SECTION 3

STATISTICAL ANALYSIS OF DATA

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Data obtained from two sources, the countermarch maneuver and the zig-zag maneuver, were subjected to statistical analysis.

Countermarch Maneuver - 2 October 1944.

In Reduction of Visibility and Range Deception.

All observers agreed that B (graded) was better than A (Admiralty) and that there was no significant difference between A (Admiralty) and C (Pattern). There was no variation in the results between port and starboard camouflage measures.

In Target Angle Deception.

Both B (graded) ship and C (pattern) ship were judged to be better than A (Admiralty) ship.

Zig-zag Maneuver

Design of the Test.

The zig-zag maneuvers were planned primarily to test the ability of the three types of camouflage to deceive observers with respect to target angle and range. Each ship had two different measures of the same general type, one on each side. In order to provide a balanced test the following specifications for the maneuver were prepared:

1. Each ship should be maneuvered over the course of the test run so as to present the two measures in equal amounts to the observers. Consequently the course was designed so that the target angles fell within three sectors in relation to the observers:

(a) A course to the left of the observer with a target angle from 30° to 60°, presenting a view of the measure on the port side of the ship;

(b) A course to the right of the observer with a target angle from 30° to 60°, presenting a view of the measure on the starboard side of the ship;

(c) A course more directly toward the observer with a target angle from 20° right to 20° left, presenting a view more or less bow on and consisting of a mixture of both measures, at least as far as the superstructures are concerned.

2. In order to avoid a systematic arrangement for the course, the actual target angles in each sector were drawn from a table of random numbers and are shown in Figure 8. The courses actually followed by the three ships in conformance with these directions are shown in Figure 9.

3. The course was planned so that no two ships presented the same view in each leg of the course and no ship presented the same view in two successive legs.

4. In order to evaluate the possibility of differential effects as the ships drew nearer to the observers the whole course was laid out in 3 groups of 3 legs each, making 9 legs in all. In case of low visibility a whole group of 3 legs might be dropped without impairing the design of the test.

5. The specifications thus laid down are those for 3 x 3 Latin squares with a cyclic rotation of the three different views of the measures on each ship. The cyclic rotation which was selected also provided a Latin square for each ship. Each ship was assigned to a particular sequence at random.

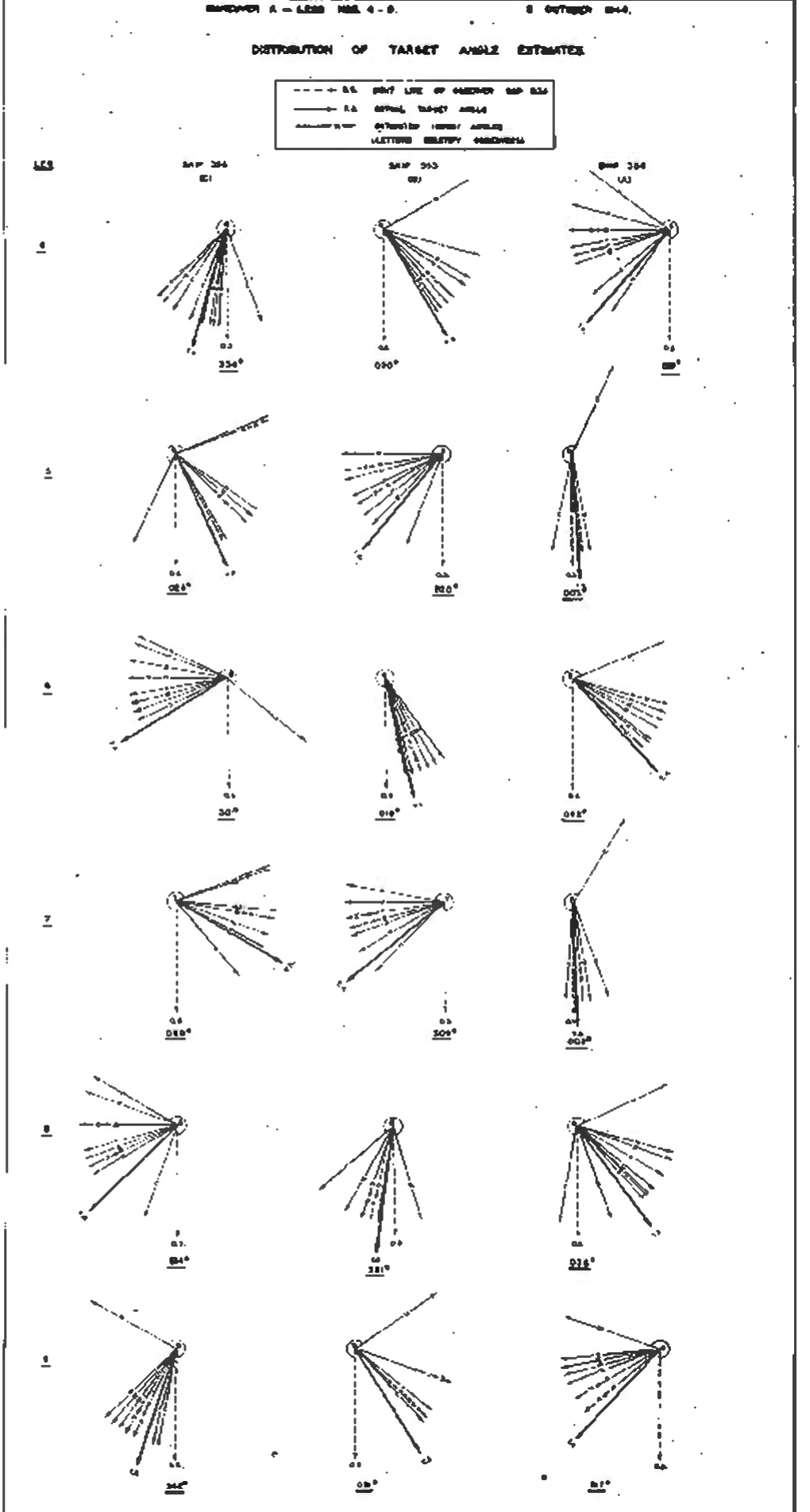
The Data on Target Angles.

The observations of the different observers are contained in the appendix, Section 4. The first run on 2 October served as a practice workout, hence the data from the second test, on the morning of 3 October, were selected for statistical analysis. The data provided by 10 observers covering the target angles of the 4th to 9th legs, inclusive, were complete and are shown in Figure 42. This graph, giving the deviation of the estimated target angles from the true, indicates that the general tendency for all observers on the average was to judge that all 3 target ships were veering away from them. This situation was considered to be important enough for a thorough statistical analysis.

Analysis of the Data on Target Angles.

The test was designed in such a way that, if reliable observations on apparent target angle were furnished, answers could be obtained for the following questions:

1. What is the effect of distance from the observer on the three types of camouflage?



2. Is there any difference between the two measures on each ship?

3. Is there any difference between the three types?

4. How consistent are the selected observers with respect to their estimates of target angle?

The reports of four observers, two British (Oates and Richards) and two Americans (Brown and Kagy), were selected for the analysis because they covered the whole course of the test and showed a satisfactory degree of consistency. The data consisted of the deviations of the estimated target angles from the true angle which was reported by the target ship for each leg. A deviation from the true angle, either to the right or left, away from the observer was given a plus sign; a deviation from true toward the observer was given a minus sign. The data are shown in table I. The analysis of the variation using the standard procedure for the analysis of variance for Latin squares was employed and the results are shown in table II. "Zones" refers to the far, middle and near regions of the test; the "trend" is the variation within zones, and the "measures" refers to the starboard, port, or bow view of the different types. "Error (a)" is the experimental error of the situation and "error (b)" is the sampling error. The latter is the discrepancy within the two groups of observers (American and British) concerning the estimate of the target angle, whereas the former provides an estimate of the reproductibility of the situation. Note that the course steered by DE355 as shown by the plot in Figure 9 is less erratic than the courses steered by DE353 and DE354. This is reflected in the experimental error terms because the experimental errors for DE353 and DE354 are each approximately 3 times that for DE355.

Table I. Showing the deviations of the estimated target angles from the true angle in the zig-zag manoeuver of 3 Oct. as reported by four observers.

Observer*	DE355 - Pattern Measures 32 and 33				DE353 - Graded Measures 12 & 22				DE354 - Admiralty Types A and D			
	H	K	O	R	H	K	O	R	H	K	O	R
Leg 1	+10	-95	+30	+25	- 2	- 7	-12	+3	-29	-24	+21	+31
2	0	+10	0	+15	+10	+12	+37	+67	- 8	-38	+27	+17
3	+25	+15	+45	+45	+16	- 2	+13	+43	- 3	- 5	- 5	0
4	- 1	- 6	+29	-11	+ 5	+10	+25	+90	+ 9	+39	+49	+34
5	+ 4	+21	+31	+36	+ 5	+20	+35	+40	+ 2	- 3	+ 2	+ 2
6	+ 6	+41	+21	+31	- 1	- 1	+ 2	+ 7	+10	+23	+33	+18
7	+ 2	+10	+20	+50	+19	+49	+24	+29	- 7	- 2	+ 3	+148
8	+19	+29	+44	+44	+11	-24	+ 6	+ 1	+ 6	+10	+24	+39
9	+12	+ 7	+27	+102	+14	+14	+14	+19	+27	+ 7	+42	+17

*Key to observers:

H = Lt. (jg) Brown, USNR

K = SP(X)2c Kagy

O = Lt. Oates, RNVR

R = Lt. Richards, RN

Table II - Showing the analysis of the variation of the data in Table I.

Source of Variation	Degrees of freedom	Sums of squares	Mean squares	Significance (Variance ratio)
Pattern Measures (32 and 33)				
Total	35	32,876.31		
Zones	2	2,422.39	1,211.20	10.58
Trend	2	4,490.89	2,245.44	19.61
Measures	2	1,431.73	715.86	6.25
Error (a)	2	229.05	114.52	
Observers (Brit. vs. Amer.)	9	12,075.75	1,341.75	
Error (b)	18	12,226.50	679.25	
Graded Measures (12 and 22)				
Total	35	16,900.75		
Zones	2	200.17	100.08	
Trend	2	442.17	221.08	
Measures	2	5,552.67	2,776.33	7.77
Error (a)	2	714.49	357.24	
Observers (Brit. vs. Amer.)	9	5,489.75	609.97	
Error (b)	18	4,501.50	250.08	
Admiralty Camouflage (Types 4 and 5)				
Total	35	32,260.0		
Zones	2	4,802.0	2,401.0	6.22
Trend	2	1,544.0	772.0	
Measures	2	350.0	175.0	
Error (a)	2	771.5	385.75	
Observers (Brit. vs. Amer.)	9	12,285.5	1,365.06	
Error (b)	18	12,507.0	694.83	

The different observers were fairly consistent with respect to their estimates on the target angles. The British observers had a tendency to estimate greater positive target angles than the Americans. This tendency is more pronounced in the case of the Admiralty and Pattern types than the Graded type. The British had a higher observation point on the observer ship than the Americans and used binoculars, two factors which may aid in accounting for the discrepance. In general the standard error of a single observation under equal experimental conditions is about 20°. This means that the observers judged the target angles within plus or minus 40° about 95 per cent of the time. Their judgment, however, was biased in the positive direction on the average by about 17° as a result of the camouflage.

Conclusions on Target Angle Deception.

The following conclusions on target angle deception appear to be warranted on the basis of the judgments of the 4 selected observers.

1. Admiralty Camouflage Measures - Types A and D.

(a) These measures showed a significant positive target angle decention (average +14°). They were the least deceptive of the three types.

(b) There was no difference with respect to target angle deception of Types A and D. The bow view was as deceptive as the port and starboard views.

(c) Both measures were just about as effective farther away, 12,000 yards, as they were nearer at hand, 8,000 yards.

2. Graded measures 12 and 22.

(a) These measures also had a significant positive target angle deception (average +16°). On the average they were intermediate between the Admiralty types and the Pattern measures. In a bow view, however, they showed no deception whatever. When viewed from angles of 20° to 60° they were just as deceptive as the Pattern measures.

(b) There was no difference between measures 12 and 22.

(c) These measures were just about as effective at a distance of 10,000 yards as they were at 7,000 yards.

3. Pattern Measures 32 and 33.

(a) These measures had the greatest overall positive target angle deception (average +21°).

(b) There was no difference between measures 32 and 33, but there was a definite indication that the greatest deception occurred when the ship presented a target angle within plus or minus 20° of the observer.

(c) These measures were definitely more effective at 7,500 yards than they were farther away at 10,000 yards. The fact is confirmed that the pattern has to be seen to be effective.

4. From the standpoint of overall target angle deception the Pattern Measures were superior to the others.