COMPARATIVE EFFECTS OF 19 STRESSORS ON TASK PERFORMANCE: MAJOR RESULTS OF THE OPERATOR SURVEY

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ABSTRACT

A survey was conducted to determine the opinions of sonar operators concerning the prevalence and judged impact of 19 stressors on various aspects of task performance: vigilance, visual information processing, auditory information processing, reasoning/decision making, perceptual-motor processes, general motivation to perform well, and overall performance effectiveness. The average rank ordering of the stressors by 212 Royal Navy operators with respect to adverse impact on overall effectiveness was as follows (worst listed first): boredom, fatigue, poor display/controls, command pressure, operator overload, poor work station, night watchstanding, heat, noise, lighting problems, minor illness, cold, motion, vibration, motion sickness, air contamination, risky peacetime operations, air pressure, wartime danger. There were differential responses among various subgroups of the operators. Some of the more important details are discussed in this paper.

INTRODUCTION

A survey of 212 Royal Navy sonar operators was conducted for the purpose and employing the methods described by Smith, Mackie, and Wylie (1985). Some of the major results are presented below.

RESULTS

The survey results were analyzed using a variety of statistical methods appropriate to the types of data generated by ranking and rating procedures. (The details of the data analyses are given in Wylie, Mackie, and Smith (1985). The ranking results generally showed that the sonar operators agreed very strongly that various stressors have different impacts on different aspects of performance. Often, however, the stressors were viewed differently depending on the operator's platform, type of sonar, and experience. The operators also rated the frequency of occurrence and the severity of the various stressors very differently depending on these factors. Table 1 summarizes the ranking of the adverse impact of the stressors on overall operator effectiveness by submarine, surface ship, and helicopter sonar operators.

Table 1 RANKING OF THE ADVERSE IMPACT OF 19 STRESSORS ON OVERALL SONAR OPERATOR EFFECTIVENESS (WORST LISTED FIRST)

	SUBMARINE OPERATORS		SURFACE SHIP OPERATORS		HELICOPTER OPERATORS
1	Boredom, monotony	1	Boredom, monotony	1	Fatigue, tiredness
2	Fatigue, tiredness	2	Fatigue, tiredness	2	Boredom, monotony
3	Command pressure	3	Displays/Controls	3	Displays/Controls
4	Displays/Controls	4	Night watchstanding	4	Operator overload
5	Operator overload	5	Command pressure	5	Command pressure
6	Work station design	6	Operator overload	6	Work station design
7	Heat	7	Work station design	7	Vibration
8	Illness	8	Noise	8	Noise
9	Noise	9	Illness	9	Cold
10	Air contamination	10	Motion sickness	10	Lighting
11	Lighting	11	Lighting	11	Heat
12	Night watchstanding	12	Heat	12	Platform motion
13	Cold	13	Platform motion	13	Illness
14	Air pressure	14	Cold	14	Motion sickness
15	Platform motion	15	Air pressure	15	Night watchstanding
16	Motion sickness	16	Vibration	16	Risky peacetime ops
17	Vibration	17	Risky peacetime ops	17	Air contamination
18	Risky peacetime ops	18	Air contamination	18	Threat of enemy action
19	Threat of enemy action	19	Threat of enemy action	19	Air pressure

Space does not permit detailed discussion of the results for all 19 stressors (see Wylie, Mackie, and Smith (1985) for a full report), so the five stressors identified as particularly important by Mackie, Wylie, and Smith (1985) will be discussed.

Boredom, Monotony

Boredom associated with monotonous operating conditions was the stressor most frequently ranked first in adverse impact on overall operator effectiveness. Nearly half of the sonar operators ranked this stress factor first (i.e. "worst") or second in impact on overall effectiveness. The rankings by all operators of the effects of boredom and monotony on each of the seven aspects of sonar operation are summarized in Figure 1. There are

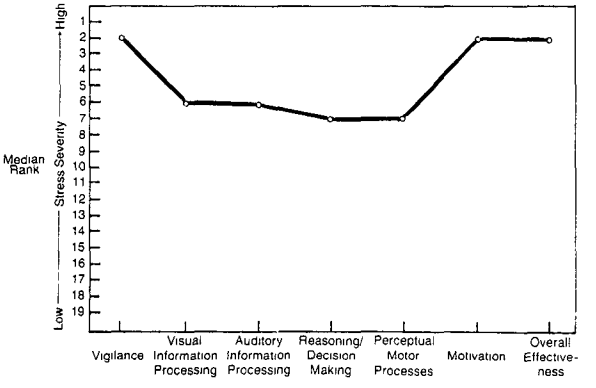

Figure 1. Rankings of BOREDOM

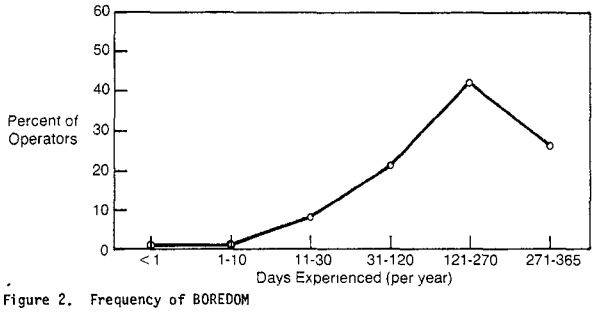

Figure 2. Frequency of BOREDOM

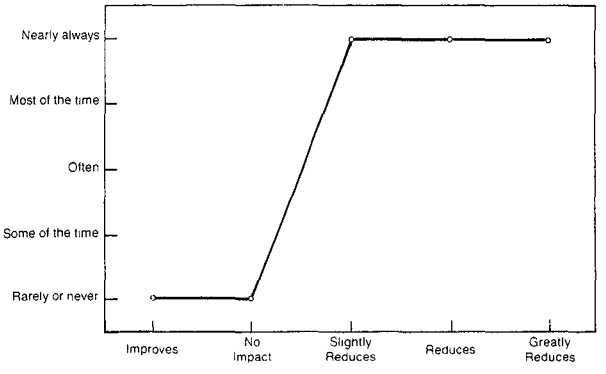

Figure 3. Severity of BOREDOM & FATIGUE

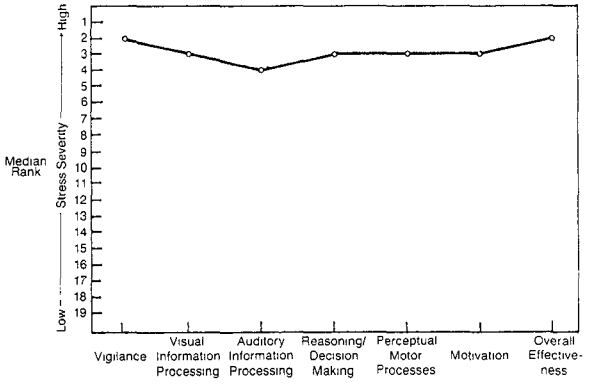

Figure 4. Rankings of FATIGUE

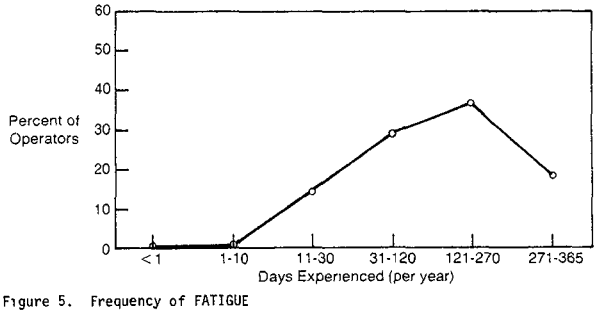

Figure 5. Frequency of FATIGUE

statistically significant differences ($p < .001$) among these rankings. It is evident that the operators judged vigilance and motivation to be most adversely affected by boredom and monotony; the median rank is 2 on each of those scales. It is interesting that although the median ranks were relatively lower on the other four elements of sonar operation, the ranking on "overall effectiveness" was nonetheless very high (median rank 2). This can be interpreted to mean that vigilance and motivation received proportionally greater weights in the sonar operators' evaluation of "overall effectiveness."

The distribution of the responses of all operators among each frequency-of-occurrence category for boredom is shown in Figure 2. There is a strong mode, or peak, in the 121-270 days per year category. Note also the next-most-frequent response category was 271-365 days per year. Boredom/monotony was judged by the operators to occur very frequently indeed, and in fact to occur more frequently than any other stressor except "poor work station design."

The severity ratings of all operators regarding the impact of boredom on effectiveness are summarized in Figure 3. In this figure, the modal (i.e., most frequent) response category (e.g., "rarely or never," "some of the time," etc.) is shown for each of the five sub-questions of the severity section of the questionnaire (i.e., "improves," "no impact," "slightly reduces," etc.) It can be seen that the operators' judgements of the negative impact of boredom were sufficiently strong that the "improves" and "no impact" categories most frequently received "rarely or never" responses, whereas the "slightly reduces," "reduces," and "greatly reduces" categories most frequently received responses at the opposite extreme: "nearly always."

Fatigue, Tiredness

Nearly equal numbers of operators, together comprising nearly 60% of the total group, placed fatigue in the top three ranks with respect to impact on overall performance. Fatigue was not placed in rank 1 as frequently as boredom, but it was ranked very high indeed by the majority of operators, and considerably higher than the other 17 stressors.

The rankings by all operators of the effects of fatigue on each of the 7 aspects of sonar operation are summarized in Figure 4. There are statistically significant differences ($p < .001$) among these rankings. It can be seen that the impact of fatigue was judged greatest on vigilance and on overall effectiveness. However, it is interesting that the judged impact was hardly less severe for the other elements of sonar operation (visual information processing, auditory information processing, etc.). This is in contrast to the rankings for boredom (Figure 1), and suggests that in breadth of impact, fatigue was judged to be more severe. There was strong agreement among operators regarding the impact of fatigue, and there were no statistically significant differences among operators grouped by platform type, Falklands experience, rate, or sonar type.

The distribution of responses of all

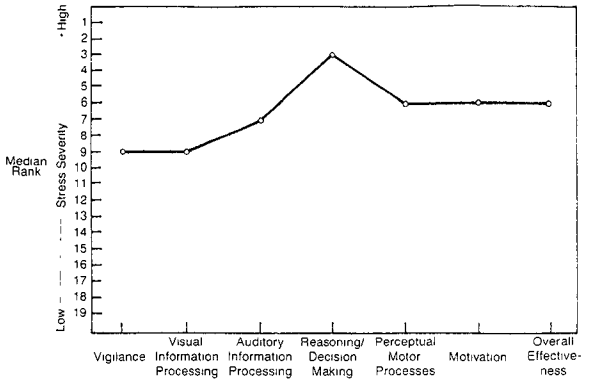

Figure 6. Rankings of COMMAND PRESSURE

operators to the frequency-of-occurrence question is shown in Figure 5. The most frequent response was 121-270 days experienced per year. Clearly, fatigue was judged to occur very frequently. Again, all operators were in substantial agreement; there were no statistically significant differences among operators grouped by platform, Falklands experience, rate, or sonar.

The severity rating responses of all operators regarding the impact of fatigue on effectiveness are summarized in Figure 3. This pattern of modal response is identical to that for boredom, and is considerably different from the other 17 stressors, which were judged to be less severe. Again, there was substantial agreement among the operators: there were no statistically significant differences among operators grouped by platform type, Falklands experience, rate, or sonar type.

Command Pressure

Command pressure was defined for the sonar operators by this statement: "COMMAND PRESSURE to get target information quickly (classification, manoeuvres, etc.)." The ranking by all operators of the effects of command pressure on each of the 7 aspects of sonar operation are summarized in Figure 6 Differences in rankings were statistically significant ($p < .001$). It is evident that the impact of command pressure was judged to be greatest on the reasoning/decision making function, a result identical to the stress associated with operator overload to be discussed next. It was clear from discussions with the sonar operators that command pressure is brought to bear under precisely those circumstances in which operators feel overloaded: during times of target contact, particularly multiple contacts. The median rank for the impact of both overload and command pressure on reasoning/decision making was rank 3. Comparison of Figure 6 to Figure 9 reveals the similarity of the two ranking patterns. There were statistically significant differences ($p < .001$) in the rankings of command pressure by submarine, surface ship, and helicopter operators. This is reflected in the rankings

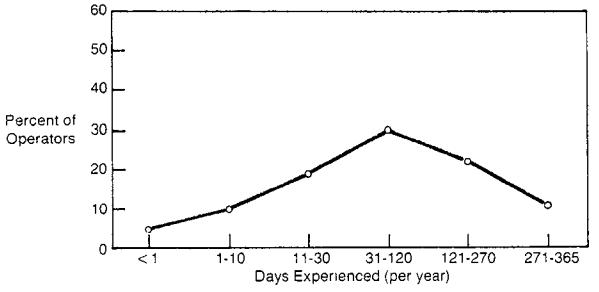

Figure 7. Frequency of COMMAND PRESSURE

shown in Table 1.

The percent of responses in each frequency-of-occurrence category by all operators is shown in Figure 7. The most frequently used response category was 31-120 days experienced per year. There were statistically significant differences ($p < .001$) by platform in response to this question also. The most frequent response for helicopter operators was 11-30 days, whereas the most frequent response for surface ship and submarine operators was 31-120 days. The response distributions indicated that command pressure apparently is felt most frequently by submarine sonar operators.

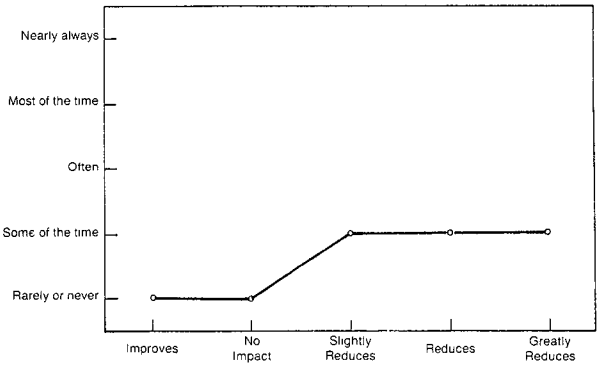

Figure 8. Severity of COMMAND PRESSURE/OVERLOAD

The modal severity ratings by all operators of the impact of command pressure is shown in Figure 8. It presents a pattern that is repeated for many of the stress factors: the effects are judged "some of the time" to have a detrimental impact at each of the three intensities: "slightly reduces effectiveness," "reduces effectiveness," and "greatly reduces effectiveness." There were statistically significant differences ($p < .001$) in the severity ratings by submarine, surface ship, and helicopter operators. Submarine operators judged command pressure to be most severe, surface ship operators were intermediate in their judgements, and helicopter operators judged it to be least severe. Helicopter crews, of course, are typically insulated from higher levels of command by several miles of air space, a factor that was commented upon frequently by operators during group discussions.

Operator Overload

It may seem incongruous that overload should follow so closely in the rankings behind boredom and monotony, but its high standing in the rankings stems from the nature of the sonar operator's job. Boredom is associated with the greatest proportion of the time, during which no targets of interest are held; overload, with that small but very important fraction of the time when contact is held on targets of significance.

The ranking by all operators of the effects of operator overload on each of the 7 aspects of sonar operation are summarized in Figure 9. There are statistically significant differences ($p < .001$) among these rankings.

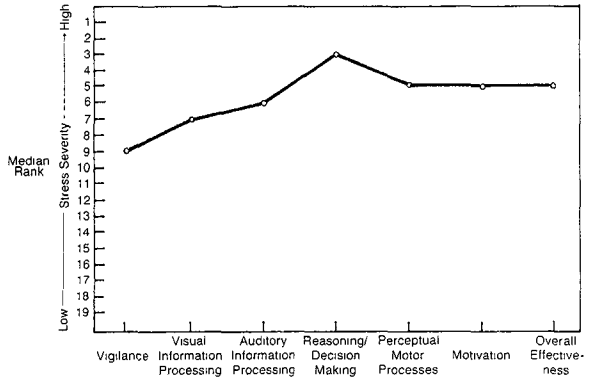

Figure 9. Rankings of OVERLOAD

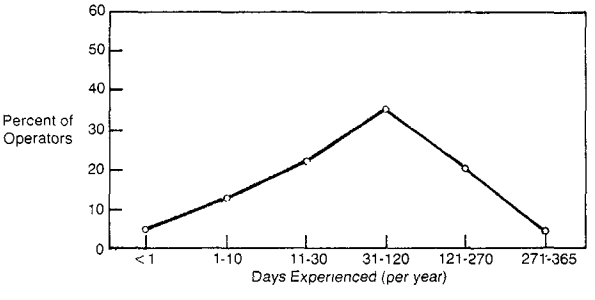

Figure 10. Frequency of OVERLOAD

The distribution of responses by all operators among each frequency-of-occurrence category for overload is shown in Figure 10. There is a strong mode in the 31–120 days experienced per year category. The modal severity ratings of overload by all operators are identical to those of command pressure, and are summarized in Figure 8.

Danger From Enemy Action During War

This stress factor was defined for the sonar operators by the statement: "DANGER FROM ENEMY ACTION DURING WAR may produce a psychological stress that affects sonar operations." Because we expected a substantial number of operators with Falklands experience to be included in the survey, we felt a unique opportunity was available to obtain first-hand reports of the effects of this stressor on performance.

"Danger from enemy action" was by a wide margin the stressor furthest down on the ranking scale, with the most frequent response being rank number 19. The ranking instructions given to the operators indicated that this end of the scale was intended for stressors whose impact was minimal, or "perhaps even helpful" to performance. Numerous written comments and comments made during group discussions indicated the operators judged that the threat of enemy action might improve operator performance in many respects. (Those operators who had not seen action in the Falklands were asked to rate

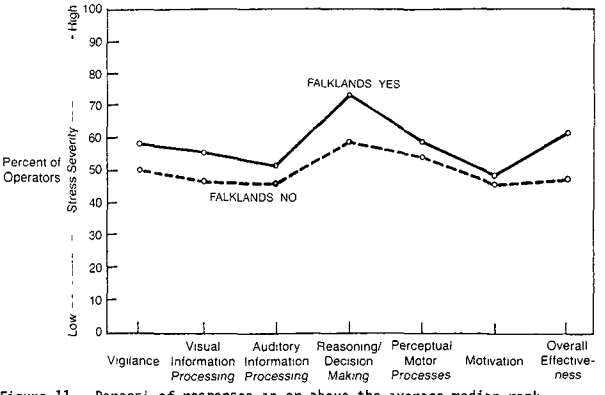

Figure 11. Percent of responses in or above the average median rank (rank 15) by Falklands experience for the stress factor THREAT OF ENEMY ACTION

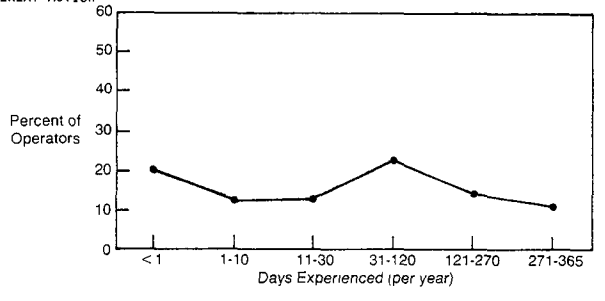

Figure 12. Frequency of WAR STRESS

this factor with respect to the impact they thought it would have).

There was a statistically significant difference ($p < .005$) between the rankings of operators with Falklands experience and those without. Figure 11 shows the percent of responses in or above the average median rank (rank 15) by Falklands experience. It may be seen that those with Falklands experience ranked wartime stress uniformly higher than those who did not have such experience (possibly meaning that those with actual wartime experience found it less helpful than imagined by those without that experience). The differences in ranking among the 7 different aspects of sonar operation

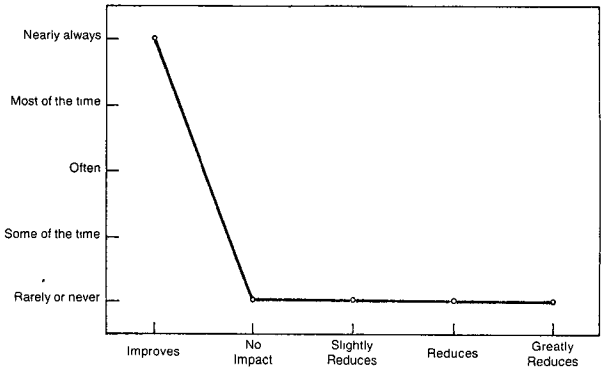

Figure 13. Severity of WAR STRESS

were statistically significant ($p < .005$), and it can be seen that both the groups with and without Falklands experience ranked the impact of wartime stress greatest (i.e., least helpful (?)) on reasoning and decision making.

The percent of responses in each frequency-of-occurrence category by all operators is shown in Figure 12. Many operators commented during group discussions that it was difficult for them to estimate how frequently they would experience psychological stress due to a state of war. A third of the operators with Falklands experience responded in the 31-120 days category, an interval which includes the duration of the Falklands hostilities.

The modal severity ratings by all operators of the impact of danger from enemy action during war on operator effectiveness are shown in Figure 13. In dramatic contrast to the severity ratings for all other stressors, the operators' responses indicated an expectation for improved performance. In fact, the most frequent response was that the effects of war would "nearly always improve" operator effectiveness.

CONCLUSIONS

Boredom, fatigue, command pressure, operator overload, poor displays and controls, and poor work station and personal equipment design were judged by sonar operators of the Royal Navy to be the most significant stressors in sonar operation. The greatest "knowledge gaps" were found regarding those very stressors whose impact is judged to be worst for sonar operation: boredom, fatigue, overload and command pressure (Mackie, Wylie, and Smith, 1985). As a matter of priorities we recommend that future research address development of effective countermeasures to the effects of boredom and fatigue, although overload and command pressure issues should by no means be neglected.

There is a potentially effective countermeasure, often suggested (Wilkinson, 1964; Wylie and Mackie, 1974; NMRDC, 1975; Wagenaar and Sanders, 1978; Wilde and Stinson, 1983) but inadequately tested (particularly for narrowband sonar), that holds promise of reducing the adverse effects of the several factors outlined above. It is fundamentally aimed at increasing probability of detection and correct classification through use of signal injection techniques combined with systematic operator performance evaluation and feedback. We are presently conducting a program of laboratory research to investigate the effectiveness and potential limitations of this approach to countering the negative effects of boredom, monotony, and fatigue. The program will try to establish optimum parameters (e.g., injected signal rates and characteristics), try to determine the practical performance implications of the method, and address potential user acceptance issues and effective responses to them.

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