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A training program designed to enhance eye movement skills was examined to determine if Navy pilot's eye movements could be improved and if the improvement correlated with improvements in pilot performance. Results showed that eye movement skills were improved, but no relationship between the improved skills and available performance criteria could be identified.

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FEBRUARY 1984

EVALUATION OF EYE MOVEMENT TRAINING FOR NAVY PILOTS

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO, CALIFORNIA

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NPRDC TR 84-28 March 1984

EVALUATION OF EYE MOVEMENT TRAINING FOR NAVY PILOTS

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FOREWORD

This research was conducted under laboratory independent research project ZR000-01-042.010 (Evaluation of Oculomotor Training for Pilots) and was carried out with the active interest and participation of Commander, Naval Air Forces, U.S. Pacific Fleet (Code 313). In this project, an eye movement training program was examined to determine its possible applicability to Navy pilot training.

Appreciation is expressed to the Commander, Fighter Airborne Early Warning Wing, U.S. Pacific Fleet, and the Commanding Officer, Fighter Squadron 124, for the assistance of their staffs during this effort.

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SUMMARY

Problem

Pilots must be able to gather visual information under extremely critical conditions. The visual skills required to monitor instruments rapidly and accurately and to search for and identify other aircraft with the greatest possible efficiency may be improvable with supplementary training.

Purpose

The objective of this effort was to examine a training program designed for improving eye movement skills and to determine its possible applicability to Navy pilot training. An attempt was also made to specify further relevant research that might be warranted to enhance understanding of eye movement training and its potential contributions to pilot training curricula.

Approach

After a literature search of relevant past work, efforts were focused on determining if: (1) a group receiving eye movement training showed a significantly better level of performance on an abstract eye movement task than did an untrained group, and (2) any skill accrued in eye movement training showed a transfer to carrier landing training tasks performed during flight training of F-14 pilots. An allied task was to examine the eye movement training curriculum and to suggest areas where better control of the variables involved might improve performance in any future eye movement training research.

Results and Conclusions

1. The eye movement training had a significant effect on the eye movement abilities of the subjects who received the training. These subjects were significantly better than were control group subjects in perceiving and reporting stimuli presented to them.

2. No significant relationship between the eye movement training and the field carrier landing practice (FCLP) or carrier qualification (CQ) portions of the Fighter Squadron 124 syllabus could be discovered, indicating that there may have been no transfer of eye movement abilities to tasks purportedly involving eye movement skills. However, there may be tasks that would make use of these skills that could not be identified within the scope of this study. Likewise, it is possible that a refinement of the stimulus conditions present during the training would result in a greater degree of eye movement skill and that this skill could then be related to pilot performance.

3. Significant questions about the utility of eye movement skills in pilot training have not been answered. These are concerned with precise stimulus parameters important to eye movement skill acquisition and the actual skills involved in air combat and in carrier landings.

Future Direction

1. Based on results of the present study, implementation of the eye movement training program as currently constituted is not recommended.

2. Basic research is needed to identify the stimulus parameters that are most relevant to eye movement skill acquisition. Research should also focus upon the actual skills that are involved in pilot tasks within the areas of air combat and carrier landing.

3. In any future investigations of eye movement training, stimulus parameters (e.g., duration, speed of movement, brightness, etc.) should be more precisely controlled than they were in the training program examined in this report. Microprocessor-based presentation of stimuli is recommended.

4. Other sources of data to show training effectiveness should be considered in addition to FCLP/CQ performance data. Specifically, measurement of eye movement abilities in air combat operations seems warranted. To obtain these data, regardless of their source, it will be necessary to intrude into ongoing squadron operations to a greater extent than was possible in the present study.

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INTRODUCTION

Problem

Pilots must be able to gather visual information under extremely critical conditions. The visual skills required to monitor instruments rapidly and accurately, to search for and identify other aircraft with the greatest possible efficiency, and to use the perceptual-motor skills required in landing an aircraft may be improvable with supplementary training.

Purpose

The primary objectives of this effort were to evaluate a training program designed to improve eye movement skills and to determine whether this program could be applied to Navy pilot training. Secondary objectives included a determination of areas where future work is indicated. This work would involve an assessment of the utility of this type of training in pilot training programs, and the specification of the direction of future research that might be undertaken to enhance understanding of eye movement training.

Background

The training program was developed by the Athletic Perception Institute (API) to improve the eye movement skills of athletes, who purportedly must have well-developed visual skills on the athletic field. For instance, baseball hitters must be able to see the flight of the ball as quickly as possible when it comes from the pitcher before they decide how to swing at it. Similarly, football quarterbacks must be able to scan their pass receivers quickly to decide which one they should throw the ball to in the time available before they are tackled. The API training program has been sold to college and professional sports teams, who apparently feel that the results have been worthwhile. However, the effectiveness of the training in the sports setting has not been formally evaluated. Further, no data are available indicating that the program can be successfully transferred to other tasks requiring a high degree of visual skills.

Staff members of the Commander, Naval Air Forces, U.S. Pacific Fleet (COMNAVAIRPAC) were briefed by an API representative and saw the possible applications to Navy pilot training. Accordingly, they asked the Navy Personnel Research and Development Center (NAVPERSRANDCEN) to investigate the usefulness of the program in the Navy pilot training pipeline and made available some of the resources of the F-14 Fleet Readiness Squadron, Fighter Squadron 124 (VF-124) for use in the investigation.

APPROACH

After an initial review of the literature on eye movement training, the API program was evaluated to determine if (1) the results claimed by API could be verified in a controlled environment and (2) any relationship with real-world visual requirements could be detected. Also, the variables involved in the training were examined to determine if a more exact and focused description could be generated of the stimuli, skills, and requirements involved.

Evaluation of API Program

Sample

Subjects used in the evaluation were 41 student pilots from the F-14 Fleet Readiness Squadron, Fighter Squadron 124 (VF-124). These pilots, who require a high level of visual skills, were trained in a manner resembling as closely as possible API's own techniques.

Equipment

API uses an eye movement monitoring device, the Eye-Trac 106 Eye Movement Monitoring system, to test trainees' eye movement skills before and after training. This system measures eye movements by shining a light beam into the eye and measuring the reflected light from the retina as the eye moves. Subjects are instructed to move their eyes in three separate specified ways, as fast as they can, and their eye movements are measured by the device. The three eye movement patterns measured are shown in Figure 1. The movements are traced onto a moving graph that remains as a permanent record. Figure 2 is a sample of the graphic output, showing a typical record for eye movements during each of the three tasks.

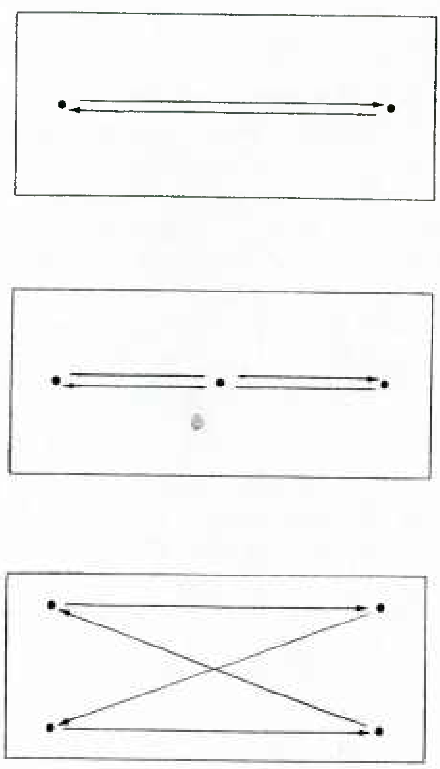

Figure 1. Pretest/posttest eye movement patterns. The subjects were shown cards with the dots, and were instructed to move their eyes from dot to dot as shown by the arrows.

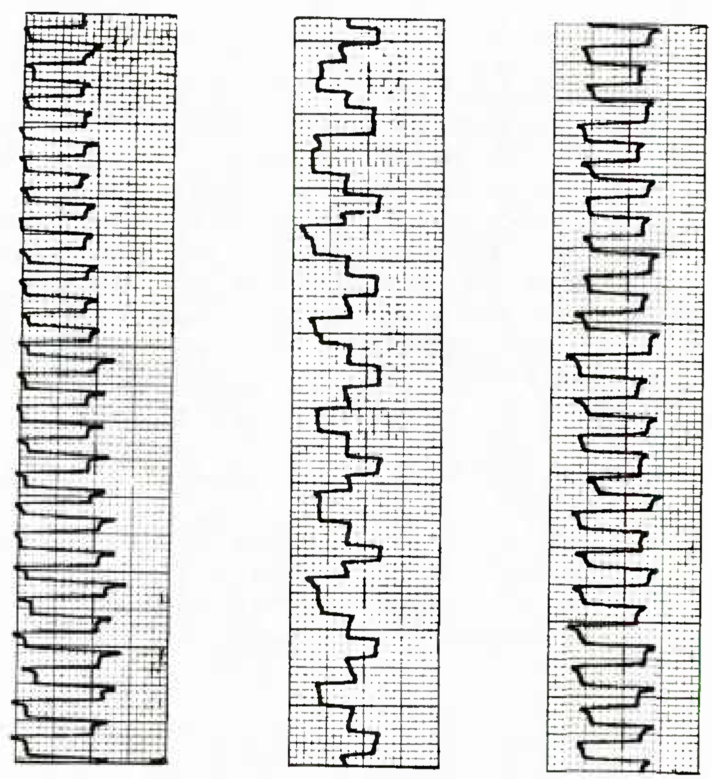

Figure 2. Typical graphic record of pretest/posttest eye movements. The left record corresponds to the top card in Figure 1; the center record, to the center card; and the right record, to the bottom card.

The system includes three training devices--the Tach Eye, the Guided Eye, and the Vu-Mate, shown in Figures 3 through 5 respectively. The Tach Eye, which has been used previously in reading research and speed reading training, projects a succession of individual displays of numbers to be "read" and recorded by trainees. A series of ten 6-9 digit numbers constitutes a session. Each number is projected out-of-focus onto a screen and is flashed into focus for perhaps a tenth of a second. The trainee's task is to read the numbers from left to right as quickly as possible and to get as many of the digits correct as possible. The score on each trial consists of the number of digits correct, reading from the left, before an error is made. Thus, for the number "3854270," a trainee's score would be 5 if he had recorded "3854207"; however, if he had recorded "3584270," his score would be 1. The display of each trial is first visible out of focus; the numbers are in focus briefly as the instructor flicks the lever on the Tach Eye from the up to the down position.

The Guided Eye is similar to the Tach Eye but has an automatic scan-and-advance feature added. The display here consists of three numerals, one at the left of the display, one at the center, and one at the right. Only one of the digits is visible at any given instant, through a rectangular "window" that advances across the display from left to right. A series of 20 to 30 displays, scanned sequentially at the speed preset on the speed control (visible in Figure 4) constitutes a trial. The trainee is briefed on a numeral to look for before each trial. His task during the 20-30 scans is to keep track of how often that numeral appears. Each trial is marked either correct (if his tally of the times the numeral appeared was accurate) or incorrect (if his tally was inaccurate). A session consists of six trials. The presentation speed is increased steadily from session to session, from 70 lines per minute in session 1 to 150 lines per minute in session 30.

The Vu-Mate presentation roughly approximates that shown with the Tach Eye. This inexpensive, plastic hand-held device is designed for individualized use. In this evaluation, each trainee was given one at the beginning of the day and he was able to use it during the short periods when projectors had to be reset or films had to be changed. However, no data were gathered on its use.

Procedure

Some of the sample members had considerable experience, with many hours in aircraft other than the F-14, while others were undergoing their first fleet readiness squadron training. After they had been pretested on the Eye-Trac device to obtain a measure of their eye movement skills, they were assigned to two groups, an experimental group and a control group, matched for experience (see Table 1) and posttest scores.

The experimental group received API's eye movement training program, which consists of 30 training sessions, presented over a period of 4 weeks, on recognition of visual stimuli projected tachistoscopically using the devices described previously. The control group received no eye movement training. Following the experimental group training sessions, both groups were given a posttest on the same eye movement skills measured during the pretest, again using the Eye-Trac device.

The data on the two groups of pilot trainees were analyzed after the API training was completed to determine if the two groups differed in eye movement skills significantly.

Performance Data Sources

In discussions with personnel from COMNAVAIRPAC, VF-124, and the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC), three areas were

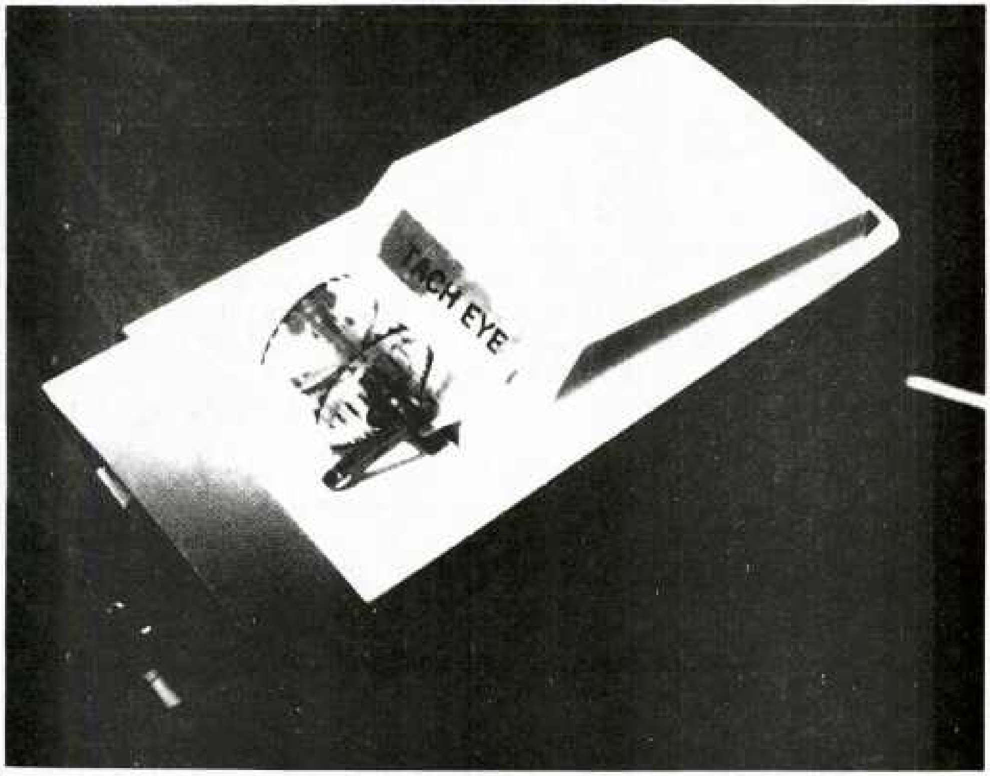

Figure 3. The Tach Eye display device.

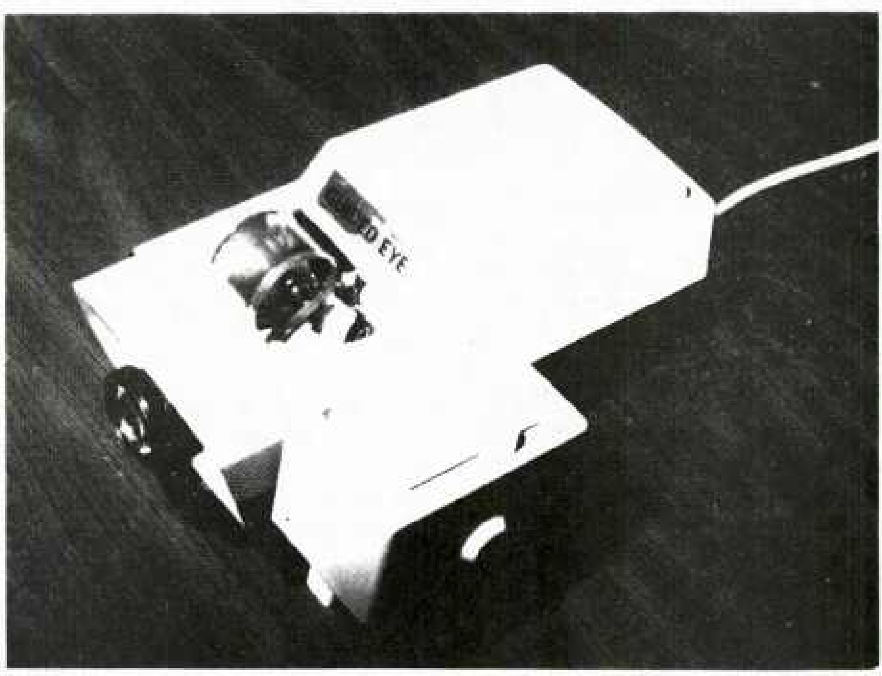

Figure 4. The Guided Eye display device.

Figure 5. The Vu-Mate display device.

Table 1

Experience of Study Groups

Group	Mean Hours	Standard Deviation
Experimental (N = 29)	1316.50	1292.05
Control (N = 21)	1122.62	878.68

identified for obtaining squadron performance data that might serve as external criterion measures for eye movement skill:

1. The operational flight trainers (OFTs) used in the training pipeline to provide simulated F-14 flights to students. The two OFTs identified were the 2F-95 and the 2F-112.

2. The field carrier landing practice (FCLP) phase of training, in which the students are graded carefully as they make simulated carrier landings on a specially marked-off portion of the runway.

3. The carrier qualification (CQ) phase of training, in which students are graded during carrier landings, both during the daylight hours and at night.

The VF-124 pilot training program did not provide an opportunity to measure subjects' abilities to scan the skies for aircraft or other objects during flight. Although this skill is important in air combat operations and might be expected to relate strongly to eye movement skills, it is not trained at VF-124 such that performance data are available to external observers.

After examining the alternatives, it was concluded that the FCLP and CQ phases of training offered the most likely sources where eye movement skill differences might be found. These phases require extensive eye movement scan by pilots from one cockpit instrument to another, as well as between the instruments and a variety of visual cues on the landing surface. Extensive data are collected during these phases for the purpose of grading the students, in accordance with the requirements of the Landing Signal Officer Naval Air Training and Operating Procedures Standardization Program (LSO NATOPS) Manual (CNO, 1975). These data were available for assessment of any evidence of relationship to eye movement skills acquired during the training sessions.

Student records on all subjects were examined for differences in ability in the FCLP and CQ phases. The data on student on-the-job performance were subjected to a t-test to determine if any differences existed between the experimental and control groups in their abilities in the FCLP and CQ portions of the VF-124 training program.

Significant Variables in Eye Movement Training

An effort was made to examine other potential areas of research to provide direction for further work that might be warranted by the results of the API training program evaluation. Also, discussions were held among staff researchers, and with interested individuals from API and from participating Navy organizations, to identify the areas where research might be undertaken to specify more exactly the variables involved in eye movement training and proficiency.

To look at ways of exercising better control over some of the variables involved in the API program, an informal investigation was begun of the possibilities of microprocessor simulation of the API program content. A program was developed in the UCSD Pascal language that permitted the presentation of stimuli roughly similar to the API stimuli. Available Terak 8600 microcomputer systems capable of high-resolution color displays were used as display devices.

The presentation consisted of stimuli located sequentially at various positions on the computer screen, requiring subjects to move their eyes to see them. Consideration was given to the use of geometric figures ("boxes") as stimuli, as well as other figures that required recognition of differences among them as well as their mere presence. The display was chosen to reduce as much as possible any patterns of stimuli presentation and to preclude guessing as an effective strategy. The presentation used was one using small clock dials, each with a small pointer directed towards one of four positions on a clock face (3, 6, 9, or 12 o'clock). The pointer was allowed to appear more than once at the same clock location in a trial, to eliminate guesses based on a process of elimination. In this way, subjects were required to use foveal vision to read the dials. With this arrangement, differences in distance between the stimuli could be varied, positions of appearance on the screen could be changed, and the sequence of stimulus events could be altered. Data was collected informally, using available NAVPERSRANDCEN personnel as subjects.

RESULTS AND DISCUSSION

Literature Review

A search of the literature on eye movement training revealed few relevant references. This is surprising considering the amount of research involved in the visual aspects of pilot training through the years. There is a large body of work on eye movements related to reading and on relationship of eye movements to perception (e.g., Rayner, 1983; Fisher, Monty, & Senders, 1981), but little having to do with training or proficiency of the perceptual-motor skills involved in eye movement.

Goodson and Rahe (1981) described a visual training program consisting of exercises designed to improve functions of accommodation, convergence, speed and span of recognition, depth perception, and hand-eye coordination that was administered to eight F-5 pilots. Details of the training program were not described; however, the training instruments included rotors, a tachistoscope, cordballs, and a stereoboard. Results showed no significant differences between the experimental group and a control group from the same squadron who did not receive the training.

Hamilton (1958) examined the effects of practice detection threshold and their transfer to a different stimulus. Results showed that practice improved detection thresholds between 20 and 30 percent and occurred within the first four sessions. Transfer occurred only when the new stimulus was less difficult to perceive than the original stimulus.

Jordan and Manfredi (1972) examined the effects of ocular pursuit training and its transferability to several tasks. Five types of visual skills were described: (1) pursuit movement (the ability of the eye to follow smoothly a moving visual target), (2) saccadic movement (rapid movement of the eye from one fixation point to another), (3) accommodation (change in focus necessary to maintain sharpness of objects as their distance from retina changes), (4) convergence (binocular coordination necessary to maintain single image with changes in object viewing distance), and (5) fixation (maintenance of a given direction of gaze). The experiments in this study were confined to the training of pursuit movements. The training device consisted of an array of lamps spaced 1/2 inch apart mounted in a 5-foot radius perimeter subtending 80 degrees of arc. Target motion was generated by sequential lighting of the lamps. It occurred initially at a slow rate of oscillation, was gradually increased, and then returned to a slow rate. The difference between successive eye movements and the correspondence between amplitude of eye movement and target excursion were used as dependent measures of performance.

Significant improvement occurred with pursuit movement training along a horizontal axis; and less improvement, when oblique and vertical axes were used. Retention of the training effect was tested 2, 4, and 8 weeks following initial training, and significant retention was found after all intervals. Transfer effects were examined on reading, number search, dot search, tachistoscopic presentation, and a simulated vehicle tracking task. All tasks showed positive transfer except the simulated vehicle tracking task. Finally, replication of the results was attempted using simpler apparatus and shorter training periods, but the level of increase in performance was not as great as that observed originally. Generally, the results indicated that, under certain conditions, controlled practice with ocular pursuit tracking improved pursuit performance, and some transfer to other tasks occurred. The failure of the simplified version of the study to yield positive effects points to the importance of carefully designed training procedures. It also suggests a possible lack of robustness in the effect of eye movement training.

Allen, Schroeder, and Ball (1978) sought to determine differences in frequency of eye movements and fixation errors between licensed and unlicensed drivers under a simulated driving task. There were no significant differences in total eye movements between the two groups. Also, there was no significant effect of amount of driving practice on eye movement frequency for either group and no interaction of practice with driving experience. Correlations between eye movements and driving adjustments and driving errors were not significant.

Gilbert (1959) examined speed and accuracy of prose reading with and without saccadic eye movements. When saccadic eye movements were required, less of the material was correctly reported than when no saccadic eye movements were required, although the material was being read at the same speed. Additionally, the requirement of saccadic movements during reading resulted in a greater loss for poor readers than for good readers. The authors could not explain why the requirement of saccadic movements reduced the efficiency of visual perception, nor why individual differences in visual loss with saccadic movements were so great. They suggested, however, that individual differences in reading decrements with saccadic movements may be related to individual differences in ocular motility.

Finally, Mackworth, Kaplan, and Metlay (1964) examined the fixation points of subjects when they watched for signals. They found that subjects frequently fixated on the signal (a 0.5 second pause in the motion of a slowly moving dial) without detecting the signal. This study illustrated the role of cognitive (attentional) factors in visual perception.

The Jordan and Manfredi (1972) study was the most relevant study reviewed, and even it did not provide clear support for a strong relationship between eye movement training and specific perceptual and perceptual-motor tasks. Generally, it was concluded that work connected with the present effort could proceed without any particular hypotheses based on past research.

Evaluation of API Program

Training Sessions

Figures 6 and 7, which provide the results of the experimental group training sessions, show that Tach Eye and Guided Eye scores for experimental subjects both improved during training. The data in Figure 6 are straightforward, but the data in Figure 7 require some explanation. The raw data are presented by the dashed line. However, the Guided Eye

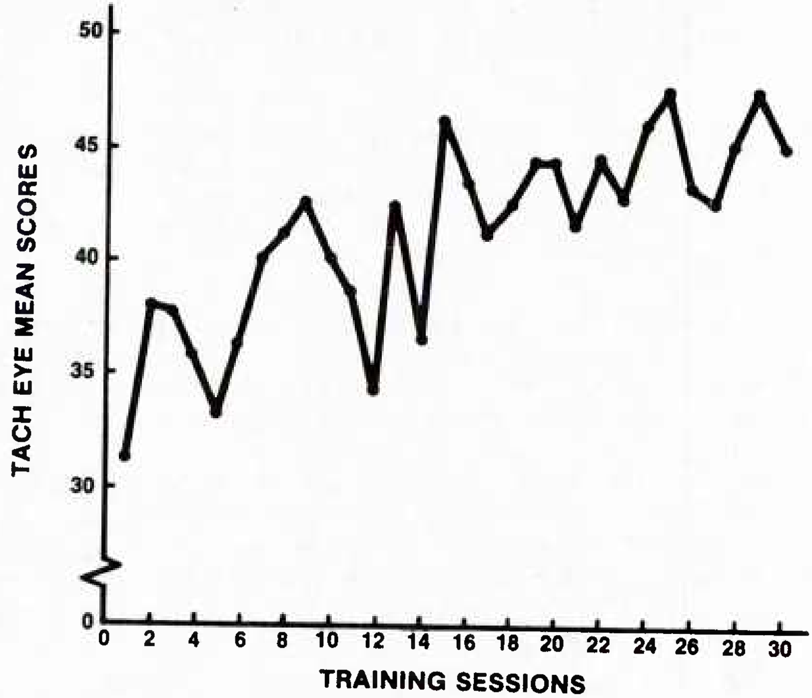

Figure 6. Tach Eye performance--Experimental group.

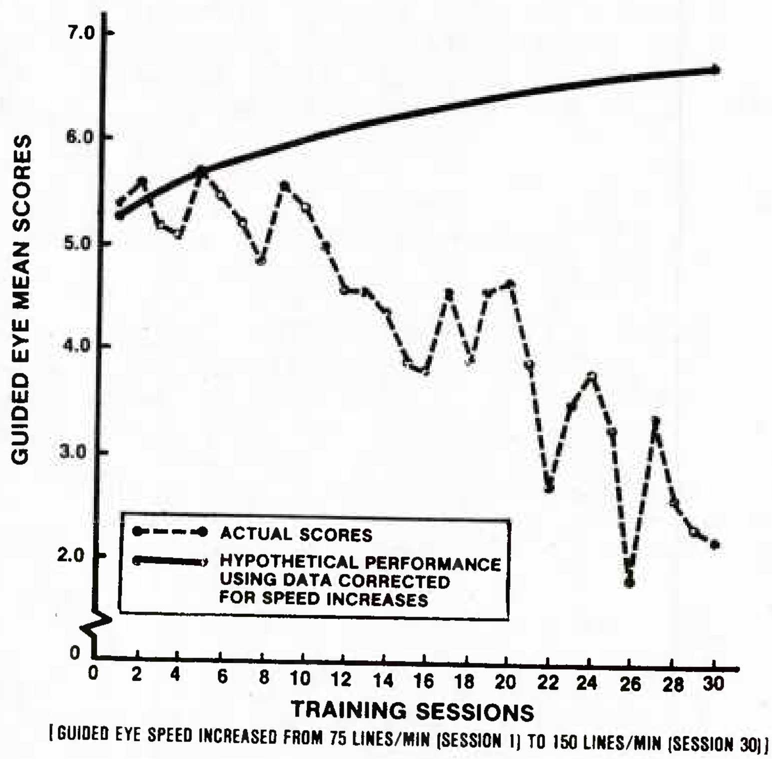

Figure 7. Guided Eye performance--Experimental group.

sessions required a progressive increase in presentation speed during the training. The solid line is an attempt to show the data in a smooth curve, correcting for presentation speed.

Table 2 provides mean pre- and posttest scores for the two groups. As shown, sufficient data for analysis were available from only 23 of the original 41 subjects (15 from the experimental group and 8 from the control group) due to attrition during training and posttesting. Although experimental group scores improved from pre- to posttest, control group scores were essentially unchanged.

Analyses performed showed (1) no significant relationships between pretest/posttest scores and flight hours reported by the trainees, (2) a significant difference ($p < .01$) between pretest and posttest scores for members of both groups, and (3) a significant difference between pre- and posttest scores for the experimental group.

As a check on the durability of the training effect, a second posttest was administered to a small sample ($N = 5$) of experimental group subjects 2 months after training had been completed. Although the sample was too small to permit statistical verification, the second posttest results appeared to be identical to those of the first, suggesting that no decrease in eye movement skills had occurred (see Table 2).

Squadron Training Data Analysis

Data from the FCLP/CQ phases of flight training were analyzed to assess the effects of API training upon performance. The extensive data compiled by VF-124 on FCLP and CQ skills of the subjects were summarized in the form of an FCLP score, a score for day CQ, a score for night CQ, and a score that was a weighted average of the other three scores. This latter score has been developed and refined over the years by the landing safety officers (LSOs) who are responsible for grading student pilots during these phases of their training.

In this analysis, FCLP/CQ data were available from 12 of the 15 experimental subjects and from 6 of the 8 control group members who participated in both pretest and posttest (Table 2). The FCLP/CQ scores for the two groups are shown in Table 3.

Since the pattern of the subscores comprising the overall CQ score did not differ from the overall score with respect to individual pilot trainees, the overall CQ score was chosen for inclusion in data analysis. A t-test was performed on the overall CQ scores of the two groups to determine if they differed in their CQ abilities. Any difference would reflect back on the training received by the experimental group. No significant difference between the two groups was found. An examination of the available FCLP and CQ data that comprised the scores shown in Table 3 likewise did not reveal any differences between groups.

Significant Variables in Eye Movement Training

Experimental subjects from VF-124 who underwent eye movement training and personnel involved in the microprocessor-based simulation of eye movement training both reported that they were sensitive to the positioning and sequencing of stimuli. It appears that other factors besides eye movement training could be involved.

Table 2

Eye Movement Training: Subjects' Mean Pre- and Posttest Scores

Subject	Pretest Score	Posttest Score	Second[a] Posttest Score
Experimental Group			
1	43.5	57.75	--
2	44.5	56.0	55.5
3	49.5	62.0	--
4	50.0	55.5	--
5	50.5	67.75	72.0
6	53.75	84.0	--
7	54.5	63.0	--
8	57.0	70.5	68.75
9	57.5	57.5	59.5
10	62.0	76.5	--
11	62.25	80.0	--
12	62.5	70.5	--
13	63.0	72.5	--
14	68.75	83.0	--
15	69.5	69.0	72.5
Mean	56.58	68.37	
Mean[b]	55.80	64.15	65.65
Control Group			
1	46.5	49.0	--
2	52.25	52.5	--
3	55.5	56.5	--
4	56.25	50.0	--
5	57.0	70.25	--
6	57.0	50.0	--
7	58.75	59.0	--
8	66.0	69.5	--
Mean	56.16	57.09	

Note. No posttest data were available on 5 experimental subjects and 13 control subjects; they were excluded from data analysis.

[a] A second posttest was given to 5 experimental subjects 2 months after training, to check for skill decrement.

[b] Mean for the 5 subjects who participated in the second posttest.

Table 3

FCLP/CQ Scores for Eye Movement Training Subjects

Subject[a]	FCLP Score	Day CQ Score	Night CQ Score	Overall[b] Score
		Experimental Group		
1	3.18	3.32	3.00	3.17
2	--	--	--	--
3	3.42	2.92	3.00	3.08
4	3.12	2.94	2.94	2.99
5	2.99	2.82	2.61	2.78
6	3.44	2.92	3.50	3.27
7	3.11	2.96	2.56	2.85
8	--	--	--	--
9	3.25	3.27	2.88	3.12
10	3.26	3.00	3.06	3.09
11	3.13	3.11	2.75	2.98
12	3.30	2.69	2.83	2.90
13	3.43	3.04	2.67	3.00
14	--	--	--	--
15	3.01	2.96	2.61	2.84
Mean	3.22	3.00	2.87	3.01
		Control Group		
1	3.02	2.92	2.68	2.86
2	3.15	3.17	2.73	3.00
3	--	--	--	--
4	3.20	2.91	2.81	2.95
5	3.22	3.00	2.56	2.89
6	2.99	2.75	2.94	2.88
7	--	--	--	--
8	3.05	3.04	2.92	3.00
Mean	3.10	2.96	2.77	2.93
Overall Mean	3.18	2.99	2.84	2.98

[a]FCLP/CQ data were not available from 3 of the 15 experimental group subjects who completed the posttest and from 2 of the 8 control subjects.

[b]The overall score is a weighted average used by VF-124 and is not a simple arithmetic mean of the three subscores.

Although no formal data were gathered for analysis purposes, results of the simulation exercise and the discussions about the factors involved in eye movement training pointed to the following areas that might be investigated in a more complete eye movement training research program:

1. There should be a differentiation between eye movement among stimuli and the comprehension of what is being viewed. It is possible for a trainee to move his eyes with much facility and not be able to understand or report on what he sees. Conversely, some individuals seem to move their eyes more slowly than do others, but are better able to comprehend and use the information they see.

2. There may be factors related to attention or to short-term memory that interact with eye movement abilities. These factors may cause the possible differences among subjects referred to in 1 above.

3. The geometric plane in which eye movements occur may be significant. API's training takes place entirely in the horizontal plane of subjects' vision. It is likely that vertical eye movements are also involved in cockpit scans of instruments, in the back-and-forth scans of cockpit instruments and an onrushing carrier deck during carrier landings, or in the scanning of the skies for potential enemy aircraft during an air engagement. Since most eye movements are in the horizontal plane, most individuals are much less used to moving their eyes vertically. Some evidence of this can be quickly gathered by simply moving one's eyes back and forth for a few seconds and comparing the resulting sensation with that resulting from moving one's eyes up and down. It might be interesting to compare readers of English with readers of Chinese in eye movement abilities in more than one geometric plane.

4. Convergence and accommodation are other factors not addressed in the API program. During a landing or in a dogfight, a pilot's eyes must move between a near focus on his instruments and a distant focus on a landing area or an approaching aircraft. Although these skills are more often exercised by most individuals than those involving movements in the vertical plane, they are not addressed in current pilot training.

5. More exact control of stimulus factors would be desirable. The API equipment did not allow accurate presentation control in many ways.

a. The Tach Eye presentation began out-of-focus and was in focus briefly during the trials. Some subjects indicated that they thought they could get a clue about the numbers to be presented if they studied the out-of-focus image carefully.

b. The nature of presentation of the in-focus image precluded exact control over its presentation time. The lever that was flipped over during the presentation allowed variations in the length of time the image was in focus, depending on how it was flipped by the instructor. Microprocessor control, on the other hand, provided exact and consistent presentation intervals.

c. The distance between subjects and the presentation surface varied. This happened because of the group presentations that required some subjects to sit behind others, and also because it was necessary to use different presentation rooms with different lighting and seating arrangements.

d. The amount of eye movement was also affected by the necessity for some subjects to sit to one side or the other from an exact 90-degree viewing angle. This meant that they would require a smaller visual angle of movement to see separated stimuli.

6. In the group training mode used in eye movement training, it might have been possible for ego-involved subjects to change their responses after a trial was completed and the answers were given to them. This does not seem likely but should be controlled in future iterations.

Although no significant relationship could be found between the eye movement training that took place and any measurable grades or scores in the VF-124 training program, it is entirely possible that such relationships would be present if training were focused more on the significant variables involved in eye movement skill acquisition. It is also possible that a significant relationship could have been found if more measurement opportunities had been available either within or outside the VF-124 training program, or if opportunities had existed for more obtrusive insertion into the pilot training process and measurement of possibly relevant variables therein.

FUTURE DIRECTION

1. Based on the results of the present study, implementation of the API training program as currently constituted is not recommended.

2. Basic research is needed to identify the stimulus parameters that are most relevant to eye movement skill acquisition. Research should also focus upon the actual skills that are involved in pilot tasks within the areas of air combat and carrier landing.

3. In any future investigations of eye movement training, stimulus parameters (e.g., duration, speed of movement, brightness, etc.) should be more precisely controlled than they were in the training program examined in this report. Microprocessor-based presentation of stimuli is recommended.

4. Other sources of data to show training effectiveness should be considered in addition to FCLP/CQ performance data. Specifically, measurement of eye movement abilities in air combat operations seems warranted. To obtain these data, regardless of their source, it will be necessary to intrude into ongoing squadron operations to a greater extent than was possible in the present study.

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