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# INVESTIGATION OF THE EFFECTS OF VIBRATION ON DIAL READING PERFORMANCE WITH A NASA PROTOTYPE APOLLO HELMET



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*JOINT NASA/USAF STUDY*

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# INVESTIGATION OF THE EFFECTS OF VIBRATION ON DIAL READING PERFORMANCE WITH A NASA PROTOTYPE APOLLO HELMET

*RICHARD W. SHOENBERGER*

# Foreword

This study was supported under National Aeronautics and Space Administration Defense Purchase Request R-58. Mr. Harris Scherer of the NASA Manned Spacecraft Center, Houston, Texas requested the evaluation of the prototype Apollo helmet with respect to dial reading performance during vibration. Mr. Scherer also made available the helmet and its related equipment, which were used throughout the experiment.

The research described in this technical report was conducted in the Vibration and Impact Branch, Biodynamics and Bionics Division, Biomedical Laboratory of the Aerospace Medical Research Laboratories, under Project 7231, "Biomechanics of Aerospace Operations," Task 723101, "Effects of Vibration and Impact." Work on this study was begun in December 1965 and completed in March 1966.

The author is indebted to Mr. R. E. Lewis of the University of Dayton Research Institute, Dayton, Ohio for his invaluable assistance throughout the experimental portion of the research.

This technical report has been reviewed and is approved.

WAYNE H. McCANDLESS
Technical Director
Biomedical Laboratory
Aerospace Medical Research Laboratories

# Abstract

Dial reading performance while wearing a NASA prototype Apollo helmet was investigated during short duration whole-body sinusoidal vibration. The subjects were in the semisupine position so that the force of gravity acted through the X-axis of the body, with the vibration acting in the X-axis in one experiment and in the Y-axis in another. In each study, dial reading was assessed (subject and dial vibrating) at 6, 11, and 15 Hz when the helmet was worn either with or without a helmet liner. The vibration intensity was $\pm 1.2$ G in the X-axis experiment and $\pm 0.9$ G in the Y-axis experiment. Static control measurements were also made both with and without the helmet. The results showed significant decrements in dial reading performance during vibration which were differentially related to direction of vibration, frequency of vibration, and to combinations of liner versus no liner with the three frequencies. The results further indicated that the effects of different directions and frequencies of vibration while wearing the Apollo helmet were quite similar to those found in previous studies under the same conditions using a Mercury helmet without a face plate. However, the data suggested that performance was somewhat poorer during both vibration and static conditions while wearing the prototype Apollo helmet. This is probably the result of visual interference produced by the curvature of the helmet face plate and by small scratches and blemishes on the face plate of the particular helmet used in this study.

# SECTION I.
# Introduction

Extensive investigations of the effects of vibration on dial reading performance have been conducted by Taub (ref 2). In his studies the subjects were in the semisupine position and, in three separate experiments, the vibratory force was directed through the X, Y, and Z axes of the body. Additional parameters that were varied in each of these vibration modes were: frequency of vibration, amplitude of vibration, difficulty of dial reading task, and conditions of helmet restraint. Throughout this series of studies the subjects wore a Mercury helmet from which the face plate had been removed. Thus, the helmet presented no visual encumbrances with respect to the dial reading task.

The present studies were undertaken to compare dial reading performance while the subject was wearing a prototype Apollo helmet (which does introduce visual encumbrances), with the results that Taub obtained in the studies described above. The frequencies used in these investigations were the same as Taub used (ref 2), and the amplitudes were those that he determined were sufficient to produce decrements in performance but not so severe as to produce undesirable symptoms or fatigue effects within the durations of exposure used. Only the more difficult dial reading task was employed, since Taub's work had shown that the easier task was not particularly sensitive to vibration effects. The present experiments were limited to the X and Y axes of vibration input, with the subject in the semisupine position.

## SECTION II.
# Method

### SUBJECTS

The subjects were seven physically qualified Air Force military personnel (volunteer members of a medically monitored vibration panel). Their ages ranged from 19 to 43 years. All subjects had near vision of 20/30 or better in both eyes. Six subjects participated in the X-axis experiment, which was conducted first. Five of these six subjects also participated in the Y-axis experiment, plus a sixth subject who had not been involved in the X-axis study.

### APPARATUS

The helmet used in this experiment was a prototype Apollo helmet furnished by the NASA Manned Spacecraft Center. This particular helmet had been used in impact tests and therefore had some small scratches and blemishes on the visor. Thus, whatever visual interference the visor introduced was a combination of factors intrinsic to its design (eg, its curvature and the material from which it was made) and the imperfections noted above.

The vibration device and the dial reading apparatus are described in detail in reference 2 and only brief descriptions will be included here. The vibration device was a Western Gear mechanical shake table, capable of producing sinusoidal vibration in either vertical or horizontal directions. The shake table was fitted with an adjustable plate couch that supported the subject in the semisupine position. An integral part of the couch was the restraint system, which consisted of a six-point chest harness, thigh and abdomen straps, ankle straps, and adjustable side plates for the areas from the knee to the hip and from the elbow to the shoulder. Also fastened to the couch were two clamps that rigidly restrained the helmet in the X and Y axes. Helmet movement in the Z-axis was not completely eliminated, since the clamps allowed the helmet to slide in this direction. Figure 1 shows the subject restrained in the couch with the helmet on.

The dial reading apparatus consisted of panels made from photographs of twelve circular dials arranged in four columns and three rows. Only the 400 range (difficult) dials were used, since Taub's work had shown that they were more sensitive to vibration effects than the 50 range (easy) dials. Each dial was 7.11 cm in diameter and was composed of white markers and numerals on a black background. The panels were constructed from a basic set of 95 different pointer settings, and each panel contained three pointer settings in each of the four quadrants. There was a total of 25 different panels with twelve dials each. The panels could be individually clamped to the back of a display box, which had a transparent window in the front. The subjects could view the panel only when the interior of the box was illuminated by ten 25-watt incandescent bulbs located inside the box. The box was mounted to the vibrating platform of the shake table by means of a rigid framework (shown in figure 2), providing essentially the same vibration input to both subject and display. The distance between the subject's eyes and the dial panels was approximately 71 cm. The brightness of the white dial markings was approximately 26 millilamberts, and the black background was one-tenth as bright.

An intercommunication system made possible continuous communication between the subject, experimenter, and control operators and also allowed the subject's verbally reported dial readings to be tape recorded.

### VIBRATION PARAMETERS

Two separate experiments were conducted, one with the vibratory force acting parallel to the

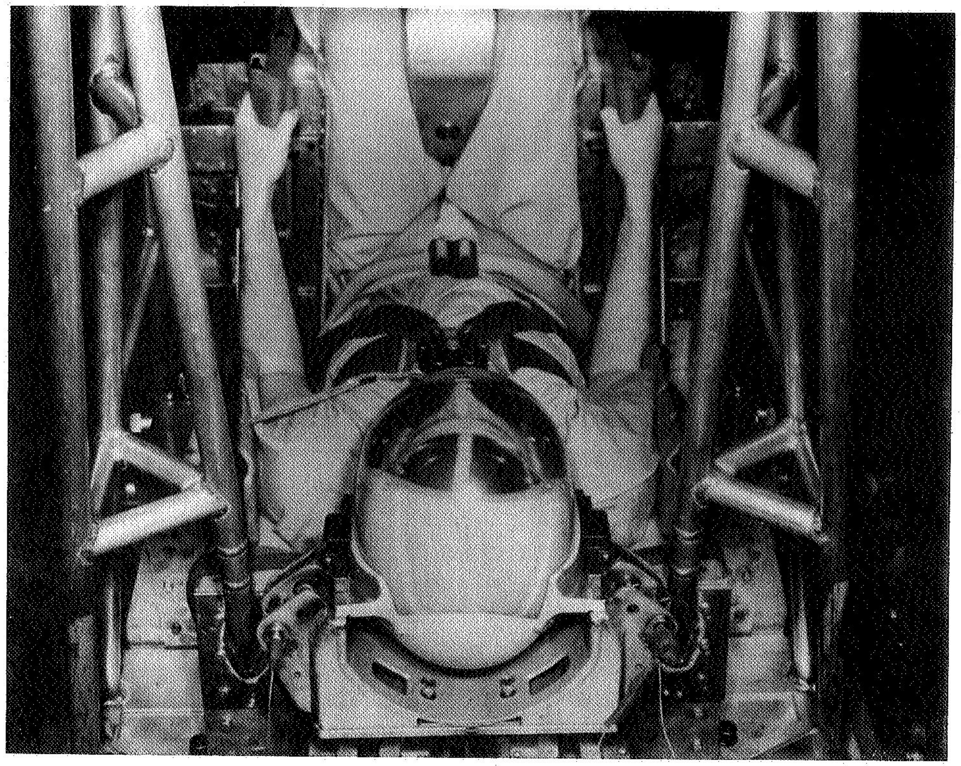

**Figure 1. Subject, test couch, helmet with the liner in place, and restraint system**

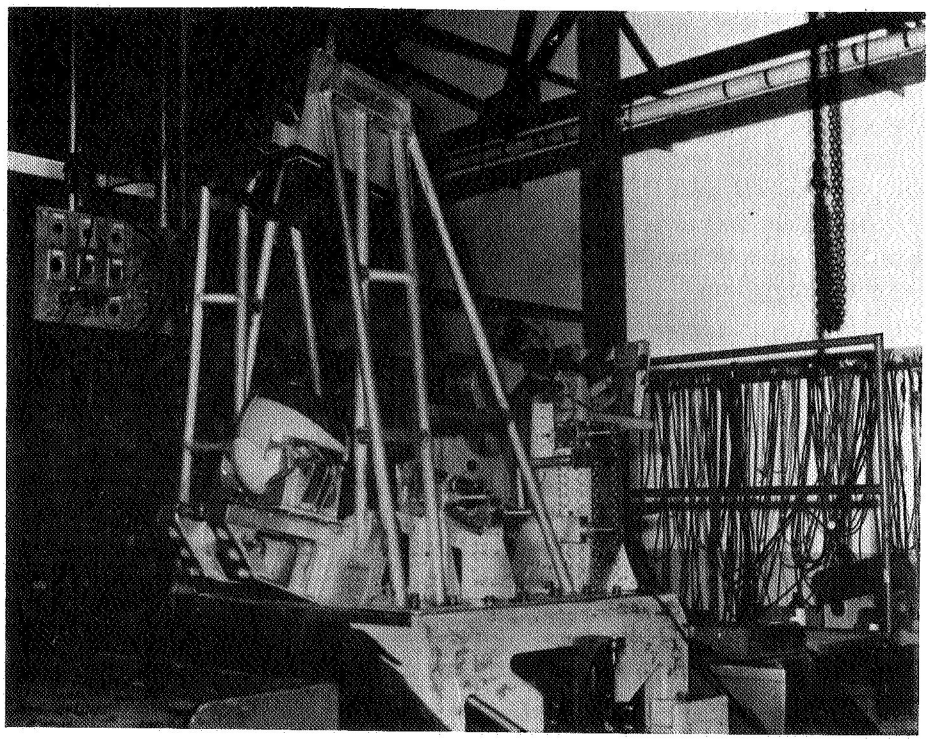

**Figure 2. Vibration table, test couch, helmet, and dial panel box**

subject's X-axis and one with it acting parallel to his Y-axis. Thus, with the subject in the semisupine position the vibration intensity was $+1\ G_x \pm 1.2\ G_x$ for the X-axis study and $+1G_x \pm 0.9\ G_y$ for the Y-axis study. In both studies the frequencies employed were 6, 11, and 15 Hz. The duration of each vibration exposure was determined by the time required to read the twelve dials on a panel, and therefore varied for each run. In no instance, however, did the duration of a vibration run exceed 120 seconds.

## PROCEDURE

The training and testing procedures were essentially the same as Taub used. Some differences were necessary to obtain static control data, both with and without the helmet, to determine whether or not the helmet face plate interfered with dial reading performance when there was no vibration.

Before the actual test sessions began, each subject received three practice sessions with the dial reading task. During the first practice session, the overall experimental plan was outlined for the subject. He was then shown the dial panels and was told that the dial markers were five units apart and that he was to interpolate between the markers in order to read the dials to the nearest unit. The subject was instructed to read the dials as accurately as possible and was told that he would have as much time as necessary to read all twelve dials. He then made a series of practice dial readings, but these were not in the test couch or with the actual display box.

In the second practice session the subjects performed the dial reading task while restrained in the test couch and with the dial panels being exposed in the display box. Practice was given both with and without the helmet, and both with and without the helmet liner in place, so that the subjects would be familiar with all of the helmet configurations that would be represented in the actual test sessions.

During the third session subjects received dial reading practice in an arrangement exactly the same as the test procedure, except that a low-level vibration input ($\pm 0.5$ G) was used. The sequence followed for this practice session and for each test session was: (a) fitting and restraining the subject in the test couch, (b) practice with sample dial panels, (c) static test without helmet, (d) static test with helmet, (e) three vibration runs (one at each frequency), (f) static test with helmet, and (g) static test without helmet. During the static tests with the helmet, the helmet liner was either in or out corresponding to whether or not the vibration runs were made with or without the liner. This testing sequence was followed for both the X-axis and the Y-axis investigations.

Since Taub's studies provided comparison data on dial reading performance during vibration while wearing a helmet that introduced no visual interference and since vibrating subjects in the semisupine position requires some form of head protection, a without-helmet vibration control condition was not included.

In each study a treatments by subjects design was used in which each subject experienced all of the experimental conditions. There were two testing sessions in each experiment, one with the helmet liner in the helmet and one with it removed. The order of presentation of the liner conditions was counterbalanced, with half the subjects tested in session one with the liner in place and in session two with it removed, and the other half tested in session one with the liner removed and in session two with it in place. The order of presentation of the three frequencies within a session was randomized. Counterbalancing and randomizing procedures were also employed during the training sessions to control for possible order of presentation and learning biases.

## SECTION III.

# Results and Discussion

### X-AXIS STUDY

Error scores for the dial reading task are expressed as a percentage of the maximum number of errors possible (eg, if six of the twelve dials on a panel were read incorrectly, the error score would be 50%). For the vibration conditions, mean error scores for total errors (any deviation from the correct reading) and gross errors (any deviation of 3 or more from the correct reading) are presented in table I and figure 3. Also shown in figure 3 and in table II are mean error scores for the static control conditions. Variations in these control measurements, as a result of whether the readings were made before or after the vibration runs or with or without the helmet liner in place, were small and nonsystematic. Therefore, they were pooled into one mean for each of the two control conditions and each type of error (as given in table II).

Inspection of the data presented in figure 3 and table I indicates that for total errors the liner made little difference in dial reading performance, but performance does seem to vary according to frequency. An analysis of variance (ref 1) was performed on the total error scores for the vibration conditions. As shown in table III, the only significant F-ratio produced in this analysis was for frequency, supporting the impressions resulting from inspecting the data.

TABLE I

MEAN ERRORS (PERCENT) FOR EACH VIBRATION CONDITION
(X-AXIS)

| *Criterion* | *Liner* | *6 Hz* | *11 Hz* | *15 Hz* |
|---|---|---|---|---|
| Total Errors | With | 72.22 | 83.30 | 81.88 |
| | Without | 68.06 | 87.46 | 76.39 |
| Gross Errors | With | 20.82 | 44.40 | 47.23 |
| | Without | 19.41 | 58.31 | 29.16 |

TABLE II

MEAN ERRORS (PERCENT) FOR THE STATIC CONTROL CONDITIONS
(X-AXIS)

| *Criterion* | *Without Helmet* | *With Helmet* |
|---|---|---|
| Total Errors | 22.24 | 33.65 |
| Gross Errors | 4.16 | 2.08 |

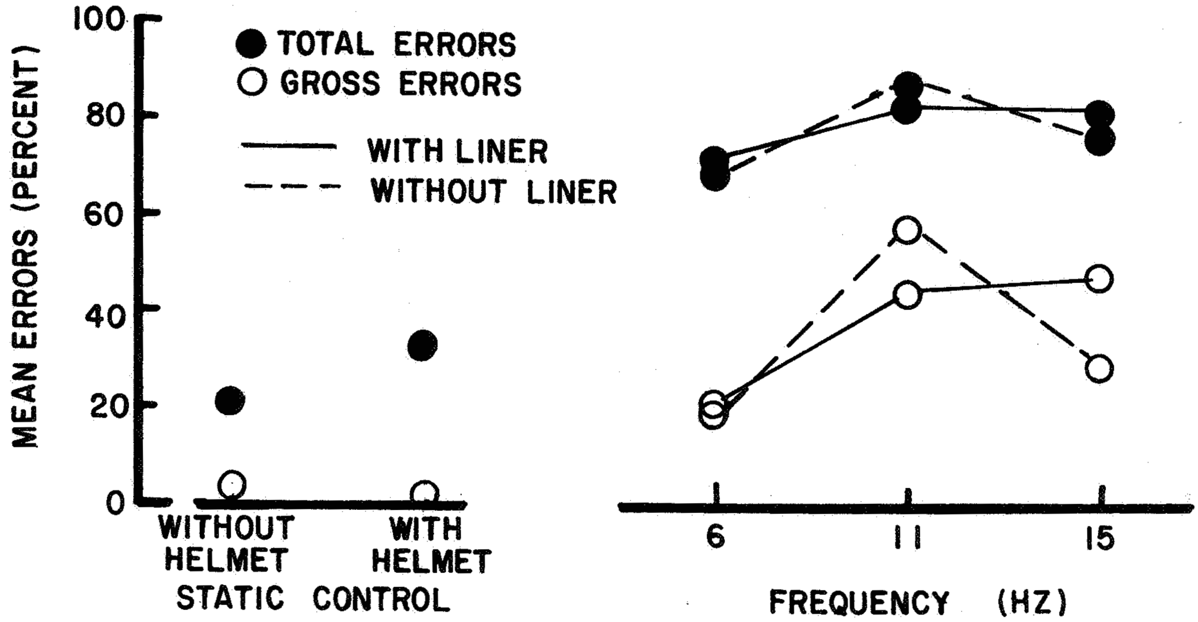


**Figure 3. Dial Reading Performance During 1 $G_x \pm 1.2$ $G_x$ Vibration, with Prototype Apollo Helmet**

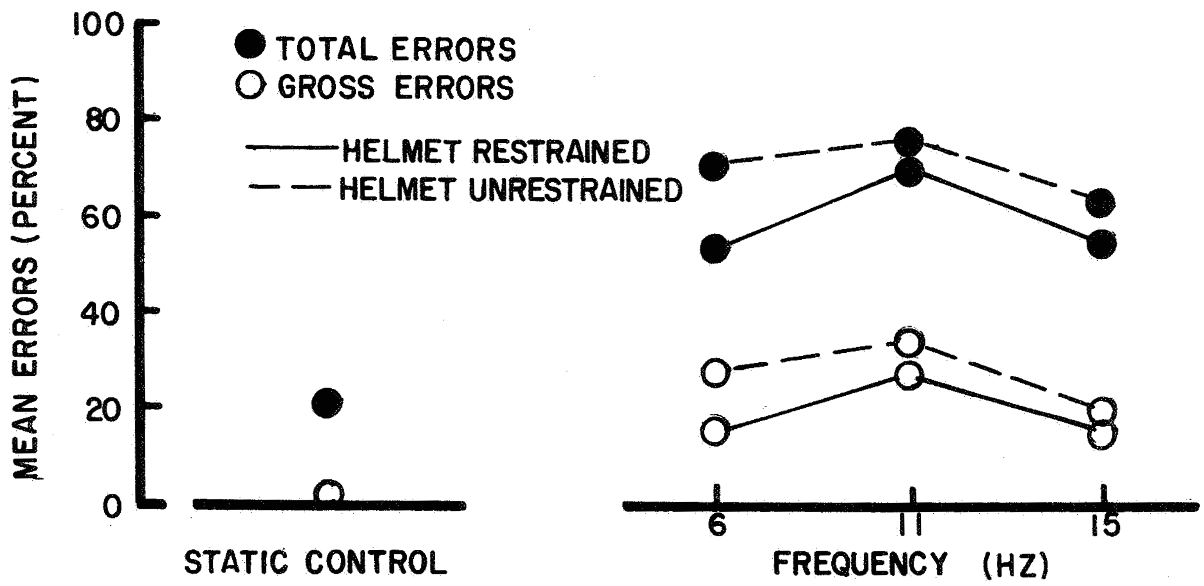


**Figure 4. Dial Reading Performance During 1 $G_x \pm 1.2$ $G_x$ Vibration, with Mercury Helmet, No Face Plate (ref 2)**

TABLE III

ANALYSIS OF VARIANCE OF TOTAL ERRORS
(X-AXIS)

| *Source* | *df* | *SS* | *MS* | *F* |
|---|---|---|---|---|
| Subjects (S) | 5 | 18.23 | | |
| Frequency (F) | 2 | 20.39 | 10.20 | 5.40* |
| Liner (L) | 1 | 0.45 | 0.45 | 0.13 |
| F x L | 2 | 2.39 | 1.20 | 0.33 |
| F x S | 10 | 18.94 | 1.89 | |
| L x S | 5 | 17.88 | 3.58 | |
| F x L x S | 10 | 36.28 | 3.63 | |
| TOTAL | 35 | 114.56 | | |

*$p < .05$

TABLE IV

ANALYSIS OF VARIANCE OF GROSS ERRORS
(X-AXIS)

| *Source* | *df* | *SS* | *MS* | *F* |
|---|---|---|---|---|
| Subjects (S) | 5 | 25.89 | | |
| Frequency (F) | 2 | 85.06 | 42.53 | 15.41** |
| Liner (L) | 1 | 0.45 | 0.45 | 0.10 |
| F x L | 2 | 22.05 | 11.02 | 7.20* |
| F x S | 10 | 27.61 | 2.76 | |
| L x S | 5 | 22.22 | 4.44 | |
| F x L x S | 10 | 15.28 | 1.53 | |
| TOTAL | 35 | 198.56 | | |

*$p < .025$
**$p < .001$

Further inspection of figure 3 suggests that for gross errors there is again an effect due to frequency, but that in this case it seems to interact with the liner conditions. The summary of the analysis of variance for gross errors for the vibration conditions is presented in table IV. Again there is statistical support for the effects suggested by figure 3. The analysis shows a significant effect for frequency and a significant frequency by liner interaction.

To compare performance during the two control conditions, a $\underline{t}$ test was made between the means for with-helmet control and without-helmet control for total errors. The value of $\underline{t}$ obtained indicated that these means did not differ significantly. No statistical test was made for the difference between the control means for gross errors, in view of the small size of this difference and the nonnormality of the data.

Statistical comparison of performance during the with-helmet control condition with performance during each of the vibration conditions was made by means of a Dunnett's t test (ref 3). The results of this test are summarized in table V. For total errors all of the vibration conditions were significantly different from the with-helmet control, and for gross errors all except the two 6 Hz conditions were significantly different from the with-helmet control.

At the conclusion of the experiment each subject was asked to give his impressions of the helmet and was specifically asked whether he preferred the helmet with or without the liner. All six subjects commented that vision through the helmet was distorted in certain spots and that

TABLE V

RESULTS OF DUNNETT'S t TEST FOR DIFFERENCES BETWEEN THE WITH-HELMET CONTROL AND THE EXPERIMENTAL CONDITIONS (X-AXIS)

| | *Significance Level** | |
|---|---|---|
| *Experimental Condition* | *Total Errors* | *Gross Errors* |
| 6 Hz with Liner | $<.01$ | NS |
| 6 Hz w/o Liner | $<.01$ | NS |
| 11 Hz with Liner | $<.01$ | $<.01$ |
| 11 Hz w/o Liner | $<.01$ | $<.01$ |
| 15 Hz with Liner | $<.01$ | $<.01$ |
| 15 Hz w/o Liner | $<.01$ | $<.05$ |

*(one tailed, df = 30, k = 7)

it was difficult for them to see some of the dials. Three subjects felt that the helmet was comfortable, while one stated that it was uncomfortable and fit poorly, and another complained of discomfort from the earphones. Four subjects felt that the helmet was more comfortable with the liner, one preferred it without the liner, and one had no liner preference as far as comfort was concerned. Two subjects commented that they felt their vision was better without the liner. During the course of the experiment two subjects complained of headache after vibration runs without the liner, while one subject had the same complaint after vibration with the liner.

Figure 4 presents the mean errors reported by Taub (ref 2) for the portion of his study which parallels the present X-axis experiment (6, 11, and 15 Hz, $+1\ G_x \pm 1.2\ G_x$). Taub's subjects all wore a Mercury helmet without a face plate and were vibrated both with the helmet restrained to the vibrating table and with it unrestrained. Comparisons between Taub's data and the data of the present experiment can only be made on a judgmental basis and without the aid of direct statistical tests. (This, of course, is also true for any interpretations based on the subjective data in the preceding paragraph.) Nevertheless, a comparison of figures 3 and 4 indicates that both total errors and gross errors are somewhat higher for the Apollo helmet data than for Taub's Mercury helmet data. The reasonableness of this contention is strengthened by the fact that the without-helmet control means and Taub's control means are very similar. In view of this, and the unfavorable comments made by all subjects concerning distorted vision, during the vibration conditions investigated visual performance is apparently somewhat poorer while wearing the Apollo helmet than under similar conditions while wearing a helmet without any face plate.

With regard to the liner variable, there seems to be little to indicate that either the with-liner or without-liner condition is superior. This applies to both the dial reading data and the subjective comments. The data do show that for gross errors the liner appears to be differentially effective at 11 and 15 Hz, better performance occurring with the liner at 11 Hz and without it at 15 Hz.

The results of the present experiment with regard to frequency agree quite well with those reported by Taub. If the liner variable is disregarded, the shape of the curves across frequencies is generally the same as for Taub's experiment. The data show that dial reading performance deteriorated most at 11 Hz, with considerable decrement also occurring at 15 Hz, and some decrement at 6 Hz – especially for total errors.

## Y-AXIS STUDY

For the vibration conditions, mean error scores for both total errors and gross errors are presented in table VI and figure 5. Also shown in figure 5 and table VII are mean error scores for the static control conditions. In this study, as in the X-axis study, variations in these control measurements, as a result of whether the readings were made before or after the vibration runs or with or without the helmet liner, were small and nonsystematic. Therefore, they were again pooled into one mean for each of the two control conditions and each type of error.

Inspection of the data in figure 5 and table VI suggests that there is generally an inverse relationship between total errors and frequency, but that there is also an interaction between frequency and the liner variable. An analysis of variance for total errors produced a significant F-ratio for frequency, but the frequency by liner interaction was not significant (see table VIII).

TABLE VI

MEAN ERRORS (PERCENT) FOR EACH
VIBRATION CONDITION
(Y-AXIS)

| *Criterion* | *Liner* | *6 Hz* | *11 Hz* | *15 Hz* |
|---|---|---|---|---|
| Total Errors | With | 73.55 | 74.97 | 77.72 |
| | Without | 87.46 | 69.39 | 55.56 |
| Gross Errors | With | 18.08 | 33.32 | 38.90 |
| | Without | 63.89 | 23.57 | 12.50 |

Figure 5 and table VI also indicate that there is again a generally inverse relationship between gross errors and frequency, but that the interaction between frequency and liner is much more pronounced than for total errors. The summary of the analysis of variance for gross errors is presented in table IX. For gross errors the frequency by liner interaction was significant, but the effect for frequency was not.

A $\underline{t}$ test was made to assess the significance of the difference between the static control mean with-helmet and the static control mean without-helmet, for total errors. The value of $\underline{t}$ obtained indicated that in terms of total errors performance during the without-helmet condition was significantly better than during the with-helmet condition ($p<.05$, df = 5, one tailed). The control

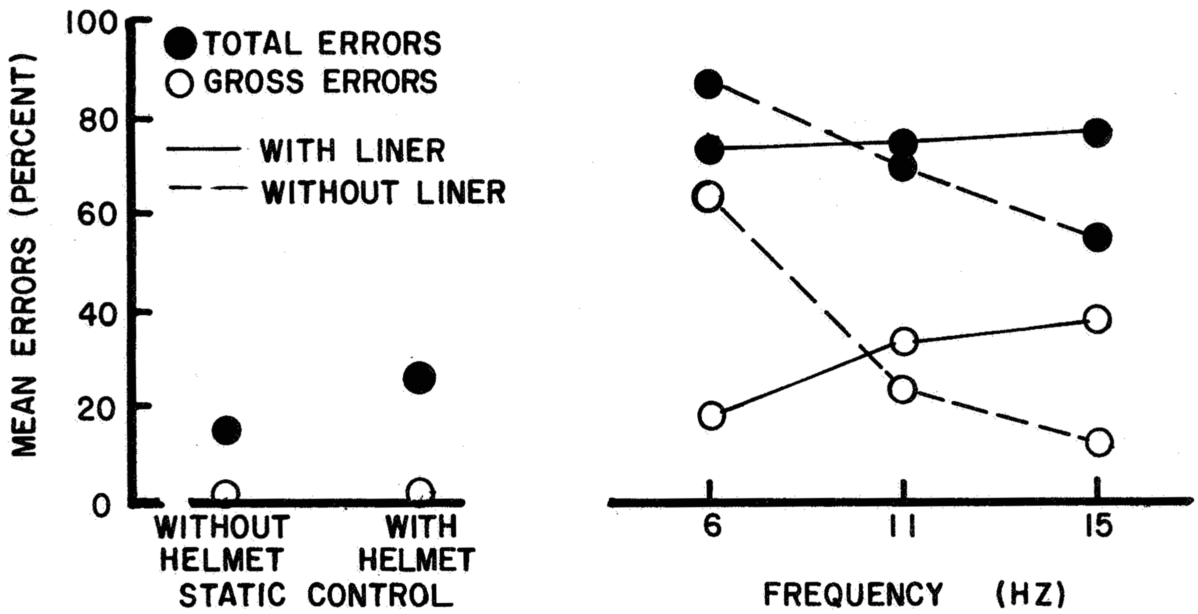


**Figure 5. Dial Reading Performance During 1 $G_x \pm 0.9$ $G_y$ Vibration, with Prototype Apollo Helmet**

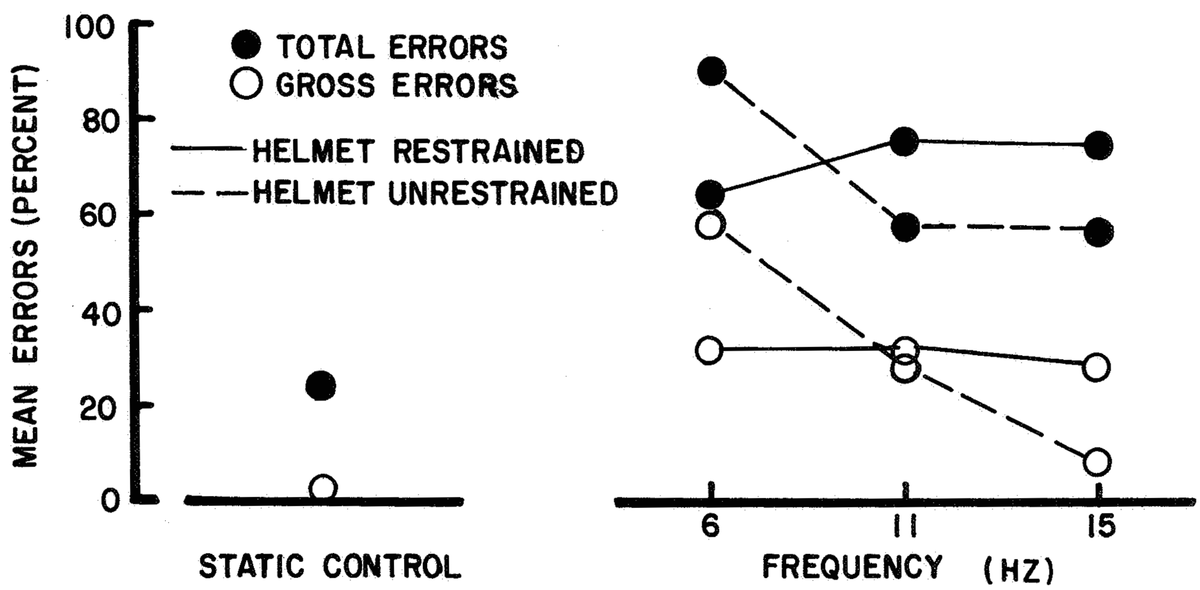


**Figure 6. Dial Reading Performance During 1 $G_x \pm 0.9$ $G_y$ Vibration, with Mercury Helmet, No Face Plate (ref 2)**

TABLE VII

MEAN ERRORS (PERCENT) FOR THE STATIC CONTROL CONDITIONS (Y-AXIS)

| *Criterion* | *Without Helmet* | *With Helmet* |
|---|---|---|
| Total Errors | 14.91 | 26.41 |
| Gross Errors | 1.00 | 1.42 |

means for gross errors differed only slightly, and the distributions of gross error scores for the control conditions showed marked departure from normality. Therefore, no statistical test was made for the difference between the gross error control means.

As in the X-axis study, a Dunnett's t test was used to compare the with-helmet control condition with each of the vibration conditions (see table X). All of the vibration conditions were significantly different from the with-helmet control for total errors; and for gross errors the 6 Hz without-liner condition and the 11 and 15 Hz with-liner conditions differed significantly from the control, while the remaining three conditions did not.

At the conclusion of the experiment each subject was asked whether he preferred the helmet with or without the liner during Y-axis vibration (general impressions concerning the helmet were not solicited at this time, since five of the six subjects had already made such comments at the end of the X-axis study). Two subjects stated that they felt the helmet was better with the liner, and the other four preferred it strongly with the liner at 6 Hz, but had little preference for either configuration at the other two frequencies. This unanimity in preference for the with-liner configuration during 6 Hz vibration is reflected in dial reading performance. The data shows consider-

TABLE VIII

ANALYSIS OF VARIANCE OF TOTAL ERRORS (Y-AXIS)

| *Source* | *df* | SS | *MS* | *F* |
|---|---|---|---|---|
| Subjects (S) | 5 | 65.22 | | |
| Frequency (F) | 2 | 16.89 | 8.44 | 13.84* |
| Liner (L) | 1 | 2.78 | 2.78 | 1.46 |
| F x L | 2 | 28.22 | 14.11 | 2.16 |
| F x S | 10 | 6.11 | .61 | |
| L x S | 5 | 9.55 | 1.91 | |
| F x L x S | 10 | 65.45 | 6.54 | |
| TOTAL | 35 | 194.22 | | |

*$p < .005$

TABLE IX

ANALYSIS OF VARIANCE OF GROSS ERRORS
(Y-AXIS)

| *Source* | *df* | *SS* | *MS* | *F* |
|---|---|---|---|---|
| Subjects (S) | 5 | 41.47 | | |
| Frequency (F) | 2 | 22.89 | 11.44 | 2.50 |
| Liner (L) | 1 | 1.36 | 1.36 | .39 |
| F x L | 2 | 123.56 | 61.78 | 18.66* |
| F x S | 10 | 45.78 | 4.58 | |
| L x S | 5 | 17.48 | 3.50 | |
| F x L x S | 10 | 33.10 | 3.31 | |
| TOTAL | 35 | 285.64 | | |

*$p < .001$

TABLE X
RESULTS OF DUNNETT'S t TEST FOR DIFFERENCES
BETWEEN THE WITH-HELMET CONTROL AND THE
EXPERIMENTAL CONDITIONS (Y-AXIS)

| | *Significance Level** | |
|---|---|---|
| *Experimental Condition* | *Total Errors* | *Gross Errors* |
| 6 Hz with Liner | $<.01$ | NS |
| 6 Hz w/o Liner | $<.01$ | $<.01$ |
| 11 Hz with Liner | $<.01$ | $<.05$ |
| 11 Hz w/o Liner | $<.01$ | NS |
| 15 Hz with Liner | $<.01$ | $<.01$ |
| 15 Hz w/o Liner | $<.01$ | NS |

*(one tailed, df = 30, k = 7)

ably fewer gross errors for the with-liner condition at 6 Hz, and a similar result for total errors, although it is less pronounced.

Figure 6 shows that data reported by Taub (ref 2) for the segment of his study which corresponds to the present Y-axis experiment (6, 11, and 15 Hz, $+1\ G_x \pm 0.9\ G_y$). A comparison of figures 5 and 6 reveals considerable similarity between the two studies in the error level during vibration and in the general effect of frequency on dial reading errors.

The liner variable in the present study and the helmet restraint variable in Taub's experiment may be considered to be roughly analogous. Even though the Apollo helmet was restrained in all conditions, the degree of coupling between the subject's head and the vibration generator is less when the helmet liner is removed than when it is in place. Similarly, the degree of coupling was less for Taub's helmet unrestrained condition than for the condition in which the helmet was restrained. Further comparison of figures 5 and 6 discloses a striking similarity in the effect of the restraint variable across frequency in Taub's study and the effect of the liner variable across frequency in the present investigation. In other words, the interaction between frequency and liner and the interaction between frequency and helmet restraint are very similar — the with-liner results corresponding to Taub's helmet-restrained results and the without-liner results corresponding to his helmet-unrestrained results.

Just what factors caused this interaction is difficult to say. One possibility is that at 6 Hz, where for a given vibration level the displacement amplitude is relatively large, the liner (or the helmet restraint) keeps the head from being jostled, by generally restricting head movement to a single axis, and thus improves performance. On the other hand at 15 Hz the displacement amplitude is smaller and more natural damping occurs, so that a closer coupling between the head and the table may simply transmit more of the vibration input to the head and cause greater performance decrements.

In summary, the results of the Y-axis study indicate that dial reading errors, while wearing the NASA prototype Apollo helmet, in general tend to decrease as frequency increases, but that there is an interaction betweeen frequency and liner — better performance occurring with the liner at 6 Hz and without it at 15 Hz. In addition, total errors on the dial reading task under static conditions appear to be greater with the helmet than without it.

## GENERAL COMMENTS

As mentioned in the procedure section, the subjects were instructed to read the dials as accurately as possible and to take as much time as they needed to complete the readings. This same procedure was used by Taub. Therefore, time was not actually a dependent variable in either of these two studies. However, Taub does report that none of his subjects took longer than 1 minute to read the twelve dials on a panel. The mean reading time for all of the X-axis vibration conditions in the present experiment was 68 seconds, and individual reading times ranged from 38 seconds to 107 seconds. Mean reading time for the Y-axis vibration conditions was 78 seconds, with individual reading time ranging from 48 seconds to 120 seconds.

Error levels obtained during Y-axis vibration were quite similar to those obtained by Taub, while error levels occurring during X-axis vibration appeared to be somewhat greater than Taub reports for this direction of excitation. The relationship between frequency and relative level of performance decrement was generally the same as Taub found, for both X and Y-axis vibration. For X-axis vibration 11 Hz produced the greatest decrement, while for Y-axis excitation there is generally an inverse relationship between frequency and performance, with the most errors occurring at 6 Hz.

The liner variable produced no consistent effects across frequency, but rather interacted with frequency in both the X-axis and Y-axis studies. The interaction was statistically significant only for gross errors. For the X-axis study there were fewer errors with the liner at 11 Hz and without it at 15 Hz, while for the Y-axis fewer errors occurred with the liner at 6 Hz and without it at 15 Hz.

Comparisons of dial reading performance with and without the Apollo helmet during static control conditions showed fewer total errors without the helmet than with it. Although this effect was present in both the X and Y-axis experiments, it reached statistical significance only for the Y-axis data.

Taking into consideration dial reading errors during both vibration and static conditions, as well as vibration dial reading time and subjective comments concerning the prototype Apollo helmet, the visual interference introduced by the face plate of this particular helmet apparently produces some decrement in dial reading performance, compared to similar performance while wearing a helmet without a face plate.

# References


1. Lindquist, E. F. *Design and Analysis of Experiments in Psychology and Education,* Boston: Houghton Mifflin Co., 1953.

2. Taub, H. A. *The Effects of Vibration on Dial Reading Performance,* AMRL-TDR-64-70 (AD 603 963), Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, July, 1964.

3. Winer, B. J. *Statistical Principles in Experimental Design,* McGraw-Hill Book Co., New York, 1962.

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13. ABSTRACT
Dial reading performance while wearing a NASA prototype Apollo helmet was investigated during short duration whole-body sinusoidal vibration. The subjects were in the semisupine position so that the force of gravity acted through the X-axis of the body, with the vibration acting in the X-axis in one experiment and in the Y-axis in another. In each study, dial reading was assessed (subject and dial vibrating) at 6, 11, and 15 Hz when the helmet was worn either with or without a helmet liner. The vibration intensity was $\pm$ 1.2 G in the X-axis experiment and $\pm$0.9 G in the Y-axis experiment. Static control measurements were also made both with and without the helmet. The results showed significant decrements in dial reading performance during vibration which were differentially related to direction of vibration, frequency of vibration, and to combinations of liner versus no liner with the three frequencies. The results further indicated that the effects of different directions and frequencies of vibration while wearing the Apollo helmet were quite similar to those found in previous studies under the same conditions using a Mercury helmet without a face plate. However, the data suggested that performance was somewhat poorer during both vibration and static conditions while wearing the prototype Apollo helmet. This is probably the result of visual interference produced by the curvature of the helmet face plate and by small scratches and blemishes on the face plate of the particular helmet used in this study.

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