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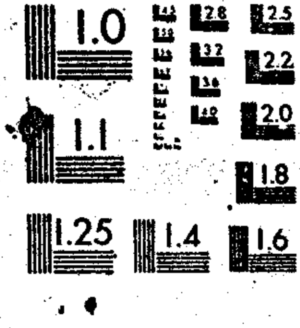

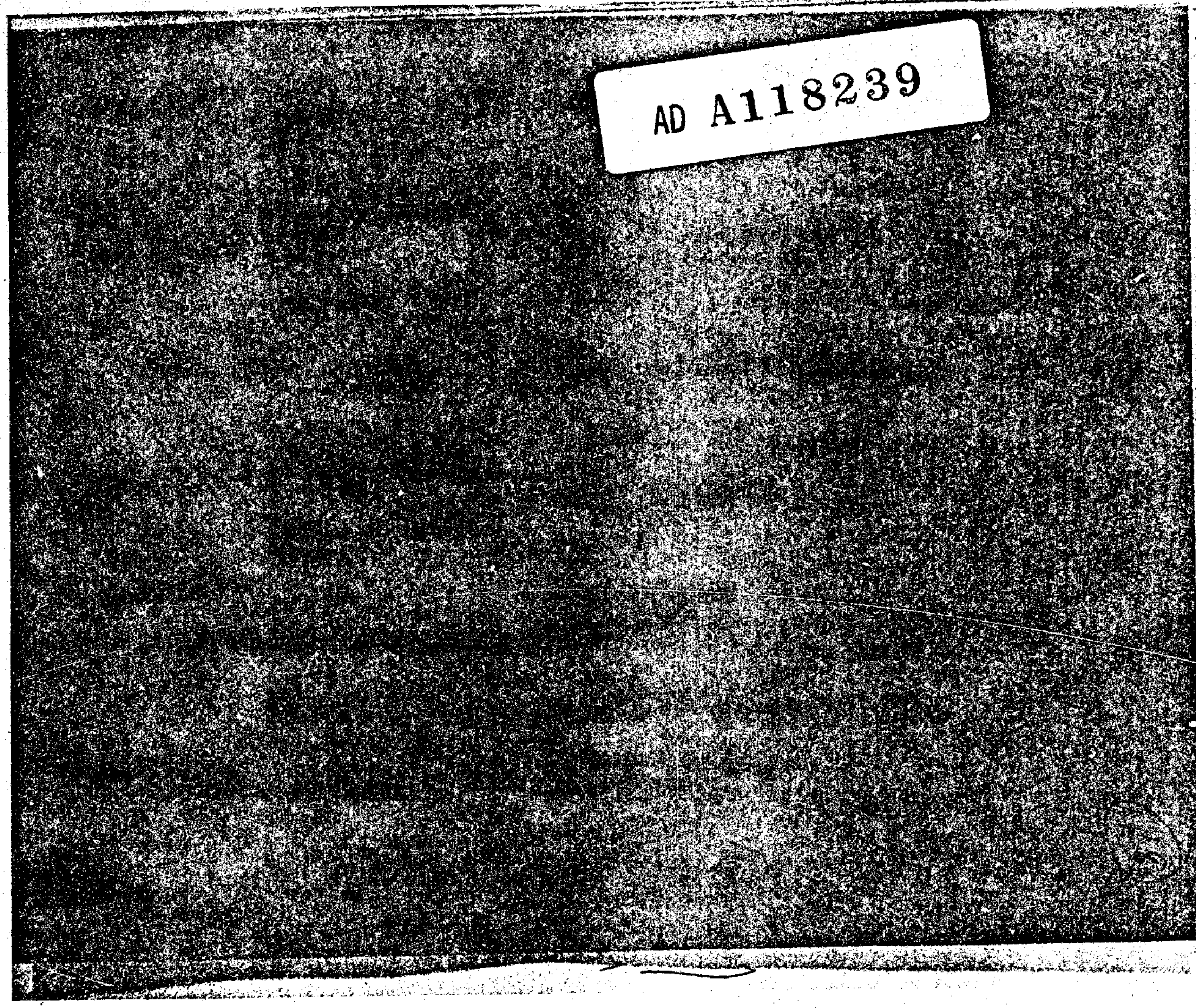

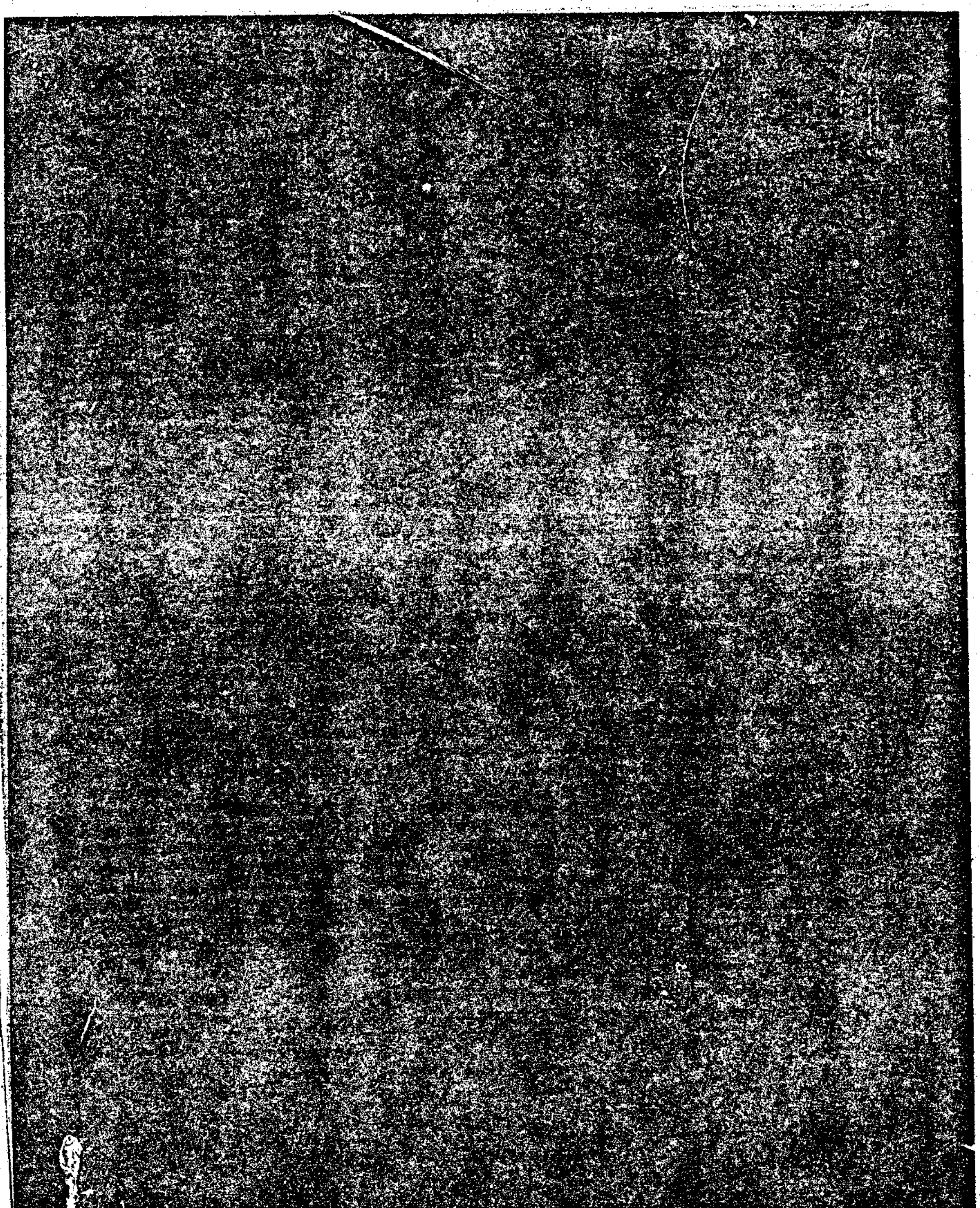

Technical Report Documentation Page

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16. Abstract

The role of the air traffic control specialist (ATCS) in proposed highly automated air traffic systems of the future is currently receiving considerable attention. At the present time, a prevalent conception of the controller's role in such systems is that of a "systems monitor" or "systems manager." Inherent in this view is the belief that the role of the future controller will be less that of an active planner and more that of a passive responder to alternative courses of action presented by the computerized system. Such a change in role has raised concerns that increased controller complacency, inattentiveness, boredom, and reduced readiness to react in emergencies may become serious problems in some of the systems being planned. A complex monitoring task was used to study the effect of complacency on attentional processes. The task was designed to approximate an automated air traffic control radar system. Sixteen experienced ATCS's were tested over a 2-hour session, with half assigned to a subject-controlled and half to a computer-controlled condition. Although the subject-controlled appeared to be generally superior to the computer-controlled condition, the differences in target detection time were not significant. Additional comparisons of ATCS's with non-ATCS's on the radar monitoring task revealed that ATCS's were significantly superior to non-ATCS's in target detection time, number of targets detected, and rated attentiveness. Both groups, however, showed a similar increase in target detection time after 90 minutes of task performance. The results suggest that 90 minutes may be the maximum time that attention can be uniformly sustained in a laboratory monitoring task of this type.

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PERFORMANCE OF AIR TRAFFIC CONTROL SPECIALISTS (ATCS'S) ON A LABORATORY RADAR MONITORING TASK: AN EXPLORATORY STUDY OF COMPLACENCY AND A COMPARISON OF ATCS AND NON-ATCS PERFORMANCE

Introduction.

The role of the air traffic control specialist (ATCS) in proposed highly automated air traffic systems of the future is currently receiving considerable attention. At the present time, a prevalent conception of the controller's role in such systems is that of a "systems monitor" or "systems manager." Inherent in this view is the belief that the role of the future controller will be less that of an active planner and more that of a passive responder to alternative courses of action presented by the computer system. Such a change in role has raised concerns that increased controller complacency, inattentiveness, boredom, and reduced readiness to react in emergencies may become serious problems in the systems being planned (2).

Over the past 5 years, our laboratory has been engaged in a program of research to examine some of these concerns, as well as several others, through the use of a simulated radar monitoring task (5,6,7,8,9,10,11). This task was designed to incorporate some of the basic skills (e.g., sustained attention, continuous scanning activity, minimal information processing) that might characterize future, highly automated air traffic control (ATC) systems. Two of the concerns noted previously (i.e., inattentiveness and boredom-monotony) have already been studied and found to show some relationship to performance decline on this task (5). Another, readiness to react and the time course of emotional recovery to an emergency situation, will be addressed in a study planned for next year.

Of all of the concerns that have been expressed with respect to high levels of automation, the one heard most frequently is that of complacency. In the context of automated systems, complacency refers to a feeling of well-being or security engendered by a system that presumably operates smoothly, efficiently, and quite reliably with minimal controller input. It now seems likely that future En Route systems will be able to process and handle most of the routine situations currently handled by controllers, leaving the controller with the task of simply verifying that those options presented by the computer are appropriate (2,3). This reduced level of controller involvement (relative to existing systems) could easily lead to some major shifts in the task of the controller in advanced systems, and the possibility that these shifts could result in increased controller complacency seems to be a realistic concern.

The present study was undertaken to explore the feasibility of one technique for varying complacency and to determine its effect on sustained attention. In essence, the study compared experienced ATCS's under one of two conditions: (i) a condition in which the subject took a designated action in order to correct departures of displayed target altitudes from assigned limits, and (ii) a condition in which the subject took corrective action only if the computer failed to correct the altitude deviation. It was hypothesized that complacency would be greater under the latter condition and that this would be reflected in a greater decline in attentiveness (increase in detection times).

In addition to studying complacency, the present study, by virtue of the fact that ATCS's were used as subjects, allowed us to compare the general performance level of experienced controllers on our radar monitoring task with the patterns obtained in our previous studies, all of which used subjects with no prior experience or training in air traffic control.

Method.

A. Subjects. Sixteen volunteer ATCS instructors (15 men and 1 woman) participated in the experiment. All were from the Federal Aviation Administration Academy at the Mike Monroney Aeronautical Center in Oklahoma City. Half of the 16 subjects were randomly assigned to the computer-controlled condition and half to the subject-controlled condition. The respective mean ages and years of field experience of subjects assigned to these two conditions were 38.75 years (age), 10.6 years (experience), and 34.75 years (age), 12.6 years (experience). The groups did not differ significantly in either age or years of experience ($p > .05$). All were tested and found to have normal near-point visual acuity (corrected to 20/20 if necessary).

B. Design and Task Apparatus. Task programing and recording of responses were accomplished using a Digital Equipment Corporation (DEC) PDP-11/40 computer. The computer was interfaced with a VT-11 (DEC) 17-inch (43 cm) cathode-ray tube (CRT), which served as the subject's display. The CRT was located in a console resembling an air traffic control radar unit. The stimuli (targets) consisted of alphanumeric data blocks, each representing an aircraft. Data blocks comprised two rows of symbols: the top row, consisting of two letters and three numerals, identified the aircraft, while the bottom row of six numerals indicated its altitude and speed. The first three of these numerals gave altitude in hundreds of feet and the last three gave groundspeed.

A simulated radar sweepline was employed that made one complete clockwise revolution every 6 seconds. A target was updated as to (i) location and (ii) any change in its data block moments after the sweepline passed the target's prior location. Sixteen targets were present at all times; as one left, another appeared on the screen. The critical stimulus or signal to which the subject was instructed to respond consisted of a change in a target's displayed altitude to a value greater than 550 or less than 150. The values of the increases or decreases in altitude were randomly determined, except that the changed altitude value could not be greater than 599 or less than 100. Ten such critical stimuli appeared in each 30-minute period; five occurred in the first 15 minutes and five in the second.

For both subject- and computer-controlled conditions, the subject's initial response was the same and consisted of pressing a button held in the right hand as soon as a critical altitude change was detected. The time between stimulus occurrence and this response constituted the measure of target detection time. In the subject-controlled condition, the button response was followed by the act of holding a light pen over the critical target which, in turn, caused the altitude to revert to its previous within-limits value. If a critical stimulus was not detected within 60 seconds, the data block automatically reverted to its previous value. In the computer-controlled condition, pressing the response button not only recorded detection time, but also served to activate a red indicator light located adjacent to the right side of the screen. This light remained on for 60 seconds. The subject was instructed to use the light pen to correct the altitude departure only if the altitude did not change to a within-limits value before the red light went off. Since a critical target always timed out (reverted to its previous value) 60 seconds after the altitude departure had occurred, the subject's variable detection time plus the 60-second time that the red light was activated ensured that a target always returned to a within-limits value prior to the red light's offset. Target detection times for both conditions were recorded by the computer for subsequent processing.

C. Procedure. On arrival, the subject was taken to the experimental room and an orientation tape played. The orientation explained that this study was one of a series designed to investigate various aspects of highly automated systems. The subject was told that the role of controllers in future ATC systems would likely be quite different from the role of present-day controllers, and that this experiment was being conducted to examine the possible effects of some of these changes. Following this, a 9-point subjective rating scale was administered dealing with present feelings of attentiveness, fatigue, tension, and boredom.

The instructions for the task itself emphasized the necessity of pressing the button immediately upon detection of a critical stimulus. The subject was told that a critical stimulus (any altitude value greater than 550 or less than 150) could occur in any target at any time, regardless of the current altitude values of the targets. It was explained that occasional large changes in altitude would not normally occur in an actual radar system, but that this departure from normal conditions was necessary to insure that all targets would be given equal priority in scanning.

In the subject-controlled condition, he/she was told to initiate an action with the light pen to correct the altitude departure after the button press had been made. In the computer-controlled condition, subjects were told to take corrective action with the light pen only if the computerized system did not act to correct the altitude deviation within the time that the red light was on, i.e., their role was to act as a backup in the event the system failed. As noted earlier, corrective action with the light pen was never necessary, since the altitude changes always reverted back to within-limits values before the offset of the red light. A 7-minute practice period followed the instructions for both conditions.

After the 2-hour task session, the subject completed a second form of the subjective rating scale. This form was identical to the first except that the subject was asked to rate each item, plus one additional item dealing with task monotony, on the basis of how he/she felt near the end of the test period just completed.

Results.

A. Comparison of Computer-Controlled and Subjected-Controlled Conditions. Figure 1 shows mean target detection times across 30-minute scoring periods for the two conditions. Analysis of variance applied to these data revealed a significant main effect for the four 30-minute periods ($F(3/42) = 6.00$, $p < .01$). Although Figure 1 suggests detection times to be slower under the computer-controlled condition, analysis of variance revealed no significant main effect for the two conditions ($F(1/14) = 1.16$, $p > .05$) and no significant conditions by periods interaction ($F(1/14) = 1.41$, $p > .05$). Likewise, there was no evidence of any difference between the conditions in the total number of critical stimuli missed. One subject in each condition missed one stimulus; the rest did not miss any.

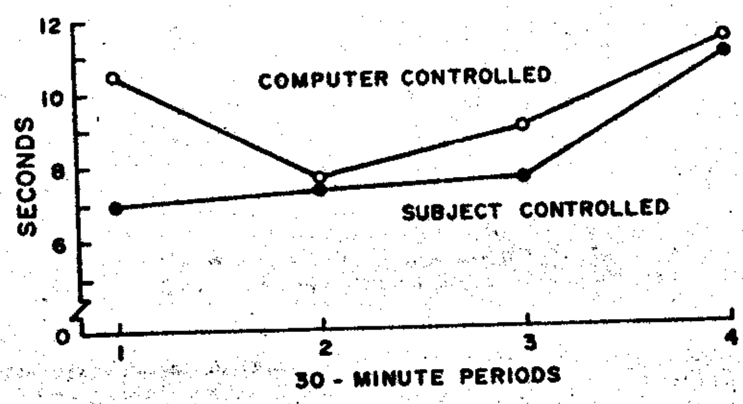

Figure 1. Mean target detection times for the subject-controlled and computer-controlled conditions.

Separate t tests applied to the rating scale data revealed no differences ($p > .05$) between the computer-controlled and subject-controlled conditions at either the beginning or end of the experiment. Statements on the scales corresponding to the mean ratings obtained at the completion of the task period suggested that the subjects felt attentive, more tired than usual, relaxed, indifferent (neither bored nor interested), but felt the task itself to be very monotonous.

B. Comparison of ATCS with Non-ATCS Subjects. Since there were no differences between the two experimental conditions, the data shown in Figure 1 were combined across groups. These combined data were then compared with data from a sample of non-ATCS's. This latter sample was obtained by randomly selecting 15 men and 1 woman from a larger group of 45 subjects used in a previous study (9). Subjects in this earlier study ranged in age from 18-29, were all college students, and were tested under conditions identical to those of the subject-controlled condition employed with the ATCS's in the present study.

A comparison of mean target detection times of the ATCS and non-ATCS subjects is shown in Figure 2. An analysis of variance of these data revealed a significant difference between groups ($F(1/30) = 4.43$, $p < .05$), as well as a significant difference between the four 30-minute periods ($F(3/90) = 12.70$, $p < .01$). There was no significant interaction effect ($F < 1.00$).

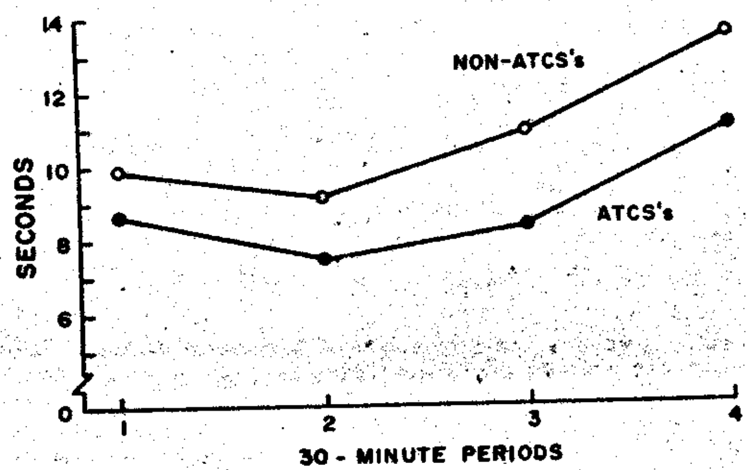

Figure 2. Mean target detection times for ATCS and non-ATCS subjects.

In addition to detecting targets more rapidly, ATCS's also missed fewer targets. Fourteen of the ATCS's missed none of the stimuli, and the remaining two only missed one stimulus. In contrast, five of the non-ATCS's missed two to four stimuli, three missed one stimulus, and eight missed none. A Fisher Exact Probability Test performed on these data indicated the differences between groups to be significant ($\underline{p}$ = .044).

A comparison of the subjective rating scale measures obtained on both groups revealed no differences between groups on any of the presession measures, but significant differences on two postsession measures. ATCS's rated themselves as being more attentive than non-ATCS's ($\underline{t}(30) = 3.19$, $\underline{p} < .01$). There were also differences in rated monotony (but not boredom). The ATCS's found the task to be "very monotonous," while non-ATCS's rated the task as only "moderately monotonous" ($\underline{t}(30) = 2.74$, $\underline{p} < .05$). These differences are not too surprising when one realizes that the requirement to maintain high levels of attentiveness is a necessity for ATCS's in the performance of their jobs. Also, it would be expected that ATCS's would find our radar monitoring task quite monotonous relative to real-life air traffic control work in contemporary systems.

Discussion.

Although target detection times of ATCS's were generally longer under the computer-controlled than under the subject-controlled condition, the difference between conditions was not statistically significant. There are several possible explanations that may account for the lack of significance. The first and most obvious one is that the experimental manipulations designed to increase complacency did not produce the desired effect. The subject-controlled condition used in the present study was essentially identical to that used in most of our previous studies, and the specific intent of this condition was to produce a task that simulated a level of passive, low involvement felt to approximate the task conditions of highly automated air traffic control systems. It may be difficult, if not impossible, to decrease the level of involvement beyond that already inherent in this condition. The second possibility is that complacency may indeed have been greater under the computer-controlled condition, but that controllers, because of their training and experience, may be able to sustain a high level of attention in spite of lower task involvement. If training and experience were relevant variables, the two conditions compared in this study might have differed significantly had non-ATCS's been used as subjects.

That controllers are able to perform a radar monitoring task more effectively and efficiently than subjects without training in air traffic control was clearly shown by the fact that ATCS's detected targets more rapidly, made fewer omission errors, and rated themselves as more attentive than did non-ATCS's. The superiority of ATCS's in speed of detecting targets was particularly striking in that this superiority was maintained across the entire 2-hour session.

Despite their superiority in target detection, however, ATCS's showed a decline in performance during the last 30-minute measurement period that essentially paralleled the decline shown for non-ATCS's. This general decline, known in the vigilance literature as the "decrement function," has been found in all of our previous studies using this task. Since this type of performance decline has been found to occur in auditory vigilance tasks as well (1), it cannot be attributed simply to visual fatigue. Rather, it appears to involve a decline in some central attentional process which is known to promote or induce drowsiness, microsleep episodes, and certain trance-like (highway-hypnotic) conditions (4). Previous research conducted with the present task has shown that this decline in performance is due primarily to an increase in long detection times which, in turn, appear to result from lapses of attention (6,7,10). Because this decline in performance (attention) occurs in ATCS's in spite of their extensive experience with similar displays, our results suggest the possibility that controllers <u>in future systems</u>, in which monitoring may be a major task requirement, may show a like decline in attentiveness after approximately 90 minutes of continuous system monitoring. The magnitude of the decline in detection efficiency shown in our study is not overly impressive in terms of the absolute increase in detection time, but if taken as an indication of decreased alertness, ability to react rapidly and efficiently to an emergency condition or sudden task overload during this period of declining attentiveness could be substantially impaired. The question of how effective <u>is</u> the response to emergency situations during a period of declining alertness will be addressed specifically in a laboratory study currently being planned using a simulation of advanced radar monitoring concepts still in the development phase.

REFERENCES

1. Davies, D. R., and G. S. Tune. 1969. Human Vigilance Performance. New York: American Elsevier Publishing Company, Inc.

2. Department of Transportation - Federal Aviation Administration Fourth Human Factors Workshop on Aviation: Air Traffic Control. May 13-15, 1981. Atlantic City.

3. Guillen, M. A., 1981. AERA: A flight into the future. Science News. 120: 125-126.

4. Shor, R. E., and R. I. Thackray. 1970. A program of research in "highway hypnosis": a preliminary report. Accident Analysis and Prevention. 2, 103-109.

5. Thackray, R. I., J. P. Bailey, and R. M. Touchstone. 1977. Physiological, subjective, and performance correlates of reported boredom and monotony while performing a simulated radar control task. In R. R. Mackie (Ed.), Vigilance: Theory, Operational Performance, and Physiological Correlates. New York: Plenum Publishing Company.

6. Thackray, R. I., R. M. Touchstone, and J. P. Bailey. 1978. Comparison of the vigilance performance of men and women using a simulated radar task. Aviation, Space, and Environmental Medicine. 49: 1215-1218.

7. Thackray, R. I., J. P. Bailey, and R. M. Touchstone. 1979. The effect of increased monitoring load on vigilance performance using a simulated radar display. Ergonomics. 22: 529-539.

8. Thackray, R. I., and R. M. Touchstone. 1979. Effects of noise exposure on performance of a simulated radar task. FAA Office of Aviation Medicine Report No. AM-79-24.

9. Thackray, R. I., and R. M. Touchstone. An exploratory investigation of various assessment instruments as correlates of complex visual monitoring performance. FAA Office of Aviation Medicine Report No. AM-80-17.

10. Thackray, R. I., and R. M. Touchstone. 1980. Visual search performance during simulated radar observation with and without a sweepline. Aviation, Space, and Environmental Medicine. 51: 361-366.

11. Thackray, R. I., and R. M. Touchstone. Age-related differences in complex monitoring performance. FAA Office of Aviation Medicine Report No. AM-81-12.

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