.9	.2	.9

Table 1d. Results of the peripheral directional localization experiment (deviation in cm).

## **ACKNOWLEDGEMENTS**

We wish to thank Monark America for the funding provided for our study. We also want to thank our advisers, Bradley Coffey and Alan Reichow, for their time and effort.