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FOREWORD

This report was prepared by the University of Wisconsin under Contract No. AF 18(600)-54. The contract was initiated under a project identified by Research and Development Order 694-49, "Human Engineering Research on Fire Control and Missile Control Systems." The contract was administered by the Psychology Branch of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center with John W. Senders acting as Project Engineer.

ABSTRACT

This experiment is part of an investigation of the problem of orientation in periscopic type sights. The problem, briefly stated, is that an operator looking through the sight has no immediate indication of where the sight is pointed, and thus may not know which way to move it to pick up a target whose position is known. The present experiment was designed to test the effect of a simple orientation aid on the speed of slewing to and acquiring targets which have been spotted outside the sight. Subjects were tested on slewing and acquisition of a series of stationary targets, using "velocity" hand controls. Two groups of subjects were tested, one with and one without the orientation aid. The aid consisted of eight illuminated lines radiating from the center of the target space and stationary with respect to the target space. This aid, although actually presented in the target space, simulated an aid which could be incorporated as a moving reticle in the focal plane of the sight.

Subjects were tested for a period of eight daily sessions. The results indicate that the subjects were performing at or near asymptotic levels at the end of this training. The group using the orientation aid showed superior performance throughout, requiring approximately 60 per cent as much time per target as the control group at all stages of practice.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

Jack Bollerud

JACK BOLLERUD
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

INTRODUCTION

In periscopic sights, the hand controls drive a scanning prism system which serves to bring a view of the external "target space" into position in the field of the sight. Thus the target space, as viewed through the sight, is displaced in azimuth and elevation so that an object on the line of sight appears to be directly in front of the operator. Target acquisition is accomplished by positioning the prisms so that the target is aligned with a reticle which always appears in the center of the field of the sight. Because the operator is fixed in position, and acquisition and tracking involve apparent movement of the exterior field, the operator has no immediate knowledge of where he is looking; that is, where the sight is pointing when he looks into it. Thus, unless some aspect of the terrain, or cloud formation, provides a reference point, an operator may be disoriented, and may not know in which direction to slew in order to pick up a target whose position is known relative to the aircraft in which he is flying.

This problem would, presumably, not be acute if direct positioning hand controls were used since the position of the controls would provide a reference. On the other hand, if some kind of aided tracking is employed, this one-to-one correspondence between line of sight and position of the controls is lost. The objective of the present program of research is to investigate methods of providing the operator with additional information regarding the direction of the line of sight, and to evaluate the influence of such information on performance.

In a previous experiment, an orientation aid consisting of four arrows which were stationary with respect to the target space was employed. Subjects were required to slew to and acquire one stationary target after another, the sight line being displaced in a direction unknown to the subject prior to each trial. The results indicated that this aid was advantageous early in training, but that after a few hours of practice, performance was approximately the same with and without the aid. The purpose of the present experiment was to perform similar tests with a slightly more elaborate orientation aid. The aid used consisted of eight colored illuminated lines radiating from the center of the target space and stationary with respect to the target space.

APPARATUS AND PROCEDURE

Apparatus. A hemispheric sight was mounted on a stand so that the head of the sight fell at the center of a roughly hemispheric field. The field consisted of a framework covered with dull black cloth. It had a radius of approximately five feet in the lower half, which increased in the upper half to approximately ten feet. Ten pre-focused flashlight bulbs, scattered on the hemispheric area and pointed toward the sight head, served as targets.

A photomultiplier unit attached to the camera mounting on the sight activated a relay when the target was centered in the reticle, providing an "on target" signal for the control circuits. This signal initiated a two-second delay during which the sight line drive moved the scanning prisms in one of four directions at random. The target and orientation aid were turned off during this interval. A new target, selected by a stepping relay, was then presented.

Possible orientation cues from the handle grip controls were eliminated by the use of a velocity control system. The velocity of movement of the sight line drive was determined by the position of the controls. The handle grips were three inches long and placed at the ends of a 11.5 inch bar pivoted at the center. Movement of the grips about the horizontal axis moved the sight line up and down. Movement of the grips and bar about the vertical axis moved the sight line left and right. The speed of the scanning prism drive motors was controlled in four discrete steps by electric contacts attached to the controls. A small deflection gave the slowest speed and a larger deflection gave increasing speeds such that approximately 9, 7, 5, and 4 seconds were required for a 180° sweep.

The orientation aid consisted of four 30-in. fluorescent lamps, two red and two yellow, suspended in front of the sight and masked so as to produce eight thin lines radiating from the center of the target space. The horizontal and vertical lines were red while the diagonal lines were yellow. With this arrangement at least one line was visible in the field of the sight for almost all positions of the line of sight, the only exception being the extreme positions of the oblique meridians. From these blank positions, a small movement (about 10 degrees) in any direction would bring some line into view. The color, position and direction of any line visible in the sight field served as a relatively unambiguous indication of the direction of the line of sight. The orientation aid was placed in the target field a few inches from the window of the sight, and hence could be seen by the subject outside of the sight as well as through the sight. This would not be the case if the aid were incorporated in the optical system of the sight. However, the position of the target relative to the orientation aid as seen outside of the sight was quite different from its position when looking through the sight, due to the relatively great amount of parallax between the two views. Presumably any facilitating effect produced by the aid could be attributed to the information provided by it when looking through the sight.

Procedure. In the present experiment, we were primarily concerned with the difficulties in slewing which might result from disorientation. Subjects were given the task of slewing to and acquiring one stationary target after another. They were instructed to "spot" the target outside the sight and then to look through the sight and manipulate the controls until the reticle was centered on the target. The first target was presented after a brief practice period during which the subject familiarized himself with the controls and observed the apparent motion of the target field as the controls were manipulated. The orientation aid was left on during this interval for all subjects. The nature of the sight and controls were explained to the subject and questions relating to the operation of the sight were answered freely. No mention was made of the purpose of the experiment or the orientation aid.

During the experiment proper the ten target lights were lighted one at a time in an irregular sequence. As each target was acquired, it was extinguished, the sight line was automatically moved in a direction unknown to the subject and the next light was presented. The room was darkened, except for the target lights and the orientation aid, to eliminate extraneous orienting cues.

A complete run consisted of 38 lights with a short break after 19 lights. Connections to three of the lights were interchanged after each run so that subject could not memorize the sequence. The cumulative slewing time for 38 lights was recorded.

Two groups of six subjects each were tested. The orientation aid was present throughout the experiment for the experimental group, and was absent throughout for the control group. All subjects were tested for a total of 26 runs (988 targets) distributed among eight daily sessions as follows: 1, 2, 2, 2, 3, 4, 6, and 6 runs per day.

RESULTS

Table 1 shows the mean time per target in seconds for each group for each of the 26 runs. Figure 1 presents the same data graphically. Table 2 presents the group means by days, the mean score for the highest and lowest individuals for each day, and the range between highest and lowest individuals.

TABLE 1

Mean Seconds Per Target By Runs

Day	Run	C	E
1	1	39.9	21.9
2	2	24.4	14.0
	3	18.6	10.0
3	4	16.7	10.4
	5	12.9	7.92
4	6	12.1	7.74
	7	11.1	6.87
5	8	10.7	6.32
	9	8.45	5.97
	10	8.48	5.90
6	11	10.1	5.58
	12	8.87	5.79
	13	8.40	5.40
	14	8.03	5.29
7	15	8.66	5.08
	16	7.74	4.92
	17	8.50	4.82
	18	8.40	5.03
	19	8.21	5.11
	20	7.03	5.08
8	21	8.16	4.84
	22	6.69	4.58
	23	7.16	4.68
	24	6.92	4.66
	25	6.82	4.58
	26	6.53	4.47

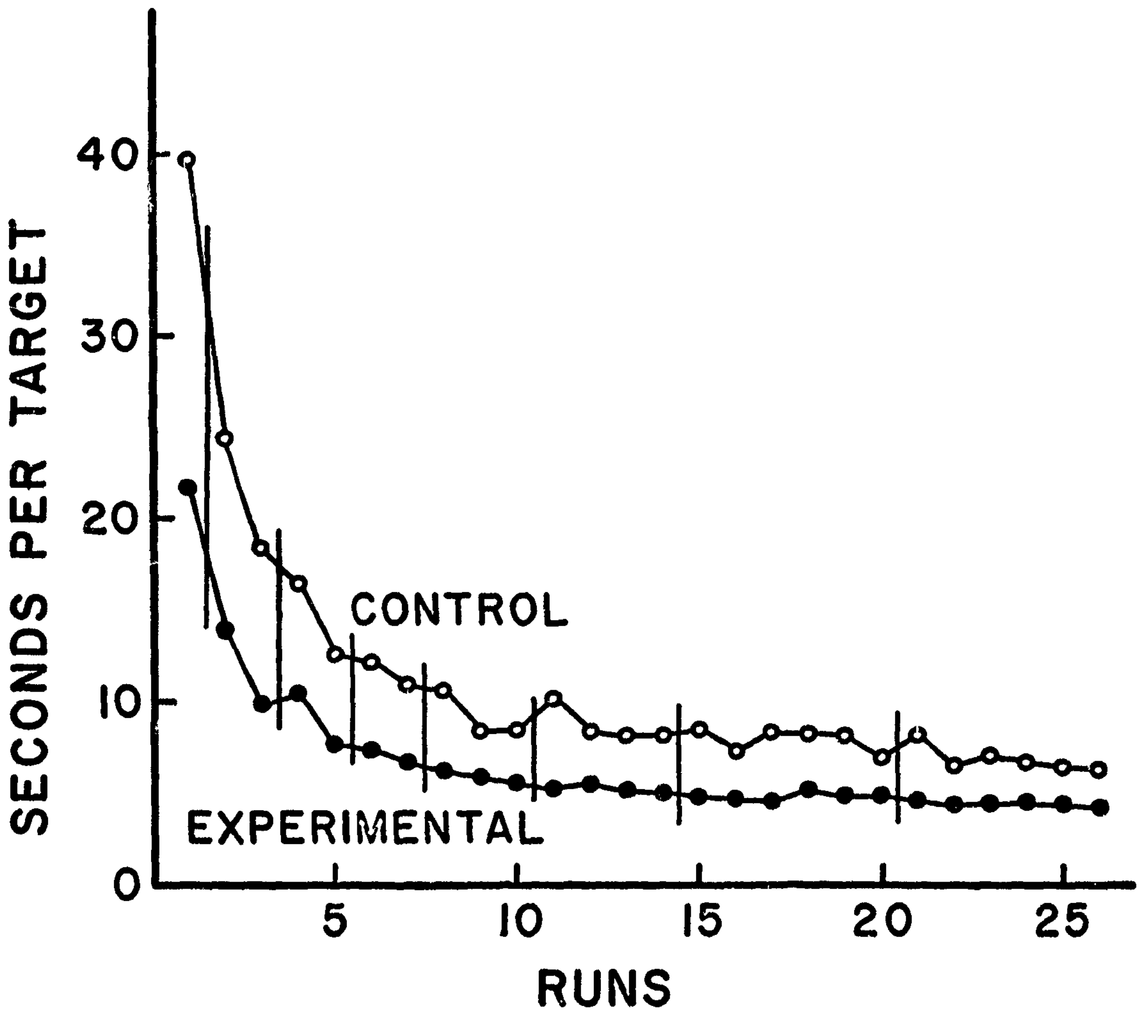

Figure 1. Seconds per target for the two groups as a function of practice. Each point represents the mean for six subjects for 38 targets. Days are separated by vertical lines.

TABLE 2

Seconds Per Target By Days

Mean = group mean for the day.
High = mean score for highest subject.
Low = mean score for lowest subject.
Range = high - low.
Ratio E/C = ratio of experimental mean to control mean.

Day		1	2	3	4	5	6	7	8
C	High	77.0	32.4	20.1	14.20	10.50	10.50	10.13	8.60
	Mean	39.9	21.5	14.8	11.50	9.22	8.85	8.10	7.05
	Low	22.5	13.0	11.5	8.75	7.95	7.50	6.71	6.03
E	High	29.9	13.4	11.40	8.35	8.15	6.08	5.55	5.08
	Mean	21.9	12.0	9.16	7.30	6.07	5.51	5.01	4.64
	Low	16.1	10.2	7.28	6.70	5.31	5.01	4.71	4.21
Range	C	54.5	19.40	8.60	5.45	2.55	3.00	3.42	2.57
	E	13.8	3.20	4.12	2.25	3.84	1.07	0.84	0.87
Ratio E/C		0.55	0.56	0.62	0.64	0.66	0.58	0.62	0.66

Inspection of these data shows (a) negatively accelerated learning curves which appear to be at or near symptotic levels by the end of the experiment, (b) uniform superiority of the experimental group throughout as indicated by lower time scores, and (c) consistently less variability in the experimental group as indicated by the lower range. The statistical significance of the difference between groups in the later portion of the experiment is obvious from the fact that the worst subject in the experimental group was scoring better than the best subject in the control group during this interval. Complete separation of this kind would occur by chance less than one time in 100 if there were no real difference.

Inspection of the ratio between experimental and control group scores (Table 2) suggests a simple method of summarizing the difference in performance produced by the orientation aid. This ratio remains in the neighborhood of 0.60 throughout the experiment indicating that the orientation aid enabled subjects to acquire targets in approximately 60 per cent of the time which would have been required otherwise; this factor remaining about the same at all stages of practice within the range of this experiment.

DISCUSSION AND CONCLUSIONS

The present experiment demonstrates the effectiveness of a relatively simple orientation aid in facilitating slewing and acquisition of targets with the hemispheric sight in a particular experimental situation. In estimating the generality of these findings certain characteristics of the experimental situation should be taken into account. First, cues which might be present in operation, such as the horizon, were eliminated. Second, the controls (straight velocity controls) were probably more difficult to operate than operational controls would be. The absence of any position component in the control system eliminated all orienting cues which might otherwise be obtained from the handle grips. In addition there was no simple method of centering the sight. However, these factors do not negate the significance of the present findings, since it would not be safe to assume that adequate cues would be obtained from these incidental factors. Another feature of the present experiment was the use of very high contrast targets. In this connection it might be expected that the orientation problem would be minimized when high contrast targets are used. If this were the case, we would expect that an orientation aid would be even more useful if low contrast targets were used. Further research along this line is indicated.

The design of the particular orientation aid used in the present experiment was influenced by considerations of convenience of instrumentation. It seems likely that other types of grids might be superior to the simple pattern of lines radiating from the center of the field used here. Further experimentation comparing the effectiveness of different grids would probably be valuable.