

## A study of visual vigilance performance of radar operators in desert terrain under environmental stress (ambient temperature)

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*A study was conducted to determine the effect of environmental stress (ambient temperature) in desert terrain on the performance of visual vigilance task by radar operators. A total of 55 trained Air Defence System Operators participated in the study. The effect of the individual's personality traits on the performance of visual vigilance task was also studied. A microprocessor-based simulated radar operators' visual vigilance task was given to the subjects under normal working condition at an ambient temperature of 20–25°C and again, when the ambient temperature was above 40°C. There was a highly significant decrement in performance after one-and-a-half hours under ideal conditions (ambient temperature 20–25°C, no noise stress, etc.). Performance deteriorated significantly after 1 h under conditions when the temperature was above 40°C. There was also a deterioration in the detection of speed and accuracy during this period. A relationship was found between performance and personality trait (introversion). The results are discussed in relation to selection criteria and work-rest schedules for the surveillance radar operators.*

**Keywords:** Vigilance task; Heat stress.

Vigilance decrement over a period of time while performing various tasks is well documented [1, 2]. The decrement could be both in detection accuracy and detection speed or reaction time. Decrement in performance depends on various factors like environmental stresses, age, effect of alcohol, drugs, etc.

The decrement in performance of radar operators induced by temperature and other environmental stress is of great practical signifi-

cance during operational planning. Monitoring of targets on radar scope requires accuracy of visual vigilance.

Most of the works on vigilance and environmental stress are laboratory-based and cannot be interpolated with the conditions prevailing in desert terrain due to the multiplicity of the stresses acting on the individual. The working/living conditions become additional stresses, more so in operational conditions.

The present study was undertaken to bring out the effect of actual environmental stress on performance of radar operators in desert terrain, and the results thus obtained can be usefully utilized in operational planning. The aim of the study was:

(a) To assess the visual vigilance performance of radar operators on simulated radar operators task in desert terrain, compare it with the ones working under ideal conditions and make recommendations regarding work and rest schedule based on the results so obtained.

(b) To make recommendations regarding selection of personnel for surveillance duties based on personality traits.

### Material and methods

The study was conducted on a total of 55 subjects, over a period of seven months from December 1992 to June 1993 at various Air Force bases in Rajasthan. Each subject was given a personal information questionnaire (PIQ) pertaining to age, educational qualification, experience, work environment, etc. Two personality tests, Cattell's 16 PF and Eysenck's Personality Inventory, were given to each subject.

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### Method

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The vigilance task was similar in presentation to the conventional radar operators' task. Four concentric, equidistant rings representing arbitrary distances from the centre were drawn. The distances presented from the centre outwards were 0-25, 25-50, 50-75 and 75-100 km. On the outer circle the bearing was marked from 0 to 345° at intervals of 15°. The linear cursor sweep covered the scope at 5 rpm. The scope had a fixed clutter in any one sector. Targets in the form of rectangular blips were presented on the scope by random generation programme. The rate of the target presented was 50 targets per 30 min. The subjects were required to remove it from the scope by pressing a key on the keyboard and continue monitoring for the next target. They were also required to identify the target with bearing and range, which was noted down by the observer or recorded on an audio tape. The maximum duration for which the target was displayed was 4500 ms. The elapsed time between display of enemy aircraft and pressing of the key was measured in steps of 75 ms. Certain targets, different in configuration from the actual target, were presented as decoy on the scope on random generation. The subjects were not expected to respond to these objects.

The computer gives a printout after every 50 targets. The information given is:

(a) *Total number of early hits.* Early hits are key strokes made after a lapse of 0.6 s after the erasure of enemy aircraft but before the appearance of decoy.

(b) *Total number of late hits.* Late hits are key strokes made after erasure of enemy aircraft but within 0.6 s after its erasure.

(c) *Total number of wrong hits.* Wrong hits are key strokes made after appearance of decoy/stray pickups but within 0.6 s after erasing them.

(d) The bearing and range of each target.

(e) The response/reaction timing in ms.

### Methodology

Tests were conducted on 30 subjects during January 1993 to March 1993, when the tempera-

ture was between 20-25°C, and again from the end of April 1993 to June 1993, when the temperature was above 40°C, under actual operating conditions. On the first day, the subjects were given the PIQ and two personality tests. This was followed by familiarization with the simulated radar operators' task.

The subjects were given considerable task practice prior to the test. Each subject had 5 to 10 familiarization runs, each run lasting for 5 to 10 min. On the day of the test also the individual was given two 5 min familiarization runs. The subjects were informed one or two days in advance about the test. They were instructed to have adequate sleep/rest, avoid consumption of alcohol and medication on the previous day and have breakfast prior to the test. An ophthalmological examination of the subject was also carried out. Heart rate and blood pressure were recorded prior to and after the test.

To assess the deterioration of performance over prolonged periods, another 25 subjects were given tests lasting for 4 h each.

### Results and discussion

The comprehensive data of scores obtained from 25 subjects during the test lasting for 4 h under ideal conditions is given in Table 1. The scores were obtained every half an hour. The mean correct hits decreased from 43.8/50 hits in the first half-hour to 32.24/50 hits in the last half-hour.

There was an increase in the reaction time from 1950 ms to 2700 ms, which is also indicated by an increase in the number of early and late hits from the first half-hour (8.16/50 hits) to the last half-hour (9.84/50 hits). There was, therefore, a deterioration in the detection speed over a period of time.

The paired *t* test was used to find the difference between scores obtained every half an hour. There was no significant deterioration in the scores obtained during the first three half-hour sessions of the 4 h run. The scores during the subsequent five half-hour sessions showed highly significant ( $P < 0.001$ ) differences. Thus,

Table 1. Scores obtained during the 4 h run under ideal conditions

Scores (out of 50)	Every half hour							
	1	2	3	4	5	6	7	8
Correct hits	45.8	43.4	43.2	40.0	37.4	35.7	34.1	32.2
Standard deviation	2.7	2.29	1.6	2.4	3.1	2.9	2.9	3.4
Early and late hits	8.16	8.04	8.6	8.08	9.74	9.2	9.8	9.84

Table 2. Comprehensive data on scores under ideal conditions and under thermal stress

Scores (out of 50)	Every half hour							
	1	2	3	4	1	2	3	4
	(Ideal conditions)				(Thermal stress)			
Correct hits	44.4	44.03	39.1	38.2	39.9	38.4	36.5	33.3
Standard deviation	2.8	2.48	9.57	7.49	6.6	2.4	3.1	3.3
Early and late hits	3.6	4.4	4.96	4.69	5.26	7.0	6.99	6.72

no significant deterioration in detection accuracy occurred during the first one-and-a-half hours of the run whereas the detection accuracy deteriorated considerably during the subsequent two-and-a-half hours. Comprehensive data on the scores obtained by 30 subjects under ideal conditions and under thermal stress are given in Table 2. The average early hits and late hits score during the first half-hour of the test under ideal conditions was 3.6/50 and 4.6/50 during the fourth half-hour. The respective scores when temperature was above 40°C were 5.2/50 and 6.72/50. The reaction time during thermal stress increased from 2100 ms to 3075 ms from the first half-hour to the fourth half-hour. There was a deterioration in the scores from 44.4/50 hits in the first hour of test during ideal conditions to 39.9/50 hits during the first hour of test under thermal stress. The number of early and late hits increased from 3.6/50 hits to 5.2/50 hits, respectively.

The paired *t* test was used to find the difference between scores obtained every half an hour during ideal conditions and under thermal stress. There is a highly significant ( $P < 0.01$ ) decrement in scores between the second and the third half-hours under thermal stress. These data show that detection accuracy and detection

speed deteriorate significantly after one-and-a-half hours under ideal conditions and after one hour under thermal stress.

A relationship was found between performance and introvertedness. Majority of the subjects (72%) who scored above 170/200 hits during a two-hour run under ideal conditions were found to be introverts (Eysneck test). Introverts were therefore found to perform better during radar operators' task. Theoretical speculations have been made earlier that introverts were better equipped for sustained monitoring tasks [3, 4]. Some studies [5, 6] have found a positive relationship between intelligence and vigilance performance. In the present study no relationship could be found.

### Conclusions

(a) There is no significant difference in the scores in the first three half-hour sessions during the radar operators' vigilance task under ideal operating conditions. There is a highly significant difference in scores during the subsequent half-hours, for the next two-and-a-half hours.

(b) There is an increase in the reaction time from 1950 ms in the beginning of the test to 2750 ms at the end of 4 h.

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(c) There is no significant difference in the scores in the first two half-hour sessions (total 1 h) when the task was done at ambient temperature of 40–45°C. There is a highly significant difference in the second, third and fourth half-hour sessions.

(d) There is correlation between the various personality traits and the scores obtained except that a majority of the subjects who had scores above 170/200 hits under ideal conditions were found to be introverts.

(e) Introverts are better suited for the visual vigilance task than extroverts.

### Recommendations

It is recommended that the duration of visual vigilance task on the radar scope for an ADSO under ideal (ambient temperature 25°C, no

noise stress, etc.) operating conditions should not exceed one-and-a-half hours, and under conditions when the ambient temperature is above 40°C it should not exceed 1 h.

### References

- 1 Davies DR, Fune BS. *Human Vigilance Performance*. New York: American Elsevier, 1969.
- 2 Razmjou S, Kellberg A. Sustained attention and serial responding in heat: mental effort in the control of performance. *Aviat Space Environ Med* 1992;63:594–601.
- 3 Broadbent DE. *Perception and Communication*. London: Pergamon, 1958.
- 4 Eysenck HI. *The Dynamics of Anxiety and Hysteria*. New York: Granger, 1957.
- 5 Caloon RL. Vigilance performance under hypoxia. *J Appl Psychol* 1970;54:69–85.
- 6 Kappaoy WE, Powe WE. Performance decrement at an audio-visual checking task. *J Exptl Psychol* 1959;57:49–56.

After one-and-a-half hours and after one

between performance of the subjects who had scores above 170/200 hits under ideal conditions (no neck rest). Introverts performed better than extroverts. Theoretical speculation that introverts are better suited for sustained monitoring tasks. We have found a positive correlation between intelligence and performance in the present study no

reference in the first two sessions during the task under conditions when there is a highly significant difference in the scores during the two-and-a-half

reaction time of the test to