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ASD TECHNICAL REPORT 61-577

THE EFFECTS OF CONFINEMENT ON INTELLECTUAL AND PERCEPTUAL FUNCTIONING

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OCTOBER 1961

AEROSPACE MEDICAL LABORATORY
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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PROJECT No. 1710
TASK No. 171002

AEROSPACE MEDICAL LABORATORY
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This research was accomplished under Project No. 1710, "Training,Personnel and Psychological Stress Aspects of Bioastronautics," Task No. 171002, "Performance Effects of Environmental Stress." It represents a collaborative effort between the Behavioral Sciences Laboratory and the Biomedical Laboratory.

The advice of Dr. W. Dean Chiles, Task Scientist, in the preparation of this report is gratefully acknowledged. We would also like to express our gratitude to the many people who contributed to this research and without whom it could not have been accomplished. Mr David Huber and Mr. John Ferguson, Research Instrumentation Section, Training Research Branch, Behavioral Sciences Laboratory, assembled and maintained the various apparatuses used. The taped tests were prepared by Mr. Thomas E. Toth and Captain John C. Simons. The food was prepared by S/Sgt Robert L. Chisholm. The monitoring burden was shared by A3C Marvin E. Souder, Mr. Robert Simpson, and Mr. Thaddeus J. Rutter II. The efforts of these people are very much appreciated by the authors.

ABSTRACT

Ten subjects were individually confined in a small capsule for 48 hours and required to work intermittently on intellectual, perceptual, and compensatory tracking tasks. Half of the subjects received conventional meals. The other half were provided a diet designed for consumption in a space vehicle. The normal cycle of sleep and wakefulness was maintained throughout the confinement period. Ten control subjects underwent the same conditions except they were confined only while eating or working. Intellectual tasks were: arithmetic, digit memory, confusing sentences, nonsense syllables, verbal analogies, same-opposite word meanings, and logical reasoning. The perceptual tasks were: warning-light monitoring, finding embedded figures, form discrimination, and aerial reconnaissance. No decrement was observed in intellectual performance. Only one perceptual task, aerial reconnaissance, reflected any deterioration in performance. Tracking performance could not be evaluated because of apparatus difficulties. Comparisons revealed no significant effects of diet on performance.

PUBLICATION REVIEW

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THE EFFECTS OF CONFINEMENT ON INTELLECTUAL AND PERCEPTUAL FUNCTIONING

INTRODUCTION

Because payload requirements in extended orbital flights will limit the size of the crew compartment, satellite occupants are likely to be cramped with little opportunity for postural changes. A prolonged period of confinement, previously defined as restriction of movement (ref. 10), that will necessarily involve some degree of sensory deprivation and also, in some instances, isolation, will be imposed on them. The man who goes into orbit will encounter all three of these restrictive stresses, in addition to other conditions that may alter these stress effects. For example, the vibration and acceleration associated with blast-off could lead to an earlier onset of muscular symptoms arising from being in the cramped quarters of the space capsule. However, weightlessness may lessen the stiffness and soreness that ordinarily occur when movement is restricted in the earth environment.

Restriction may affect performance in various ways. It may produce motivational effects that will interfere with performance and perhaps even survival. Possibly the physical inactivity involved will result in physiological changes that contribute to lowered alertness and decreased efficiency. Freedman and Greenblatt (ref. 7) have stated that the stimulation provided by free motility is crucial in preventing hallucinations which they found to occur in as little as 8 hours of sensory deprivation.

To determine what importance should be assigned to confinement stress as a contributor to the overall burden on the man in an orbiting space capsule, much information is needed. Much of the work done to date, some of it involving other stresses, has measured psychomotor and simple perceptual functions: e.g., the cockpit confinement studies of Chiles (ref. 5) and McGehee, Sabeh, and Chiles (ref. 12), and the cabin confinement work of Steinkamp et al. (ref. 15). The effects of stress of confinement on intellectual abilities have not been measured to any appreciable extent, and only limited data has been obtained on the more complex perceptual processes.

Arithmetical computation was a task in the work-rest cycle studies by Adams and Chiles (refs. 1, 2), both experiments involving some degree of confinement. Deterioration was observed in the second study but not in the first. The second study imposed a rather stringent work-rest cycle of 4 hours on, 2 hours off, for 15 days, and the decrement was interpreted as a result of fatigue rather than confinement. Thus, their findings are ambiguous with respect to the effects of confinement.

Confinement studies by Gaito et al. (ref. 9) and Gerathewohl (ref. 10) suggested that the intellectual functions would not decline if the confined subjects did not have to follow a severe work schedule. The former confined their subjects as a group. The latter had an unusually competitive situation influencing their subjects.

Intellectual functioning has been measured in sensory deprivation studies, but these do not adequately simulate anticipated Air Force situations. Intellectual functioning has been tested, with

conflicting results, by Bexton, Heron, and Scott (ref. 3), Freedman and Greenblatt (ref. 7), Holt and Goldberger (ref. 11), Scott et al. (ref. 14), Vernon and McGill (ref. 16), and Vernon and Hoffman (ref. 17).

Experimentation in this general area of research has been somewhat limited and exhibits wide variations in method. As pointed out previously (ref. 13), these variations make interpretation of the data a difficult undertaking. The types of variations are often critical ones. The subject populations sampled have varied widely in background, intelligence, and familiarity with the problem under investigation. The relative contributions of the conditions of sensory deprivation, confinement, and isolation change from one experiment to another and are quite difficult to estimate. The differences in instructions and in environmental conditions also have varied greatly. The duration of the experimental condition imposed on the subjects, ranging from 8 hours to 15 days in the studies referenced, is also important. Finally, some studies involved the confinement of each subject singly, while in others the subjects were confined in groups.

Therefore, the research that has been done leaves many gaps in our knowledge of the effects of confinement on the intellectual functions. These, along with man's perceptual abilities, are the human functions that make him a valuable component in aerospace systems. The specific intellectual activities expected of the man include making reports, following instructions, and handling and analyzing data. The perceptual abilities required of him include detecting and reacting to warning indicators and recognizing and sorting reconnaissance information.

In this study we investigated the effects of 48 hours of confinement on intellectual and perceptual performance. A proposed diet for crews on early space missions was tested both for its effects on performance and its acceptability.

METHOD

Subjects

Twenty male Air Force officer volunteers (age range, 23-40) participated as subjects in the study. They were either pilots or had flying experience. The low number of volunteers prohibited any attempt to control height or somatotype to any extent beyond that exerted by Air Force selection standards. Their heights varied from 5 feet, 6 inches, to 6 feet, 3 inches, and all were approximately of normal weight. Equal numbers of subjects were randomly assigned to each of the four possible combinations of treatments.

Enclosure

The capsule used to confine the subjects was a mockup of a proposed aircraft escape capsule (figure 1). The cockpit dimensions were 5 feet from headrest to footrest and 2 feet from the seat to the canopy. At its widest point the cockpit measured 2 feet, 9 inches. Foam plastic padding and cushions were used at all major contact points and air conditioning was provided. Confined subjects had to remain in the capsule throughout the 48-hour test period, whereas those in the nonconfined groups were in the capsule only while working on tests or eating. Even if an interval between tests was quite brief, the nonconfined subject had to get out of the capsule during the interim period. An intercom suspended from the canopy lid allowed the subject to communicate with the monitor at any time. Windows in the canopy permitted looking to either side of the capsule, but partitions around the capsule restricted the view considerably. Water was stored in a vacuum bottle near the footrest. A relief tube for urination was provided. Defecation was unnecessary as each subject consumed a low-residue diet during the 72 hours immediately prior to confinement.

Diets

Three diets were involved in the nutritional aspects of the experiment. These included the low-residue diet served during the 72-hour pre-test period, the diet designed for orbital flight (test diet), and a conventional diet (control diet). The test and control diets are shown in Appendices A and B, respectively. The test diet consisted of bite-size solids, semisolids, and liquids. Subjects

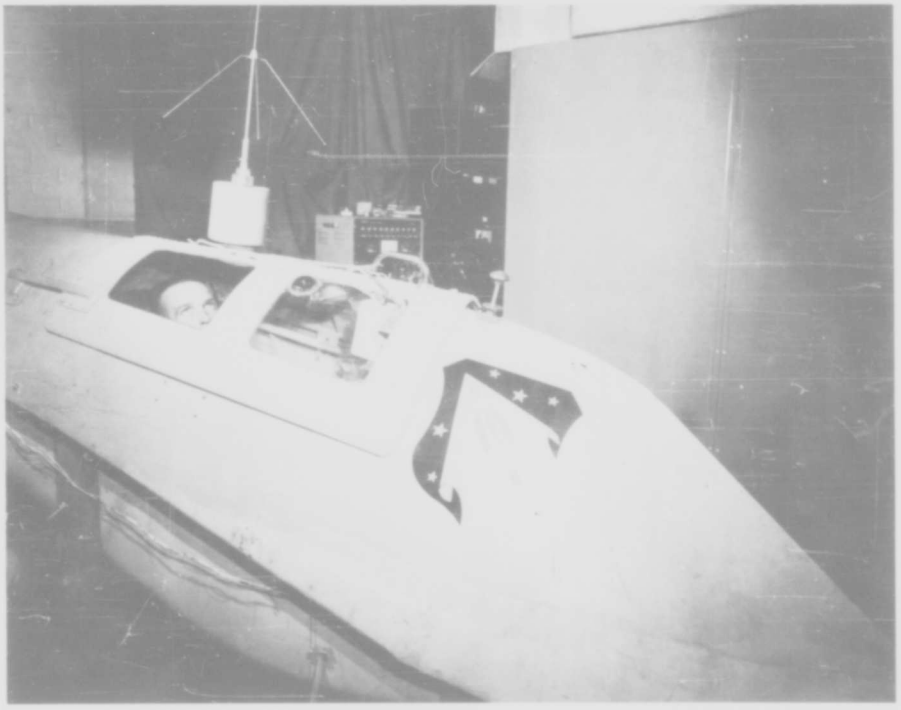


Figure 1. Subject Confined in the Capsule, Taking a Test

on the test diet received their entire daily food supply at the beginning of the 48-hour experimental period and each morning thereafter. The confined subjects on this diet stored their daily rations in an unrefrigerated container in the capsule, and no provision was made for heating the food. Subjects receiving the control diet were served appropriately heated meals on trays at regular mealtimes. Although both diets had a favorable distribution of fat, protein, and carbohydrate, the test diet had a lower caloric value since diminished energy needs are anticipated for short-term orbital flights. The test diet also provided a lower sodium intake than the control diet.

Two questionnaires were used to obtain the subject's impressions of the food they received under the three diets. The first questionnaire, which concerned the low-residue diet, asked the subject: (a) if he had experienced a need to defecate during the experiment and, if so, when, and (b) if he had suffered any gastrointestinal disturbances, e.g., gas pains. The second questionnaire, the Food Preference Questionnaire, was devised to obtain ratings of selected food items (Appendix C) on a 9-point scale ranging from "dislike extremely" to "like extremely." Space for additional comments was provided. This questionnaire was enclosed with each food serving and completed by the subject immediately after eating.

Intellectual Tests

Most of the test instructions were presented on tape. All but two of the tests of intellectual functioning were administered in four forms. The Memory for Confusing Sentences and Paired Associates Learning Tests called for repeated administrations of the same stimuli.

Preceding each intellectual test, sample items were given to assure the subject's understanding of what was required. Subjects were directed beforehand to work as fast and accurately as they could. None of the taped items was repeated.

Each form of the first test, the Arithmetic Test, selected to tap numerical and reasoning factors, consisted of 10 aurally presented problems arranged in order of difficulty from simple computational items to longer ones requiring more thought. Answers were scored as either right (1 point) or wrong (0 point). A bonus point was added if, on a given item, the subject's latency score (for a correct response) fell more than one standard deviation below the mean of the distribution of latency scores for all subjects on that item. The score was the total number of points earned.

The second test, Memory for Digits, was designed to measure a combination of immediate recall and concentration. Series of 3 to 10 digits were presented in order of increasing length to the subject to be repeated without error. He received all series regardless of errors made. The first group of eight series was repeated backwards. The subject's score was the total number of digits in the longest series correctly repeated forward plus the number in the longest series successfully repeated backward.

The third test, Memory for Confusing Sentences, was constructed with the intention of measuring immediate recall of difficult verbal material (e.g., " 'The light is red,' said Ed to Fred. 'The light is red, Ed,' to him said Fred."). The same eight sentences were administered each time, so that some learning effects would occur. The subject's score was the total number of sentences repeated without error.

Same-Opposite Word Meanings, the fourth test in the intellectual group, was aimed at determining level of verbal ability. Twelve word pairs were presented to the subject, each pair to be designated as having the same, opposite, or unrelated meanings. His score was the total number of correct responses.

The fifth test, Verbal Analogies, required verbal reasoning in addition to verbal ability. Each of its forms consisted of ten analogies. Upon hearing the item, the subject had to select the correct one from among the four stated. Again the score was the number of items answered correctly.

Sixth came Paired Associates Learning, involving the taped, aural administration of a list of ten pairs of four-letter nonsense syllables. After the complete list had been heard, the subject was given the first syllable of each pair and asked to respond with the second syllable previously associated with it. The order of the pairs was varied randomly each time the list was administered. The score was the number of correct pairs.

The seventh test was Logical Reasoning. This test was composed of syllogisms and required the subject to judge whether the conclusion drawn from a set of premises was true or false. Each item, consisting of three statements, was presented on a 5 x 8 card, rather than aurally, because of the length and complexity of the statements. There were four alternate forms, each of which contained ten items. The subject was instructed to respond either "agree" or "disagree" to the conclusion offered. The score was the number of correct responses.

Perceptual Tests

The one simple test in the perceptual battery, Warning Light Monitoring, was used to keep a check on monitoring alertness. It required the subject to throw a toggle switch as soon as he perceived a red signal which was presented randomly at intervals of from 1 to 30 minutes. No signals were presented during work on other tasks nor during the scheduled sleep period. A standard timer was used to measure the response latency.

The complex tests of perception were somewhat more demanding. They were designed to measure fine form discrimination and perceptual speed and accuracy. The first one, the Target Identification Test, emphasized fine form discrimination. The subject compared an irregularly shaped, solid-white form, a target, on a card held in his hand with a large number of such forms making up a matrix that was projected on an overhead screen. The tape instructed the subject that,

upon finding the target, he was to announce the quadrant number according to a numbering system displayed on the face of the intercom. His score was the number of seconds taken to find the correct form within a 2-minute time limit. Sixteen targets were presented, some of them appearing in the same matrices.

The second complex perceptual test was the Embedded Figures Test, consisting of four alternate forms with 12 Gottschaldt figures in each. As in the previous test, the items were slide projected. The subject had to select which of five simple figures could be found in a complex figure consisting of various superimposed geometric designs. The instructions emphasized that the simple figure had to correspond perfectly in size, shape, and orientation with the one in the complex figure. The test was scored for accuracy and the response time of the subject within a 3-minute time limit.

The third complex perceptual task was the Aerial Reconnaissance Test. The test consisted of ten slides of aerial photographs taken at altitudes ranging from 66 to 120 miles. The subject was given a checklist of 17 objects that might appear in the photographs (e.g., airports, railroads, lakes, a rocket nose cone, etc.). Actually, two of the objects on the checklist did not appear in any of the slides. The taped instructions told the subject to refer to the checklist and to report by quadrant the objects he spotted. The objects reported were listed by the monitor, who clarified with the subject any responses that involved hedging. The two scores derived were rights minus wrongs (R-W) and number of omissions, i.e., objects present but not reported by the subject. The R-W scoring method was used to penalize the subject for guessing questionable objects in the hope of increasing his score. The checklist and scoring key were made up from a list of recognizable objects found in the pictures by aerial reconnaissance experts.

Dual Compensatory Tracking Task

The tracking task required the subject to maintain a blip at the center of a cathode-ray tube. He had to compensate for a vertical and a horizontal sine-wave forcing function by the rotary manipulation of two knobs, one with each hand. The subject was given a block of five 2-minute trials every 2 hours during the "duty" hours of the confinement period. At the end of each block of trials, a high-pitched, squawking noise was fed through a speaker behind the subject's headrest. The duration of the sound stress was based on the amount of decrement, if any, which the subject's performance exhibited during the preceding trials. Unfortunately, during the course of the experiment, the analog computer used to measure integrated error proved unreliable. However, the remaining subjects were still required to perform the task and were not told that their performance was not being scored. Thereafter, the duration of the sound stress was determined as an approximation based on the unreliable error measure and the particular pattern previously exhibited by the subject being tested, but in no case did the duration of the sound exceed 3 minutes.

Procedure

The subject reported to the laboratory for Monday morning breakfast to receive his first meal of the low-residue diet, and continued to take all his meals there through Wednesday lunch. While on the low-residue diet the subject was instructed not to eat any other food. Black coffee, tea, carbonated drinks, and water were permitted ad libitum. At some time during this period, the subjects to be confined were shown the capsule and given an orientation aimed at reducing any unpleasant anticipations they might have.

Upon entry into the capsule the subject was made as comfortable as possible, and the controls for the air conditioning were pointed out. He was reminded that no reading matter was allowed in the capsule. Instructions were given in the operation of the intercom, the control of the lights inside the capsule, and the opening of the canopy. The subject was assured that he could smoke any time he wished and that there was no restriction on communication with the monitor. He was shown the location of the warning light indicator and the toggle switch for turning it off. This was followed by a demonstration during which quickness of response was emphasized. The operation of the control knobs for the compensatory tracking task was then demonstrated, followed by a practice trial to give the subject the feel of the controls. He was told that both the time and the distance the blip was off-center determined his error score and this in turn affected the duration of the sound stress.

The detailed schedule of the subject's activities during the experimental period is shown in table I. The 48-hour experimental period began at 1400 on Wednesday and ended at 1400 on Friday. For the confined subjects a sleep period of 8-1/2 hours was allowed each night. After getting settled the subject was given a block of tracking trials which were repeated at 2-hour intervals. Following the tracking the perceptual tests were given at 1420. The intellectual tests were given at 1820 on the first day, and at 2205 the last tracking session occurred. The first tracking session for the second and third days began at 0705. The last tracking session on day 2 was at 2105 and on day 3, at 1305. The perceptual tasks and the intellectual tasks were each given twice on day 2, once in the morning and once in the afternoon, and once on day 3. The aerial reconnaissance task was only given twice: at 1530 on day 1 and at 0920 on day 3.

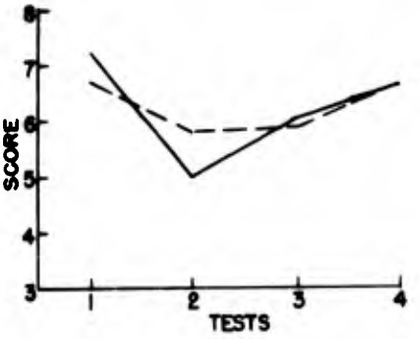
TABLE I

SCHEDULE OF ACTIVITIES DURING
48-HOUR EXPERIMENTAL PERIOD

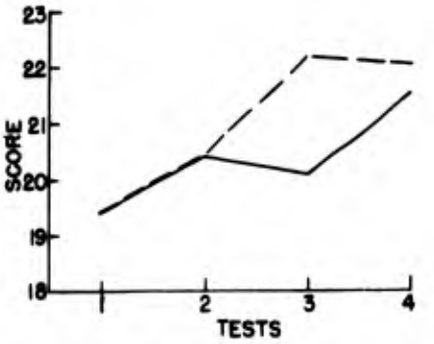
WEDNESDAY		THURSDAY	
1400	Enter Capsule	0700	Reveille
1405	Tracking	0705	Tracking
1420	Target Identification	0720	Target Identification
1455	Embedded Figures I	0800	Meal
1530	Aerial Reconnaissance I	0820	Embedded Figures II
1605	Tracking	0905	Tracking
1700	Meal	1000	Intellectual Tests II
1805	Tracking	1105	Tracking
1820	Intellectual Tests I	1200	Meal
2005	Tracking	1305	Tracking
2205	Tracking	1505	Tracking
2230	Taps	1645	Meal
		1705	Tracking
		1720	Target Identification
		1755	Embedded Figures III
		1905	Tracking
		1920	Intellectual Tests III
		2105	Tracking
		2230	Taps

FRIDAY	
0700	Reveille
0705	Tracking
0720	Target Identification
0800	Meal
0820	Embedded Figures IV
0905	Tracking
0920	Aerial Reconnaissance
1000	Intellectual Tests IV
1105	Tracking
1200	Meal
1305	Tracking
1400	Exit from Capsule

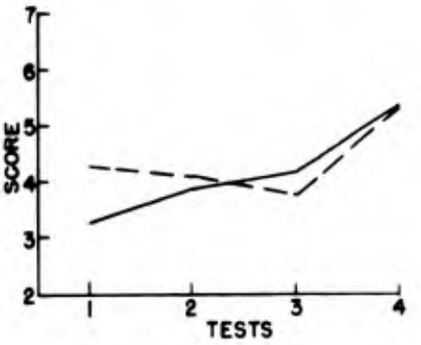
Note: Warning signal was administered at random intervals during periods of inactivity. The duration of the intellectual and perceptual tasks varied according to the subject's rate of progress.



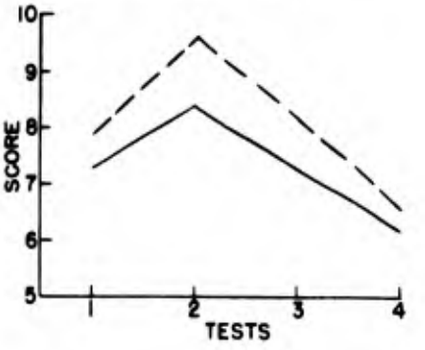
2a. *Arithmetic*



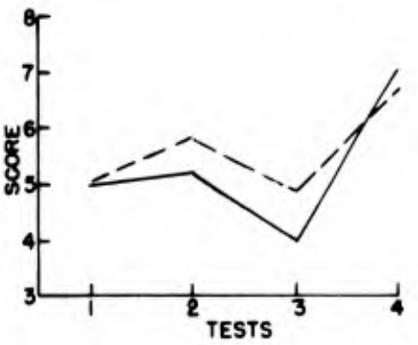
2b. *Memory for Digits*



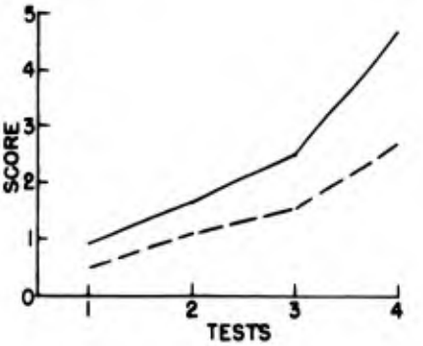
2c. *Memory for Confusing Sentences*



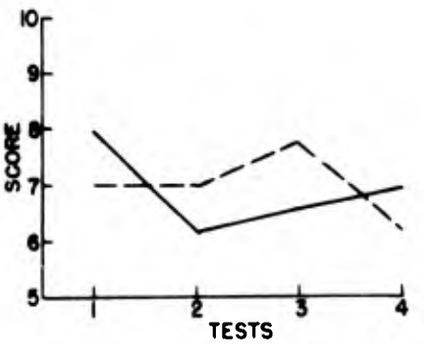
2d. *Same-Opposite Word Meanings*



2e. *Verbal Analogies*



2f. *Paired Associates Learning*



2g. *Logical Reasoning*

Figure 2. Results of the Intellectual Tests for Confined (———) and Nonconfined (-------) Subjects

RESULTS

Intellectual Tests

The trends of the mean intellectual test scores are graphically presented in figure 2. In each case a high score indicates good performance. Because inspection of the data showed that diet had no appreciable effect on intellectual performance, the curves shown are for the confined and nonconfined groups, regardless of diet. The performance curves of the two groups are quite similar. Visual inspection of the data seemed sufficient to determine that no consistent and meaningful differences occurred between the groups on any of the tests with the possible exception of the Paired Associates Learning. A Mann-Whitney U Test of the learning that occurred on that test showed that the greater improvement of the confined subjects was not significant.

Perceptual Tests

Since there were no errors on the Target Identification Test, only the response latency will be considered. The difference between groups consuming test and control diets was subjected to an analysis of variance and was not significant. The median latency for each testing, combining test and control diet groups, is plotted in figure 3. Steady improvement was shown by both the confined and nonconfined groups.

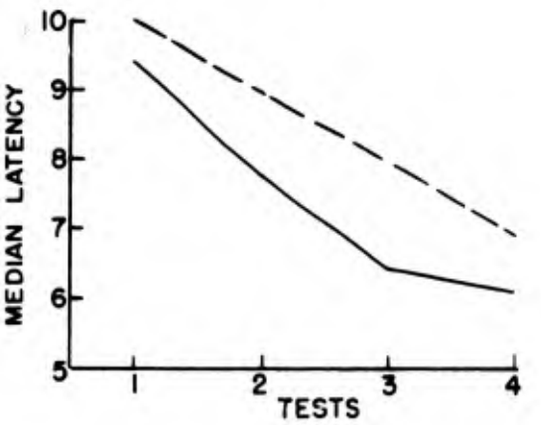
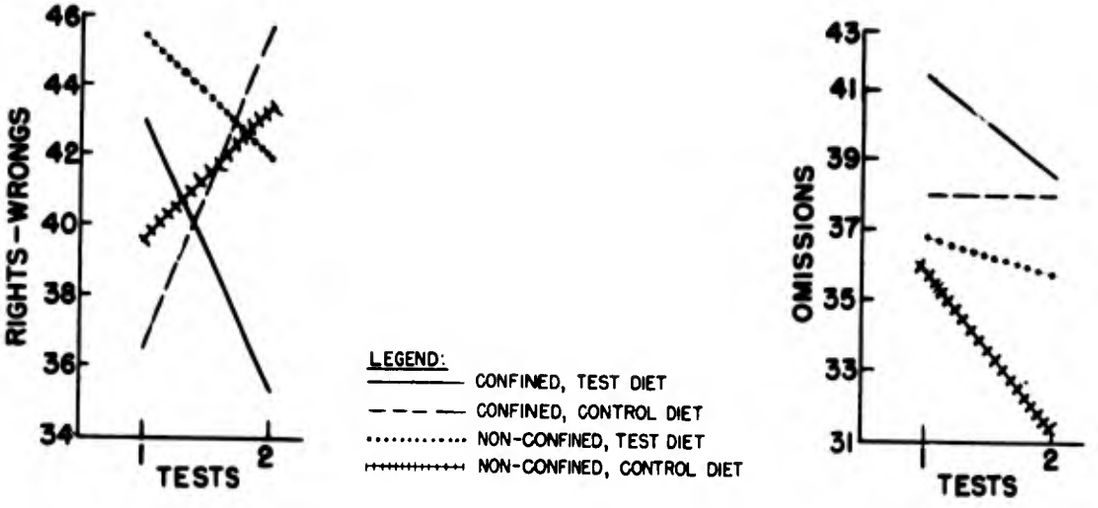


Figure 3. Trend of Median Response Latency Periods for Confined (————) and Nonconfined (-------) Subjects on the Target Identification Test

The single statistically significant finding among all of the tests used in this experiment emerged from the Aerial Reconnaissance Test. An analysis of variance showed that, although the mean scores computed by the R-W formula did not differ significantly, the interaction between diet and test was statistically significant ($p < .005$). The subjects on the test diet, whether confined or not, showed a decrement in performance from the first to the second administration of the Aerial Reconnaissance Test, whereas those on the control diet, confined or not, showed a considerable improvement in their scores (figure 4a). The differences in the mean omission scores (figure 4b) were not significant when tested in the same way, nor did any significant interaction emerge from the analysis.

The performance of both the confined and nonconfined groups on the Embedded Figures Test showed improvement (figure 5), with no apparent effects due to diet.



4a. Rights Minus Wrongs

4b. Omissions

Figure 4. Changes in Scores of Rights Minus Wrongs and Omissions on the Aerial Reconnaissance Test

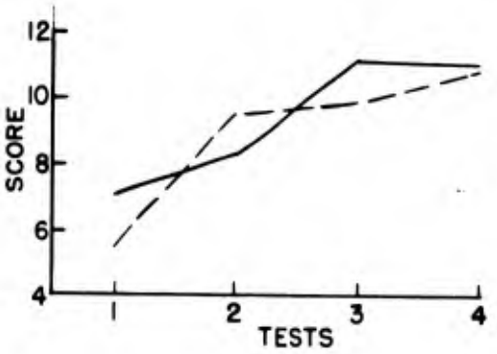


Figure 5. Trends of Scores on the Embedded Figures Test for the Confined (———) and Nonconfined (-------) Subjects

Because of the skewness that typically characterizes monitoring response distributions, medians were used to represent the central tendency of the responses made to the warning light during each of the four time periods (figure 6). Neither the differences between the two confined groups nor those occurring from one time period to another were significant. The elevated median shown for the first time period is primarily the effect of one subject who frequently fell asleep, and whose median response latency for that period was 0.737 minute.

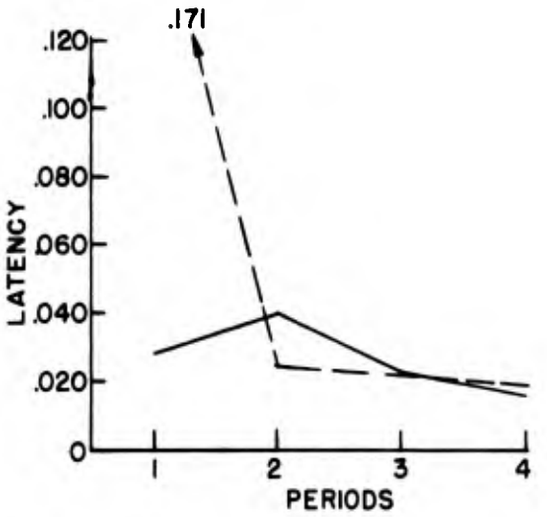


Figure 6. Median Response Latency Periods by Time Segments of Test Diet (————) and Control Diet (- - - - - - -) for Confined Subjects on the Warning Light Monitoring Task

Diet

The physical effects of the pre-experiment, low-residue diet were generally favorable. None of the confined subjects found it necessary to defecate during the 48-hour experimental period. Gastrointestinal disturbances, usually described as gas pains, were reported by 9 confined and 4 nonconfined subjects. However, no subject complained of the severity of this condition. There were no other gastrointestinal problems that were believed to be attributable to either the test or control diets. Test diet subjects, with an average daily consumption of approximately 1800 calories, did show a mean weight loss of 2.15 pounds over the 48 hours, whether they were confined or not. The subjects on the control diet, who consumed approximately 2900 calories per day, experienced a mean gain of 0.4 pound. These differences in weight change may be attributed to the test diet containing fewer calories and, thus, less sodium content. The latter could be expected to reduce water retention.

The test diet subjects assigned lower preference ratings to their foods. The ratings shown on their Food Preference Questionnaires were significantly lower than the ratings of control diet subjects, according to a two-tailed Mann-Whitney U test ($p < .02$). This can, in large measure, be attributed to variety, texture, temperature, packaging, and mode of food service. Comparison of the preference ratings of test diet subjects failed to show any significant difference between the confined and nonconfined groups. A similar comparison of control diet subjects also showed no significant difference.

Qualitative Observations

Behavioral observations taken on the confined subjects yielded some interesting qualitative results. One frequent observation was that the confined subjects tended to become increasingly irritable as shown by remarks about the test items, frequent adjustment of the capsule temperature, and restlessness. Some of the confined subjects on both diets made negative comments about the food. However, this irritability concerning food was not revealed in their mean food ratings. One subject was discovered reading a book, which he knew to be contrary to instructions. Another

subject was found writing on the quadrant chart positioned on the intercom to aid him in computing the answers to the Arithmetic Test items. This same subject also turned on the intercom during the administration of the sound stress presumably to force the experimenter to listen to it as well as he. A third subject made loud clicking noises by repeatedly throwing the warning light toggle switch in the middle of the night when no warning signals were occurring. This was possibly intended to disturb the sleep of the monitor. A fourth subject refused to continue when the lights were dimmed at taps the first night. However, the subject agreed to remain with the condition that more light be allowed in the room. Since this was the first subject, the increased level of illumination was adopted for the remaining subjects.

Though no comments were solicited during the experiment, emotional reactions were verbalized by some of the confined subjects. One particularly noteworthy remark was made by a subject who described the confinement as "oppressive," making him feel like pushing the canopy away. He was a former fighter pilot with extensive experience flying alone. When questioned after the experiment was over, he could offer no explanation as to why this confinement bothered him but flying alone on long missions had not. Remarks were frequently made by others that indicated a feeling of relief was experienced at times when the canopy was opened briefly to pass materials in or out. Confined subjects also tended to complain of muscular fatigue and stiffness or soreness.

DISCUSSION

The absence of any decrement in performance on the arithmetic task in this study probably should not be interpreted as conflicting with the results of Adams and Chiles (refs. 1, 2, 6,) who found a decrement in the arithmetical computations of 5- and 6-man groups confined in a cabin simulator. They suggested that the decrement they found was primarily the product of fatigue resulting from loss of sleep on a 4 hours on, 2 hours off, work-rest cycle during the 15-day study. Wide individual differences were found in their study with two subjects either maintaining their level of performance or improving, while most of the subjects showed decrements in performance.

Gerathewohl (ref. 10) conducted two confinement studies, one for 7 days and one for 10 days, with one and two subjects, respectively. In neither study did the subjects show any consistent downward trend on an addition test performed 1 hour each day.

The absence of deleterious effects of confinement on intellectual functioning in the present study is in general agreement with the study of group confinement by Gaito et al. (ref. 9). Their study involved five tests of intellectual functioning, four of which were quite similar to those used here. They confined six subjects to a compartment for 7 days, but the work-rest cycle was much easier than the one imposed by Adams and Chiles in their later studies (ref. 2). Apparently, intellectual functioning as measured by these sorts of tests does not suffer from the effects of individual or group confinement when there is no severe work-rest cycle involved.

Experiments concerned with sensory deprivation do not exhibit the extent of agreement found among the confinement studies. For example, Holt and Goldberger (ref. 11) tested the intellectual functioning of subjects during an 8-hour period of sensory deprivation. Except for one 10-item test no decrement in performance was found. In contrast to these results, Bexton, Heron, and Scott (ref. 3) found significantly inferior performance of sensorily deprived subjects on 4 of 7 tests. However, Scott et al. (ref. 14), using the same types of tests, found no significant differences between groups. Instead performance improved on nearly all the tests though to a lesser extent for the experimentals than the controls. Associative Learning, a test similar to one used in this study, was one of the tests that did not show a decrement in performance. This result is similar to the findings of Vernon and McGill (ref. 16) and Vernon and Hoffman (ref. 17), who found that the ability to learn lists of adjectives was not impaired by sensory deprivation.

In this study we found no evidence of the inability to concentrate on problems or disorganized thinking reported by some experimenters in studies of sensory deprivation (refs. 7, 14) but not by others (refs. 3, 16, 17). However, with the exception of an experiment by Hauty (reported by Bulban, ref. 4) in which subjects reported bizarre visual experiences, such disturbances have not been reported by investigators of the effects of confinement.

In discussing the results of the perceptual tasks, as Chiles and Adams (ref. 6) have pointed out, the degree of activity inherent in performing a task or set of tasks may sharply affect the findings in studies which, from the subject's point of view, are monotonous. In this respect, the monitoring of the warning light in the present experiment required little activity and had a very simple mode of response. However, the signals on this task were interspersed between periods of fairly high levels of activity on the other tasks, and this may account for the fact that the monitoring task revealed no performance decrement. On a similar task, Adams and Chiles (ref. 2) reported inconsistent trends toward an overall performance decrement accompanied by wide variability. Essentially, the same results were reported by Gaito et al. (ref. 9) on a monitoring task. The 8-hour confinement periods used by Ormiston (ref. 13) and Freedman and Greenblatt (ref. 7) also produced no obvious decrement in performance.

Upon examining our monitoring data, we found a hint of a negative relationship between age and monitoring alertness. However, the rank order correlation of .54 between the ages of the subjects and their overall median monitoring scores proved not to be significant. In general, these studies suggest that monitoring performance holds up satisfactorily in individually confined subjects on an easy work-rest cycle for up to 48 hours, but decrements may result from longer periods of confinement with longer work sessions and shorter rest periods.

Our findings on the more complex perceptual tasks agree with those of a number of other investigators (refs. 2, 4, 6, 15) in showing no performance decrements. This is probably the result of the active participation required of the subjects, which tends to relieve monotony and boredom and, in this manner, serves as a mitigating factor in confinement situations.

The significant interaction between diet and administration on the Aerial Reconnaissance Task must be considered questionable for three reasons. First, there was no obvious relationship between the times at which the task was presented and mealtime. Second, the reliabilities of the test and its scoring method are unknown and may be low. Third, there is no rationale for expecting the test diet to have an effect specific to this task. Therefore, unless future studies confirm this finding, this should be considered a chance result.

The effects of sensory deprivation on the performance of a complex visual task was assessed in the study by Scott et al. (ref. 14). An embedded figures test similar to that of the present study was used and no decrement was found. The improvement we observed on this task was probably the result of some learning that took place in how to approach the task, or perhaps interest in the test increased during later administrations.

The more general behavioral effects of laboratory-induced confinement have not been nearly so dramatic as those observed in some of the subjects undergoing sensory deprivation. This is expected as a consequence of the fundamental differences in the natures of the two situations, as has been discussed in an earlier report (ref. 13). In the literature cited, under both sensory deprivation and confinement conditions, only a few investigators (refs. 3, 6) have reported the increase in irritability that was found in this study.

Intense fear does not seem to occur very frequently in confined subjects. Steinkamp et al. (ref. 15) report that panicking sometimes resulted when a subject lost track of time. Our subjects were well informed concerning the passage of time so this was not the cause of our sole incident of panic, which arose when the first subject of the experiment wanted out after the room had been darkened for the night. He did not disclose at the time why he wanted out, and his responses were vague to post-experimental questioning about the incident.

Although the feelings expressed about the diets were not extreme, the lower acceptability of the test diet as compared to the control diet suggests that more unfavorable reactions might be expected during longer periods of confinement as noted by Finkelstein (ref. 8). Gaito et al. (ref. 9) found rather severe problems of food acceptance (perhaps partially due to group influences) in the form of decreased appetite, nausea, and vomiting. However, these reactions were apparently not severe enough to produce performance decrements. The subjects in the 15-day confinement study by Adams and Chiles (ref. 2) indicated that they felt the high quality of the food was a very important morale factor. In the study by Steinkamp et al. (ref. 15) the acceptance of the diet was enhanced by allowing the subjects to preselect food. Their subjects felt that this boosted their motivation. Some of our subjects suggested that preselection would improve the food service.

SUMMARY AND CONCLUSIONS

In this study we first of all undertook to measure any variations in the performance of selected intellectual, perceptual, and psychomotor tests when an individual is confined for 48 hours in an escape capsule. Second, we sought to determine the acceptability of a proposed diet for use in orbital flights and its effects on performance.

Twenty Air Force officer volunteers acted as subjects, split equally into confined and non-confined groups that were further divided into equal numbers on the test and control diets. They worked periodically on arithmetic, memory for digits, confusing sentences, nonsense syllables, verbal analogies, same-opposite word meanings, logical reasoning, embedded figures, form discrimination, aerial reconnaissance, and dual compensatory tracking. Also, warning light monitoring was required throughout the time period except when working on tasks. Food acceptance was measured by ratings of foods in a questionnaire.

Confined subjects were required to remain in the capsule throughout the 48 hours, whereas those not confined stayed in the capsule only while working. A normal sleep period began at 10:30 and ended at 7:00. Defecation need was adequately reduced by a low-residue diet given for 3 days prior to the experimental period. The test diet provided cold food presented in the forms of liquids, semisolids, and bite-size solids. This diet was lower in calories than the control diet but was nutritionally adequate.

With one exception, there were no significant differences between the performance trends of the treatment groups. The exception was the unexpected finding of a statistically significant interaction between diet and changes in score from the first to the second administration of the aerial reconnaissance test. We believe this to be a chance result. With respect to food, the mean rating made of the test diet was significantly lower than that of the control diet. The test diet subjects showed a small mean weight loss whereas the latter showed a small mean weight gain.

These findings were examined in the light of results obtained by other investigators and the following conclusions were reached:

1. Individual, close confinement for 48 hours apparently has no appreciable effect on intellectual functioning, as measured by items similar to those of standard intelligence tests.

2. Perceptual speed and accuracy and form discrimination appear to be readily maintained under confinement conditions.

3. Warning light monitoring does not seem to suffer during confinement.

4. Confinement generally brings about an increase in irritability in the subject that may promote the expression of undesirable behavioral tendencies normally kept under control.

5. Neither bizarre behavior nor performance decrement are so likely to occur in confined subjects as in sensorily deprived subjects. However, intense fear or panic may occur occasionally.

6. Temporary exposure to foods with less acceptability than conventional foods is not likely to produce any appreciable decrement in performance.

7. Confinement may or may not affect food acceptance. This seems to depend on such factors as variety, texture, temperature, packaging, and presentation of food, as well as social influences that might occur in group studies.

8. Whether or not the individual is confined, optimum food service should permit subjects to preselect the food items, include warm foods, and provide variation in texture and consistency.

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APPENDIX A

TEST DIET PER MAN PER DAY

SAMPLE DAY'S MENU

Food

American Cheese Sandwich
Beef Cubes
Ham Cubes
Tomato Juice
Pineapple Juice
Applesauce
Apricot Sauce
Fruit Bars
Brownies
Caramels
Chocolate Squares
Mints
Chocolate Milk

Nutritive Value

Calories	-	2040
Protein	-	76 gm
Fat	-	80 gm
Carbohydrate	-	254 gm

Plus

3 Liters of Water per Day

APPENDIX B

CONTROL DIET PER MAN PER DAY

SAMPLE DAY'S MENU

Breakfast

Tomato Juice
Rice Krispies — Milk
Scrambled Eggs — Canadian Bacon
Toast
Butter — Jelly
Coffee

Lunch

Vegetable Soup — Crackers
Hamburger
Tossed Salad — Olives
Bread — Butter
Strawberries — Cookies
Milk — Coffee

Dinner

Fruit Cup
Steak
Green Peas — Baked Potato
Lettuce Wedge — French Dressing
Roll — Butter
Brownies
Milk — Coffee

Nutritive Value

Calories	-	3200
Protein	-	120 gm
Fat	-	175 gm
Carbohydrate	-	285 gm

Plus

3 Liters of Water per Day

APPENDIX C

FOODS USED IN PREFERENCE RATINGS

Control Diet

Wednesday Dinner:
- Pork Chop
- Sweet Potato

Thursday Breakfast:
- Hard-Cooked Eggs
- Canadian Bacon

Thursday Lunch:
- Macaroni and Cheese
- Hamburger
- Strawberries, Frozen

Thursday Dinner:
- Fruit Cup
- Buttered Peas
- Brownies

Friday Breakfast:
- Scrambled Eggs
- Milk

Friday Lunch:
- Cream of Tomato Soup
- Swiss Cheese Sandwich
- Spiced Peach

Test Diet

Wednesday:
- Peppermint Candy
- Fruit Bars
- Applesauce
- Tomato Juice
- Roast Beef Sandwich

Thursday:
- Chocolate Milk
- American Cheese Sandwich
- Apple Juice
- Turkey Cubes
- Beef Cubes

Friday:
- Caramels
- Orange Juice
- Brownies
- Apricot Sauce
- Ham Cubes

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