Naval Submarine Medical Research Laboratory

NSMRL REPORT 1176 **30 DECEMBER 1991**

EFFECT ON TARGET DETECTION OF ISOLATING THE TARGET BEARING AREA ON A WATERFALL DISPLAY WITH A NEUTRAL FILTER

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Report 1176

Naval Medical Research and Development Command
Research Work Unit 65856N M0100.001-5003

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SUMMARY PAGE

THE PROBLEM

To improve target detection on a waterfall display by isolating and highlighting the target bearing with a neutral density filter.

THE FINDINGS

Although the performance of 9 out of 12 subjects was improved using the filter, the difference was not statistically significant.

APPLICATION

This simple method of delineating the target bearing does not reliably improve performance with waterfall displays.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Naval Medical Research and Development Command Research Work Unit 65856N M0100.001-5003, Enhanced performance with visual sonar displays. The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. It was approved for publication on 30 December 1991 and has been designated as Naval Submarine Medical Research Laboratory Report 1176.

ABSTRACT

DiVita and Hanna (1987) have shown that target detection on a waterfall display suffers, and performance is improved if the pixels of the target bearing are displayed in red without, however, adding any additional target information. The reason appears to be that the operator has difficulty in keeping the relevant bearing isolated. We tested the effect on target detection of isolating a target bearing with a neutral density filter on the face of the CRT which dimmed the surround slightly but kept a narrow area about three pixels wide around the target bearing at full luminance. Although this improved the performance of 9 out of 12 subjects, the difference was not statistically significant.

Effect on target detection of isolating the target bearing area on a waterfall display with a neutral filter

INTRODUCTION

Signals from passive sonar systems are typically presented as multiple-channel, time-history displays in which bearing is represented along the horizontal axis and time along the vertical axis. Signal strength is encoded as pixel intensity. The information from every bearing at any given moment is seen along a horizontal line, and this information is updated at regular intervals: the current information is displayed on the top line, and the older information drops to the next lower line, and so on. This produces a display which appears to scroll downward, and it is, therefore, called a "waterfall" display. Random ocean noise appears as a random dot display ("snow" is a common description), and a target appears as a discrete track. If the target remains at the same bearing over time, it produces a vertical line through the display.

When the signal strength of the target is not much greater than that of the background, the target is, of course, difficult to detect. But DiVita and Hanna (1987) found that target detection was much worse than would be expected on the basis of what is known about the ability of the visual system to detect faint stimuli. They argued that this was the result of an inability to isolate and follow a given target bearing. They found that encoding the target bearing by color improved target detection, because the observers no longer confused information presented on adjacent bearings with that presented at the target bearing.

Since it is not readily possible to have the computer "highlight" a target bearing on current sonar displays, Luria, DiVita, and Shim (1990) tested the effect of delineating a target bearing with a straight-edge. The assumption was that if an operator suspected the presence of a target at a given location on the display, he could simply hold a straight- edge along that bearing and that might make the target track more visible. Target detection was not improved, however, for seven observers.

One problem with this procedure was that the presence of the straight-edge completely blocked out part of the display. We have, therefore, investigated a different procedure in which a neutral density filter with a narrow slit is placed over the display. The filter transmitted 25% of the light. This appears to dim the background only slightly and allows a narrow part of the display around one of the bearings to be seen at full luminance. The bearing of interest is, thus, in effect isolated.

METHOD

Subjects

Nine staff members and three other individuals volunteered to participate. Only one had had experience as a subject with these displays.

Apparatus

The apparatus and display have been described in a previous study (Luria, DiVita, and Shim, 1990). A VAX 730, a Ramtek 9400 graphics display generator, and a Matsushita standard phosphor color monitor (1024 by 2080 pixels; 100 pixels to the inch) were used to simulate the waterfall display. The color of the pixels was green. The ambient illumination on the screen was 0.8 cd/m2 from fluorescent lamps covered with neutral density filters located behind and above the observer.

The Display

The display simulated one depression-elevation sector of a spherical array passive broadband short-term averaging display. There were 60 columns and 128 rows. At a viewing distance of about two feet, the display subtended about 9 deg visual angle in height and 5 deg visual angle in width. Targets were presented at a signal strength of -5 dB. The target bearing (column) was always in the same location in the middle of the display, and a white cross-hair was placed directly above it.

A narrow area, about three columns of pixels wide around the target column was delineated by a sheet of neutral density filter placed on the face of the CRT. Its density was 0.6, transmitting 25% of the light. A vertical slit in the center of the filter, 9 deg long and 1 mm wide (about three pixels wide), allowed the target bearing to be seen at full intensity while dimming the rest of the display. The subject viewed the display with his head in a chin and forehead rest.

Procedure

Each subject had 12 experimental sessions, six with the filter to delineate the target bearing and six without it, in an "ABBA" design. Half the subjects observed first without the filter; half observed first with it. Thus, a subject might have three sessions with the filter, then six without it, and finally three more with the filter for the total of 12 sessions.

One session consisted of these events. The display scrolled at a rate of about 10 lines/sec until the complete block of data (128 lines) was presented. It then stopped and remained visible. The subjects had an unlimited amount of time to decide if a target was present, although they could respond while the display was still scrolling. After the response was entered on the computer keyboard, the display again began scrolling, and a new block of data began to appear. This was repeated 100 times in a session. The probability that a target was present on any trial was 50%, although the subject did not know this. At the end of the 100 trials in each session, the computer reported how many correct target identifications the subject had made.

There were three separate sets of practice sesssions. The subjects were permitted as many practice sessions as they wished until there was no further improvement in their performance and until they felt confident that they could make the judgment. They were given feedback during the practice sessions, but not during the experimental sessions. For example, assume that the subject observed first without the filter. The subject was given practice prior to the

Table I
Mean percentage (and standard deviations)
of correct target identifications

Subjecct	No Filter	Filter
SL	67.7 (5.61)	76.0 (6.57)
WA	59.3 (5.85)	68.7 (4.50)
SG	67.3 (8.02)	69.3 (5.82)
MP	74.8 (2.86)	69.3 (4.27)
JJ	69.2 (5.38)	71.5 (9.18)
TR	66.0 (3.52)	63.5 (5.50)
KK	56.8 (1.47)	67.8 (3.25)
JD	70.7 (3.33)	74.3 (3.98)
TL	73.0 (3.16)	74.8 (5.23)
AD	70.3 (4.31)	71.2 (0.75)
MC	76.2 (5.16)	76.5 (4.32)
JM	78.5 (5.61)	76.7 (2.80)
Mean	69.2 (4.52)	71.6 (4.68)

first experimental sessions. After the initial three experimental sessions without the filter, he or she was then given further practice with the filter prior to the experimental sessions with the filter. After the six experimental sessions with the filter, the subject was allowed further practice without the filter prior to the final three sessions without the filter.

RESULTS AND COMMENT

Table 1 shows the mean percentage of correct identifications during the 600 trials with the filter and during the 600 trials without the filter for each subject. Nine of the 12 subjects identified more targets with the filter in place than without it. This was not statistically significant according to the Wilcoxon Matched-Pairs Signed-Ranks Test. A paired t-test also fell short of significance ($T = 1.74$, $df = 11$, $p < .11$), with the differences between the means equal to 2.4 and the standard error of the mean for all the data equal to 1.43. These results were, nevertheless, a noticeable improvement over the previous attempt to use a straight-edge, in which only three of seven subjects showed an improvement (Luria, DiVita, and Shim, 1990).

Table 1 also gives the standard deviations of the correct identifications for the six runs in each condition. There is little difference in the variability of the performance with and without the filter. Although the filter may have tended somewhat to improve the number of correct responses, it did not reduce the variability of the performance.

We conclude that these results support the contention of DiVita and Hanna (1987) that isolating the target bearing enhances the ability of the viewer to detect the presence of a target at that bearing. Our premise was that if an operator suspected the presence of a target, he could improve his confidence as to what he saw by aligning the filter over the suspected track. Although the trend of the results was in the predicted direction, the present method did not, however, produce an operationally useful improvement in performance.

The reason for the failure of the present method to be more effective seems clear when the two methods of highlighting the display are compared. It is immediately apparent to every observer that displaying the target bearing in red is a much more effective method of isolating the target bearing. The filter narrowed the area of interest to a column only about three pixels wide. This appears to be better than our previous method with the straight-edge, but it still apparently introduced enough confusion to significantly degrade performance compared to the red highlighting.

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF THE REPORT
Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
NSMRL Report 1176

5. MONITORING ORGANIZATION REPORT NUMBER(S)
NA

6a. NAME OF PERFORMING ORGANIZATION
Naval Submarine Medical Research Laboratory

6b. OFFICE SYMBOL *(If Applicable)*

7a. NAME OF MONITORING ORGANIZATION
Naval Medical Research and Development Command

6c. ADDRESS *(City, State, Zip Code)*
Box 900, Naval Submarine Base NLON
Groton, CT 06349-5900

7b. ADDRESS *(City, State, Zip Code)*
National Naval Medical Center, Bldg 1, Tower 12, Bethesda, MD 20889-5044

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
Same as 7a

8b. OFFICE SYMBOL *(If Applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State, Zip Code)*
Same as 7b

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*
Effect on target detection of isolating the target bearing area on a waterfall display with a neutral filter

12. PERSONAL AUTHOR(S)
Luria, S. M., DiVita, J., and Johnson, K.

13a. TYPE OF REPORT
Interim

13b. TIME COVERED
FROM ______ TO ______

14. DATE OF REPORT *(Year, Month, Day)*
1991 Dec 30

15. PAGE COUNT
6

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Target detection; waterfall display

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[X] UNCLASSIFIED/UNLIMITED [ ] SAME AS REPORT [ ] DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
Susan Monty, Publications Office

22b. TELEPHONE *(Include Area Code)*
(203) 449-3967

22c. OFFICE SYMBOL

DD Form 1473, JUN 86

Previous editions are obsolete.
S/N 0102-LF-014-6603

SECURITY CLASSIFICATION OF THIS PAGE
CLASSIFIED