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**PERFORMANCE IN AN AUDITORY VIGILANCE TASK WHILE  
SIMULTANEOUSLY TRACKING A VISUAL TARGET**

Technical Report 740-2

**HUMAN FACTORS RESEARCH, INCORPORATED**  
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PERFORMANCE IN AN AUDITORY VIGILANCE TASK WHILE  
SIMULTANEOUSLY TRACKING A VISUAL TARGET

Technical Report 740-2

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1112 Crenshaw Boulevard  
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Subcontract: T&M-8134-B  
Under Prime Contract: Nonr 1076(00)  
Army-Navy Instrumentation Program

April 1962

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## ABSTRACT

Previous research has shown that under certain rather explicit conditions it is possible to facilitate performance on a vigilance task by performing another vigilance task simultaneously. The question arises as to whether or not performance on an auditory vigilance task is facilitated by simultaneously performing a continuous tracking task. It was concluded from the study reported here that in such a situation performance on the vigilance task is not facilitated. On the other hand, simultaneous tracking did not significantly impair performance on the vigilance task.

From this study we infer that, in auditory monitoring situations where occasional signals must be detected and responded to, operator performance will not be impaired by the simultaneous performance of some task such as steering or piloting.

Table of Contents

	Page
Abstract . . . . .	111
List of Tables and Figures . . . . .	v
INTRODUCTION . . . . .	1
METHOD . . . . .	2
RESULTS . . . . .	5
DISCUSSION . . . . .	11
CONCLUSION . . . . .	12
REFERENCES . . . . .	13

## List of Tables and Figures

Table		Page
I	Analysis of Variance of Numbers of Signal Detections During the Main Watch for All Experimental Conditions . . . . .	5
II	Analysis of Variance of Numbers of Signal Detections for the Four Experimental Conditions During the Pre- and Post-tests and the Main Watch . . . . .	7
III	Analysis of Variance of Numbers of Signal Detections for the Four Experimental Conditions and as a Function of Time on the Main Watch . .	9

### Figure

1	Mean percentages of signal detections during the main watch when the vigilance tasks were performed alone and when performed simultaneously with the tracking task . . . . .	6
2	Mean percentages of signal detections during the pre- and post-tests (pooled) and during the main watch . . . . .	8
3	Mean percentages of detections during the main watch shown as a function of the four quarter-hour periods. Mean pre- and post-test scores (pooled) are also shown . . . . .	10

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INTRODUCTION

In reviewing the literature relating to alternation of attention between simultaneously performed tasks, Broadbent (1958) asks whether two tasks can, in fact, be performed without impairing performance on either, and concludes that the answer "must depend on what is meant by the word 'task'."

The type of task of interest here is one involving prolonged vigilance, and in this particular area, Broadbent was able to cite but a single experiment, by Elliott (1957):

"A last curious feature of Elliott's experiment was that his subjects were allowed to read or write as they chose during the experiment; but that this had no effect on their performance."<sup>1</sup>

Two recent studies have suggested, on the other hand, that under certain rather explicit conditions the simultaneous performance of a second vigilance task actually facilitates performance on the first.

In the first study (Buckner and McGrath, 1961) it was found, not surprisingly, that when a relatively difficult vigilance task was performed simultaneously with an easier vigilance task, performance on the more difficult task was inferior to that achieved when it was performed alone, but, rather unexpectedly, performance on the easier vigilance task was better when performed in conjunction with the other than when performed alone. That is, when both tasks were performed simultaneously, performance on the easier was facilitated at the expense of that on the more

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<sup>1</sup> Elliott's paper makes no mention of this experimental condition and we assume that this was a personal communication to Broadbent.

difficult.<sup>2</sup>

In this first study task difficulty was confounded with sense modality but in a second study, specifically designed to examine the phenomenon, the facilitating effect was confirmed by McGrath (1962).

How general is the phenomenon? It is difficult to conceive of, for instance, two simultaneously performed motor tasks where it could occur, but there is appeal in the possibility that it might occur when a motor task is performed simultaneously with a vigilance task. Such a proposal in addition to appearing plausible, offers the appeal of possible practical application.

The experiment reported here was consequently undertaken to determine whether the phenomenon occurs when an auditory vigilance task is performed simultaneously with a visual tracking task.

#### METHOD

##### The Tasks

In the auditory vigilance task subjects were required to detect an increment (a signal) in the loudness of an intermittent 750-cps tone presented over headphones. The tone was on for one second and off for two seconds. The task lasted one hour during which period 20 auditory signals were presented, five during each 15-minute period. Intersignal intervals were selected from a rectangular distribution: the briefest interval was 30 seconds, and the longest 300 seconds. Subjects pressed a response button whenever a signal was detected. The performance measure was the number of signals detected.

The tracking task involved continuous two-handed pursuit,

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<sup>2</sup>It is known, of course, that a phenomenon similar to this can be demonstrated by offering rewards of different values for excellence of performance on two simultaneously performed tasks--see Bahrick, et al. (1952).



using a freely moving swivel-mounted "gun," of a 2-inch spot of light, 2 inches in diameter, which moved continuously in a random pattern over a 5' x 5' vertical screen mounted 12 feet from the subjects' chairs. The pattern of target movement was difficult to track, involving sudden changes in acceleration and direction. The response button to auditory signals was mounted on the gun handle.

### Subjects

Subjects were 24 male fraternity pledges from 19 to 26 years of age, tested in the week between semesters. They were paid for their participation.

### Procedure<sup>3</sup>

Groups of four subjects were tested simultaneously in a large room containing four booths. Two of the booths contained the auditory task only. The other two booths, mounted side by side, contained both tasks, the open fronts of the booths on the side facing the screen being used to erect the "gun" mountings. The only illumination in the room was that provided by the moving target, while a steady ambient masking tone of white noise was employed to mask possible extraneous sounds such as scuffling feet and those consequent to periodic tours of the experimenter to ensure that subjects were tracking.

While the difficulty level of the tracking task remained constant throughout the experiment, two levels of difficulty were employed in the vigilance task. Signals in the "easier" vigilance task were of an intensity such that 90 per cent of them were detected under alerted conditions. Signals in the "more

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<sup>3</sup>The original experimental design called for measures of tracking performance: light sensitive cells were located inside the gun barrels with the output being fed to a recording system. Catastrophic failure of the cell systems occurred very shortly before the subjects, who were available only for the period concerned,

difficult" tasks were detected in 80 per cent of the presentations under alerted conditions. These signal levels were empirically established in a preliminary psychophysical study involving signals of varying loudness during 3-minute watch periods. The eight subjects for this preliminary study were obtained from the same pool as those employed in the main study.

Four conditions were studied. For convenience they are symbolized as follows.

- Ve Easy vigilance task performed alone
- Vd Difficult vigilance task performed alone
- VeT Easy vigilance task performed simultaneously with tracking task
- VdT Difficult vigilance task performed simultaneously with tracking task

Each of the 24 subjects undertook each condition in a single day, with an hour of rest between conditions. The experimental design was such that conditions and possible order effects due to time of day were counterbalanced.

Each experimental session was conducted as follows. After receiving appropriate instructions for the condition in question a number of practice signals was given until each of the four subjects indicated that he recognized the practice signals. During the 2-minute period following, a pre-test of six signals was given. This was followed by 15 seconds of silence in the earphones, after which the main watch commenced and lasted one hour. At the termination of the hour another 15 seconds of silence was followed by a 2-minute post-test of six signals.

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were scheduled to arrive. The decision was made to proceed with the experiment though with a much less sophisticated design, i. e., the tracking task was not varied in difficulty as originally planned, nor, of course, could tracking performance be recorded. However, subjects were given the impression that their tracking performance was being recorded and periodic monitoring by the experimenter revealed no cases in which tracking had ceased.

Subjects tracked during the pre- and post-tests as well as during the main test.

## RESULTS

In Figure 1 are shown the percentages of signals detected when the vigilance tasks were performed alone, and when performed simultaneously with the tracking task. An analysis of variance of these data is given in Table I.

Table I  
ANALYSIS OF VARIANCE OF NUMBERS OF SIGNAL DETECTIONS  
DURING THE MAIN WATCH FOR ALL EXPERIMENTAL CONDITIONS

<u>Source of Variation</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>Significance Level</u>
Tracking vs. non-tracking (T)	1	19.00	2.44	NS
Difficulty (D)	1	96.00	7.22	.025
Subjects (S)	23	67.3	-	-
TXD	1	3.00		NS
TXS	23	7.78		
DXS	23	13.00		
TXDXS	19 <sup>4</sup>	28.80		
Total	91			

In Figure 1 it appears that performance on VeT was at a lower level than that on Ve, while there is a negligible difference between Va and VdT. However, from Table I it can be seen that the trend is not significant, i.e., under neither level of difficulty was detection performance when tracking significantly different from that when not tracking. The only significant difference (0.025 level) is that between the two levels of difficulty, which was, of course, as intended.

<sup>4</sup>Four subject hours were lost due to apparatus failure.

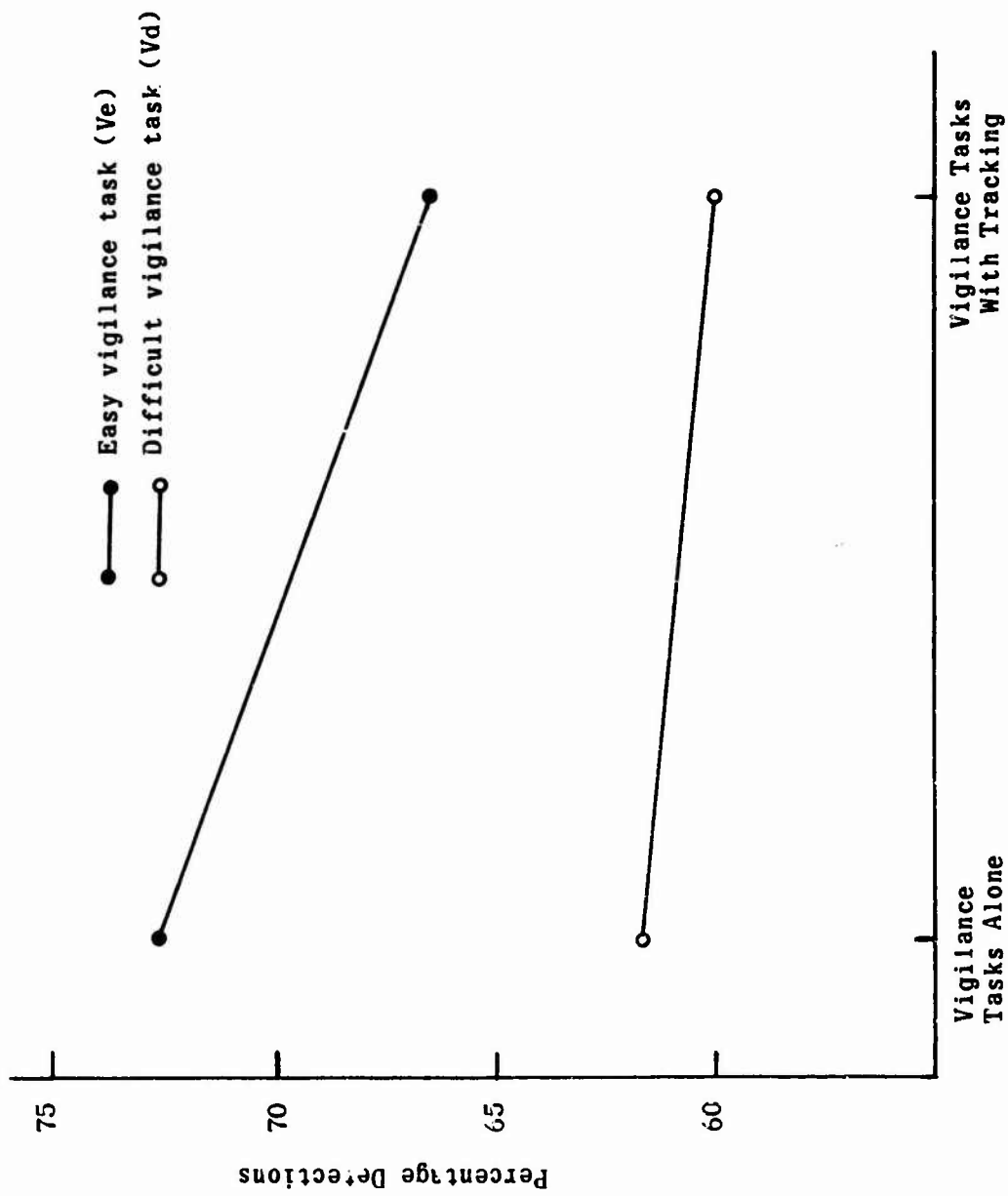


Figure 1. Mean percentages of signal detections during the main watch when the vigilance tasks were performed alone and when performed simultaneously with the tracking task.

The second analysis concerned the difference between mean performance during alerted condition (percentage detections during the pre- and post-tests pooled), and that during the main watch. The pertinent data are shown in Figure 2, while the variance analysis is given in Table II.

Table II  
ANALYSIS OF VARIANCE OF NUMBERS OF SIGNAL DETECTIONS  
FOR THE FOUR EXPERIMENTAL CONDITIONS DURING THE  
PRE- AND POST-TESTS AND THE MAIN WATCH

<u>Source of Variation</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>Significance Level</u>
Tracking vs. non-tracking (T)	1	70.0	5.88	.025
Pre- and Post-test vs. Main Watch (C)	1	732.0	32.80	.001
Difficulty (D)	1	291.0	15.60	.001
Subjects (S)	23	69.4	-	-
TXD	1	7.0		NS
TXC	1	5.0		NS
DXC	1	10.0		NS
TXS	23	11.9		
DXS	23	18.7		
CXS	23	22.3		
TXDXC	1	12.0		NS
TXDXS	23	10.3		
TXCXs	23	4.8		
DXCXs	23	6.7		
TXDXCXs	15 <sup>4</sup>	7.4		
Total	183			

From Figure 2 and Table II it is apparent that mean performance during the main watch was at a significantly lower level than during the pre- and post-tests combined. The difference is generally of the order of 10 to 15 per cent signal detections.

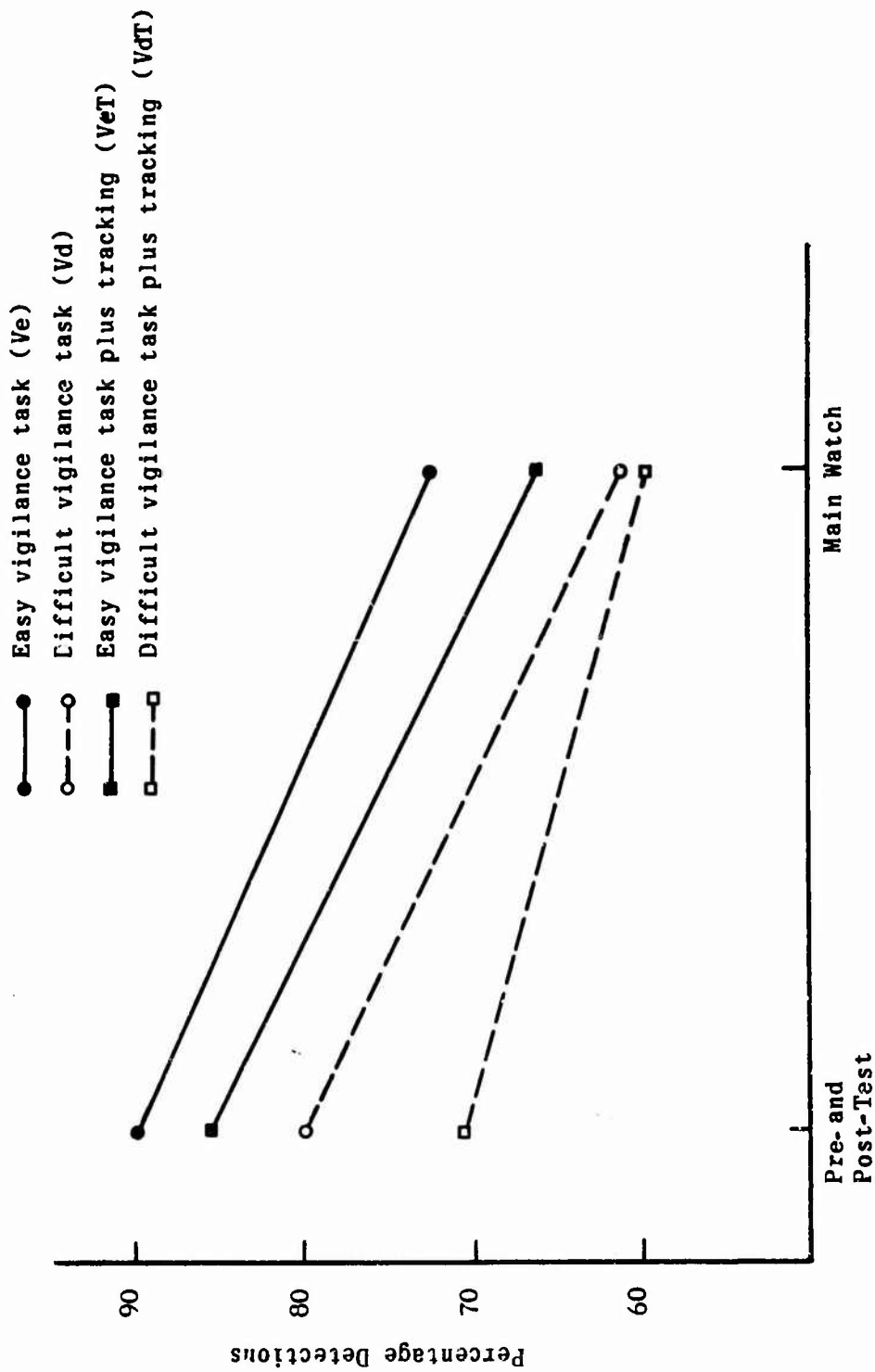


Figure 2. Mean percentages of signal detections during the pre- and post-tests (pooled) and during the main watch.

It is further apparent that there was a significant difference between tasks (and, of course, between levels of difficulty), performance during vigilance alone being superior to that while simultaneously tracking. As it has been shown in Table I that there was no significant difference between these tasks during the main watch considered alone, the difference reported might be attributable to a number of factors such as increase in N, less variance in the pre- and post-test scores, or more reliability in these scores.

The third analysis was concerned with performance during the four quarter-hour periods comprising the main watch. The data are shown in Figure 3, and the analysis of variance is given in Table III.

Table III

ANALYSIS OF VARIANCE OF NUMBERS OF SIGNAL DETECTIONS  
FOR THE FOUR EXPERIMENTAL CONDITIONS AND  
AS A FUNCTION OF TIME ON THE MAIN WATCH

<u>Source of Variation</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>PI</u>
Tracking vs. non-tracking (T)	1	4.0	2.04	NS
Difficulty (D)	1	24.00	7.21	.025
Quarter-hours (Q)	3	3.67	2.64	NS
Subjects (S)	23	16.8	-	-
TXD	1	2.00		NS
TXQ	3	0.33		NS
TXS	23	1.96		
DXQ	3	2.00		NS
DXS	23	3.30		
QXS	69	1.39		
TXDXQ	3	0.66		
Residual	214	1.65		
Total	367 <sup>4</sup>			

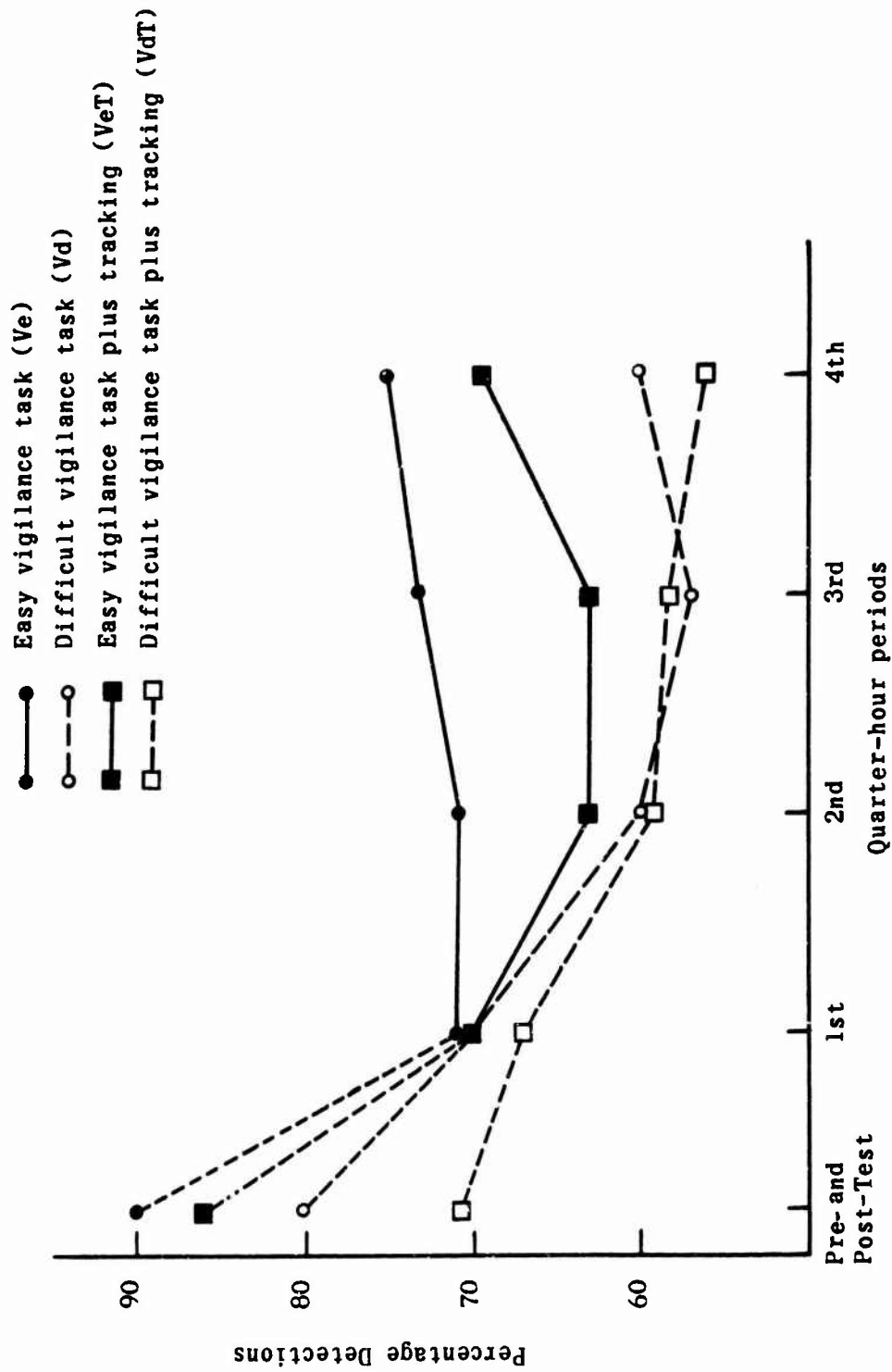


Figure 3. Mean percentages of detections during the main watch shown as a function of the four quarter-hour periods. Mean pre- and post-test scores (pooled) are also shown.



While inspection of Figure 3 might lead one to suspect that there were differences in performance on the main watch as a function of time, with possibly two of the conditions, Vd and VdT, resulting in a performance decrement, it can be seen from Table III that such was not the case. There were no significant differences between tasks of same difficulty level, or between quarter-hour periods, though once again a significant difference was revealed between difficulty levels.

A final analysis was undertaken to determine whether there were any differences in performance between morning and afternoon sessions and none was found to be significant.

#### DISCUSSION

This experiment was undertaken to determine whether performance on a relatively easy auditory vigilance task could be facilitated by having subjects simultaneously perform a visual tracking task. The results showed that no facilitation occurred in such a situation and the phenomenon must be regarded, to date, as peculiar to the simultaneous performance of vigilance tasks. On the other hand, it is of interest and possibly of practical significance, that performance on an auditory vigilance task was not significantly different when performed alone from when it was performed simultaneously with a task involving visual and motor coordination. (We consider that the significant differences which were found when performance scores during alerted sessions were combined with those during the main watch to be of secondary interest only, our primary interest being in performance during the main watch.)

The absence of a decrement in performance during the main watch is not an unusual finding, particularly when there are marked individual differences. In addition it has been hypothesized (Baker, in press) that under certain conditions performance on a vigilance task can even be expected to improve with time. In the present situation, however, it was possibly a consequence

of any, of a combination of any, of several parameters such as signal frequency, signal amplitude, intersignal interval, etc. These are all known to affect the level of performance in such a situation.

The lack of a difference in level of performance between morning and afternoon watches is, on the other hand, of some interest. Two investigators have found significant differences between performance in the morning and afternoon. Jenkins (1958) found that detection performance and latency of response were both inferior in the afternoon. Colquhoun (1960) found introverted subjects to be superior in the morning while extraverted subjects were superior in afternoon sessions. On the other hand, an analysis of data reported by Baker, et al. (1961) show, as do the data reported here, no difference as a function of time of day. It is not possible to determine from the study by Baker, et al., or from the present study, whether there was a differential effect of time of day consequent to temperamental differences, though in this general connection we consider it improbable that Jenkins' subjects became more introverted as the day proceeded. The question remains unanswered to date.

#### CONCLUSION

An auditory vigilance task can be performed as well when a visual tracking task is simultaneously performed as when it is performed alone.

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