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EFFECTS ON MUSCLE TENSION AND TRACKING TASK PERFORMANCE OF SIMULATED SONIC BOOMS WITH LOW AND HIGH INTENSITY VIBRATIONAL COMPONENTS

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16. Abstract

To determine the relative contribution of the vibrational component generated in a room from simulated sonic booms on the electromyographic and performance responses of human subjects, four subjects were assigned randomly to each of the following groups: (1) paced tracing task, with booms and with relatively low intensity vibration (subject's chair and tracing table on a vibration-isolation platform); (2) paced tracing task, with booms, and with relatively high intensity vibration (subject's chair and tracing table on floor); (3) reading of light material, with booms, and with low intensity vibration; and (4) paced tracing task only.

As a result of simulated sonic booms with a relatively high vibrational component, Group 2 obtained greater electromyographic responses and greater decrements in tracing performance than did Groups 1, 3, and 4. However, the statistical significance of the results is questionable because of the initial variability within and between the groups in contrast with earlier studies which employed subjects who were not adapted to these type noises.

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EFFECTS ON MUSCLE TENSION AND TRACING TASK PERFORMANCE OF SIMULATED SONIC BOOMS WITH LOW AND HIGH INTENSITY VIBRATIONAL COMPONENTS

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I INTRODUCTION

Sonic booms when perceived indoors typically have both acoustic and vibrational components, and both components may influence the responses of people to those sonic booms. In an earlier study (Ref. 1), the effects of simulated sonic booms and subsonic jet flyover noises, both as heard indoors, on electromyographic "startle" responses and performance on a paced tracing task were compared. It was found that sonic booms resulted in a brief increase in potential of the trapezius muscle which did not appear to habituate, and in a decrement in performance on the tracing task. Similar electromyographic changes and performance decrements were not observed in a group stimulated by subsonic jet flyover noise of an intensity judged (Ref. 2) equivalent to that of the sonic booms.

It is known that the frequency spectra of sonic booms and the flyover noise from subsonic jets are different. However, the frequency differences may not be of sufficient magnitude to account for the different effects of these stimuli on awake individuals, even though stimulus frequency differences apparently lead to different results with sleeping people (Ref. 3). Consequently it was suggested that the low frequency vibrations induced in the floor of the test room by the booms may have been a major cause of the electromyographic and performance effects observed.

II OBJECTIVE

The tests were designed to determine the relative contribution of vibrations produced in the floor by sonic booms to the total effect of sonic booms on skeletal muscle activity and a performance task requiring a high degree of visual-motor coordination.

III METHOD

Subjects

The subjects were 16 tool and die makers and machinists between 40 and 62 years of age, with a mean age of 50 years. Ten of the subjects had normal hearing, but six showed evidence of a noise-induced loss of 10 to 30 dB at frequencies above about 1000 Hz. These losses were not considered significant because the sonic boom as an acoustic stimulus peaks in intensity at a frequency of about 5 Hz, and the signal at 1000 Hz is at least 50 dB below the peak level.

Stimuli

Sonic booms, simulated by a device described in detail in Ref 4, had a duration of about 300 ms, an intensity of about 2.5 psf, and an effective rise time of about 10 ms, as if measured outdoors. Peak sound pressure levels in the test room were about 128 dB, i.e., 8 dB less than the estimated peak outdoor level. In Figure 1 the energy spectrum of the simulated boom as present inside the test room is compared with that found in an actual house struck by a boom. The differences in spectra at frequencies above about 200 Hz are due to differences in rise times of the simulated and actual boom, i.e., booms with faster rise times produce relatively more intense high frequencies. Microphone roll-off accounts for the dissimilarities at frequencies below about 30 Hz (Ref 4).

Apparatus

The test apparatus is described fully in Ref 1 and will not be redescribed here. Briefly, however, the subjects were required to

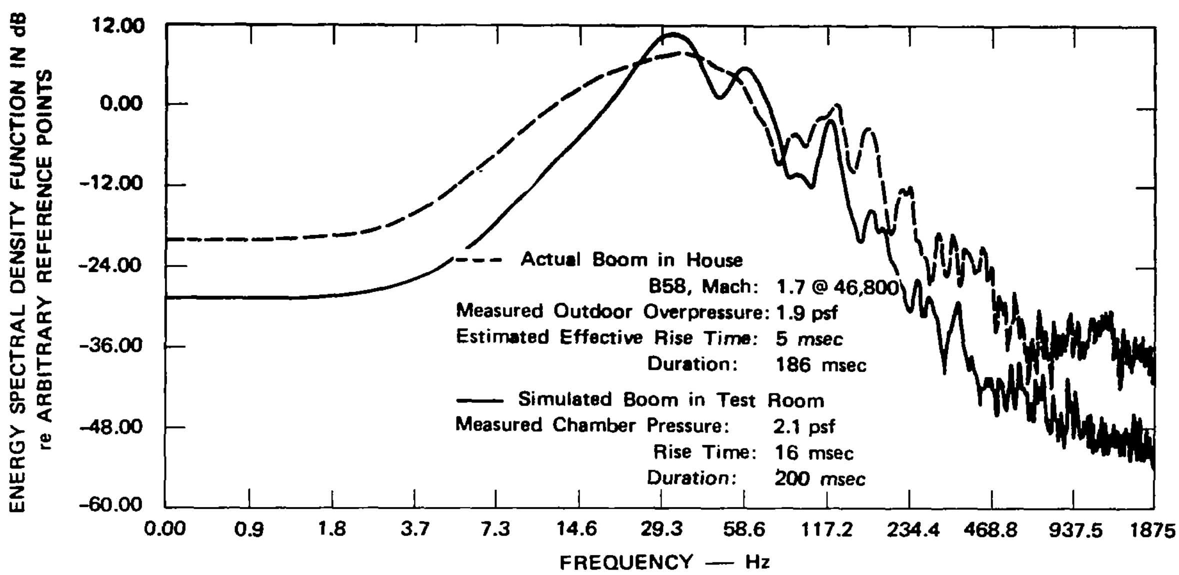

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FIGURE 1 INDOOR ENERGY SPECTRAL DENSITY FUNCTIONS OF AN ACTUAL 1.9 PSF B-58 SONIC BOOM AND A 2.1 PSF SIMULATED SONIC BOOM

demonstrate fine visual-motor coordination by tracing with a stylus a 1/16-inch wide track. This track was near the center and was one of five tracks each separated by 1/32 inch and circumscribing a square 13-1/2 inches on a side. The surfaces of the tracks and the intervening spaces were on the same smooth plane. Subjects were permitted 20 seconds to move the stylus one time around the track and paced so that the stimuli occurred when the subjects were near the corners of the board.

Response Measures

Three response measures were obtained:

1. Time-on-Track (TOT) was obtained by two digital counters with accuracies of ±1 ms. The equipment was arranged so that TOT was recorded for the 2.5 second interval before the boom and for the 2.5 second interval after occurrence of the sonic boom. Since the booms occurred when the subject's stylus was within 1/2 inch of the corner

of the board and since the board was 13-1/2 on each side, the before-boom TOT was a measure of the time the subject was on the assigned track as he moved on about 6-3/4 inches of track before the occurrence of the boom. The after-boom TOT was the time the subject was on the 6-3/4 inches of assigned track after the occurrence of the boom.

2. Electromyographic Activity Level (EMG) was obtained from the trapezius muscle (located in the shoulder) contralateral to the arm being used in the tracing task. The raw EMG signal was rectified and integrated over 1/2-second intervals and the results recorded as a pulse with amplitude proportional to the energy generated by the muscle during the interval.

3. Errors were calculated as the number of times the subject was off the assigned track.

Procedure

In the previous study, the subjects were permitted five sessions (a session consists of 64 turns, or trials, around the board with interspersed rest periods of 2 to 3 minutes after each group of eight trials) to learn the task and acquire skill, but in the present study the subjects were allowed only one turn about the board to learn the rudiments of the required task; thereafter the test trials began. This procedural modification appeared reasonable in light of the results of an earlier experiment (Ref 4) in which the same tracing task was used, but paced by the subject. The results of that study suggested that the periodic occurrence of noise coincidential with acquisition of skill hindered the attainment of speed, but did not affect attainment of accuracy on the task. A similar result was found in a study by Teichner, Arees and Reilly (Ref 5) who reported that with a subject-paced decision task, noise produced negligible errors, but did result in changes in decision times that were roughly proportional to the change in noise intensity relative to the background noise level. If in this study, the externally paced task were well learned before occurrence of the booms, the noise-elicited responses theoretically would compete briefly and possibly unmeasurably with task performance. If, in contrast, the task were being learned as the noise was being introduced, the response to booms should impair learning and the performance of the group stimulated by booms would attain the performance level of a group not similarly stimulated only after several test sessions, i.e., after the "incorrect" (unwanted) responses to booms were extinguished. (See Ref 5 for a fuller description of the theoretical basis underlying this analysis.)

The 16 subjects were randomly assigned to one of four experimental groups: (1) boom and tracing with low intensity vibration, (2) boom and tracing with high intensity vibration, (3) booms only (subjects read light material) with low intensity vibration, and (4) tracing only.

Fifteen simulated sonic booms of 2.5 psf (as if measured outdoors) were presented during each of seven sessions. Twelve booms were presented at random during the tracing portion of each session, with the restriction that at least one boom must occur when the subject was near each corner of the board during each session, and that two booms should occur in two successive corners of the board at least once during each session. The remaining three booms were presented during the rest periods, but no more than one boom during any rest period.

For any given group, the order of stimulation for each subject was varied and the order of stimulation for each session for any particular subject in that group was different. The order of stimulation for the groups were the same, i.e., Subject 1 in Group 1 had his counterpart (paired randomly) in Group 2, so that both subjects in the two groups were stimulated in the same order.

The subjects were not informed when, how many, or if any stimuli would be presented in each session. To maintain a modicum of motivation, the subjects were informed of their relative performance during their rest periods and, where appropriate, were encouraged to do better.

Technique for Vibration Isolation

When the experimental condition required the subject to be stimulated by low intensity vibration (in addition to the usual acoustical components associated with the boom), four squares (each about 2 square inches) of commercially available vibration isolation pads (Isomode) were slipped under specific locations near the corners of a rectangular piece of 3/4-inch plywood. The plywood was of sufficient size to accommodate the seated subject and the table into which the tracing task board was affixed. The Isomode squares raised the plywood off the floor and measurably decreased the intensity of the boom-induced vibrations. Average acclerations of about 0.12 G (with a predominant frequency near 4 Hz) were measured at the center of the plywood board with a subject sitting at the tracing-task table; with the plywood board raised by the vibration isolation pads and other conditions remaining the same, an average acceleration of about 0.06 G near 4 Hz was obtained.

IV RESULTS

Electromyographic Response

Comparison of Baseline EMG Levels

Statistically similar mean electromyographic levels were found in the four groups before the first boom. These data are presented in Table I as an analysis of variance summary. Four measures of the EMG, integrated over 0.5 second each, were obtained for each subject during his performance (tracing in the case of Groups 1, 2, and 4, and reading in the case of Group 3) just before the first boom or, in the case of Group 4 (tracing task only), before a "simulated boom." "Simulated boom" trials in the case of Group 4 are those designated as "boom" trials on the basis of the actual boom trials of Groups 1 and 2, but during which for Group 4 the booms did not occur. In other words, they effectively were control boom trials for Groups 1 and 2 as well as Group 4. One subject in Group 2 (tracing task with booms without vibration isolation) showed abnormally high EMG levels during the first several minutes of the first session apparently because of a temporary malfunction or misalignment of the recording equipment. His data are not included in Table I, therefore the total number of degrees of freedom is 59 rather than 63 (16 X 4 -1). The mean EMG levels of the four groups during the 2-second period before the first boom occurred are presented in Table II.

Table I

SUMMARY ANALYSIS OF VARIANCE

OF BASELINE ELECTROMYOGRAPHIC LEVELS

TWO SECONDS BEFORE THE FIRST SIMULATED SONIC BOOM

Source of Variance	Mean Square Variance	df	F	Significance Level
Groups	16.26	3	1.24	$p > 0.05$
Within Groups (Error)	13.07	56		
TOTAL	13.23	59	1.01	$p > 0.05$

Table II

MEAN ELECTROMYOGRAPHIC LEVELS BEFORE THE FIRST SIMULATED SONIC BOOM

Group Number	Mean (mm)	Standard Deviation	Number
1. Tracing task, booms, low intensity vibration	3.75	1.97	16
2. Tracing task, booms, high intensity vibration	5.45	2.34	12
3. Reading, booms, low intensity vibration	3.09	1.60	16
4. **Tracing task only**	3.09	3.24	16

Response to Simulated Sonic Booms

An earlier study (Ref 1) suggested that groups exposed to simulated sonic booms, which included the associated vibrations, showed skeletal muscular responses to the booms. The data obtained in this study suggest that reducing the intensity of the associated vibrations reduced the skeletal muscle response. It can be seen in Figure 2 that Groups 1

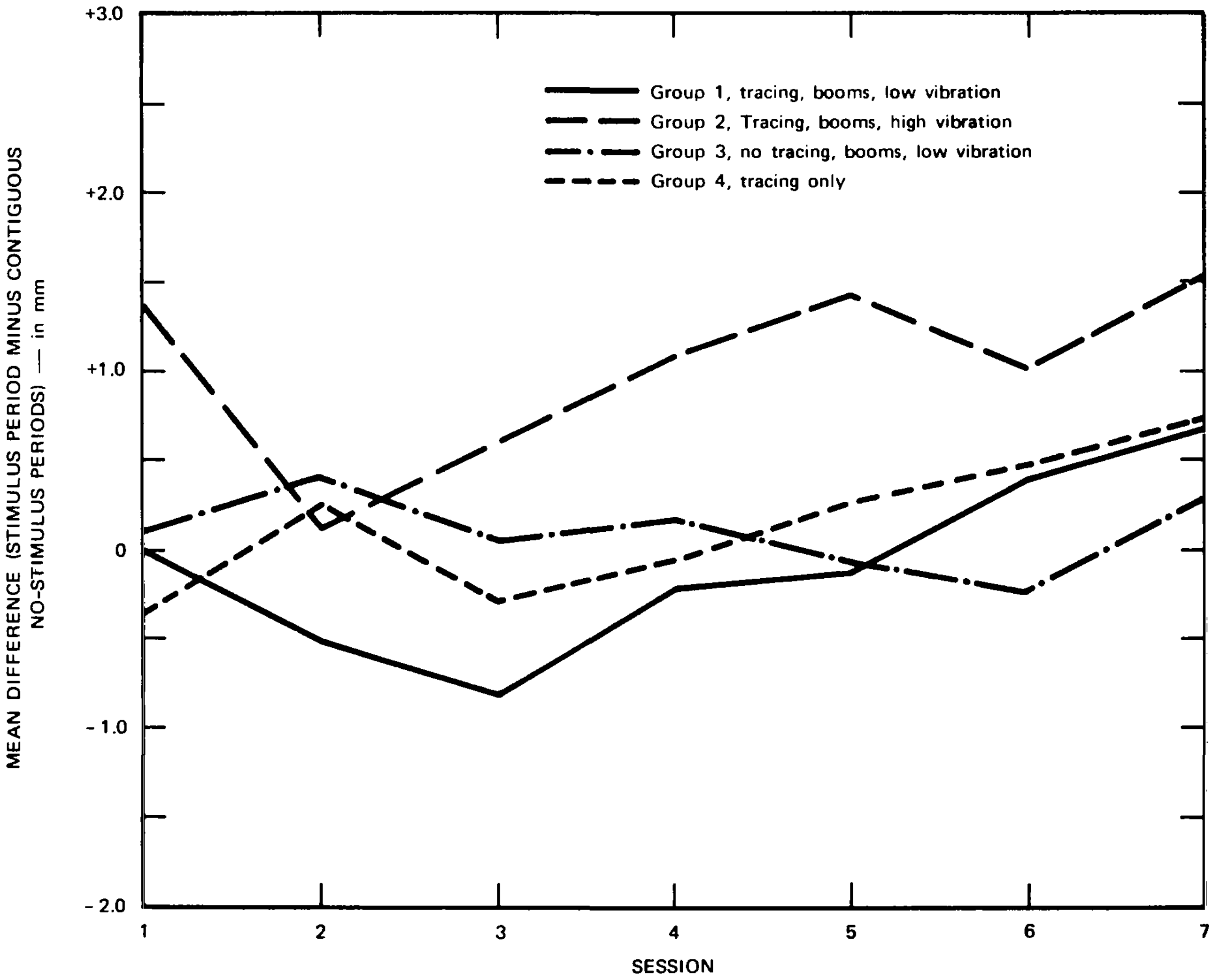

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FIGURE 2 NORMALIZED ELECTROMYOGRAPHIC RESPONSE IN TRAPEZIUS MUSCLE TO SIMULATED SONIC BOOMS DURING A TRACING TASK and 3, who heard the boom-associated acoustic stimuli, but for whom the vibrational intensity was reduced, had little change in mean EMG level between the one-second period during which booms and their effects occurred as compared to the mean EMG level one second before and one second after the stimulus period. Group 2, who heard the boom and felt its vibrations more intensely, responded with electromyographic responses of greater magnitude.

Further analysis suggests that the interpretation above should be qualified. Table II shows that the mean preboom EMG level of Group 2 is at least 1.5 units higher (although statistically insignificant) than found in the other groups. Davis (Ref 6) reported that subjects with higher initial EMG levels show larger changes to acoustic stimuli than subjects with initially lower resting EMG levels, which suggests that the responses (changes in potential) of Group 2 should be of greater magnitude than any of the other groups. In addition, statistical analysis of the EMG changes in response to the simulated booms indicates the significant differences obtained may be due to variance differences between the groups rather than group differences in mean performance.

A summary of the analysis of variance of the normalized responses of Groups 1, 2, and 3 to booms is presented in Table III. Data from Group 4 are not included in this analysis because the group was not stimulated by booms and because the variance of the group appeared unusually high (see Table II) mainly because of the great variability of the base-line EMGs of two subjects. In Table III, the two main effects and the interaction effect were significant. However, as noted in Table II, there is a fairly large discrepancy between the standard deviations and variances of the three groups, and the discrepancy holds even when the variance of Group 4 is deleted. Therefore, to assure that

Table III

SUMMARY ANALYSIS OF VARIANCE

OF ELECTROMYOGRAPHIC CHANGES DURING THE ONE SECOND OF BOOM EFFECT

RELATIVE TO THE ONE SECOND BEFORE AND ONE SECOND AFTER THE BOOM STIMULUS

Source of Variance	Mean Square Variance	df	F	Significance Level
Groups	246.631	2	20.42	$p < 0.01$
Sessions	25.507	6	2.11	$0.05 > p > 0.01$
Group X Session	36.773	12	3.04	$p < 0.01$
Residual(Error)	12.077	1995		
TOTAL	12.497	2015	1.03	$p < 0.01$

the significant effects reported in Table III are mean differences and not variance differences, a test with Hartley's largest F ratio (Ref 7) was conducted; it showed that the variances associated with the significant interaction were, in fact, statistically different. ($F_{max} = 109.3$, with $k = 21$, and $n = 95$, $p < 0.01$. Assuming large errors of measurement in the two extreme cases, another F_{max} was calculated using the second most extreme variances. The result was similar: $F_{max} = 12.20$, with $k = 19$, and $n = 95$, $p < 0.01$.)

The mean change in electromyographic level to booms and the associated standard deviations obtained by the four groups are listed in Table IV. It should be noted that in agreement with the statistical analyses, the differences in mean electromyographic changes registered by the groups in the sessions are relatively small; a maximum of about 2.28 mm between Group 1 during session 3 and Group 2 during session 5. In contrast, the standard deviations were found to range between 0.11

Table IV

MEAN ELECTROMYOGRAPHIC CHANGES TO SIMULATED SONIC BOOMS

	Group 1 Tracing, Booms, Low Intesnity Vibration		Group 2 Tracing, Booms, High Intensity Vibration		Group 3 Reading, Booms, Low Intensity Vibration		Group 4 Tracing Task Only	
Session	Mean	σ	Mean	σ	Mean	σ	Mean	σ
1	-0.02	3.15	1.35	5.95	0.11	3.05	-0.36	2.00
2	-0.51	4.46	0.18	2.46	0.43	1.28	0.25	0.11
3	-0.80	4.39	0.61	2.70	0.34	3.92	-0.31	0.75
4	-0.18	4.05	1.13	3.03	0.18	0.57	-0.06	0.54
5	-0.05	3.62	1.48	3.87	-0.08	2.31	0.31	4.52
6	0.36	3.85	1.07	4.12	-0.19	3.15	0.53	4.21
7	0.67	4.39	1.58	3.24	0.33	1.34	0.77	2.74

and 5.95, and because of their magnitude contributed more to the observed statistical significance than did the small differences between means.

Effects of Simulated Sonic Booms on Performance

Comparability of Groups on TOT Measures

Statistically significant differences were obtained between the Time-on-Track (TOT) measures of Groups 1, 2, and 4 during the no-boom trials of the first session. Pertinent data are shown in Table V and are illustrated in Figure 3. It is clear from the tabularized data and the illustration that the initial performance of the groups during session 1 was different; Group 2 performed the poorest and Group 1 performed the best. The implication of this information is equally clear: the performance of any given group with respect to the effects of booms can be compared only with its own performance on no-boom trials.

Effect of Simulated Sonic Booms on TOT Performance Measure

Simulated sonic booms were found to have slight but statistically insignificant effects on TOT of Groups 1 and 2 who heard booms of equivalent acoustical intensity but that differed with respect to the intensity of floor vibrations. These data are presented in Table VI. However, the fact that Group 4, which performed the tracing task only, showed statistically significant differences between no-boom and "boom" trials (i.e., trials designated as "boom" trials but during which booms did not occur) suggests that the slight differences in performance found in Groups 1 and 2 may exist because of random errors. Table VII shows that the effects of "booms" on Group 4 were to reduce the relative number of TOTs in the 2.50-2.26 interval and to increase the number in

Table V

NUMBER AND PERCENT OF NO-BOOM TRIALS
IN WHICH TIME-ON-TRACK OF DIFFERENT DURATIONS
WERE OBTAINED DURING SESSION 1

Group	Number (N) and Percent	Time-on-Track Interval (seconds)*				
		2.50-2.26	2.25-1.76	1.75-1.26	1.25-0.76	0.75-0
1. Tracing task, booms, low intensity vibration	N	66	169	130	42	9
	%	15.9	40.6	31.2	10.1	2.2
2. Tracing task, booms, high intensity vibration	N	21	126	139	97	33
	%	5.1	30.3	33.4	23.3	7.9
4. Tracing task only	N	43	166	124	64	19
	%	10.3	39.9	29.8	15.4	4.6

$X^2 = 68.69$, 8 df (degrees of freedom), $p < .001$

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[*] Use of parametric statistics was precluded by the truncated distribution of time-on-track. Consequently, the range of possible time-on-track was divided into the intervals shown and the frequency of measures in each interval was tallied to develop this and the tables that follow.

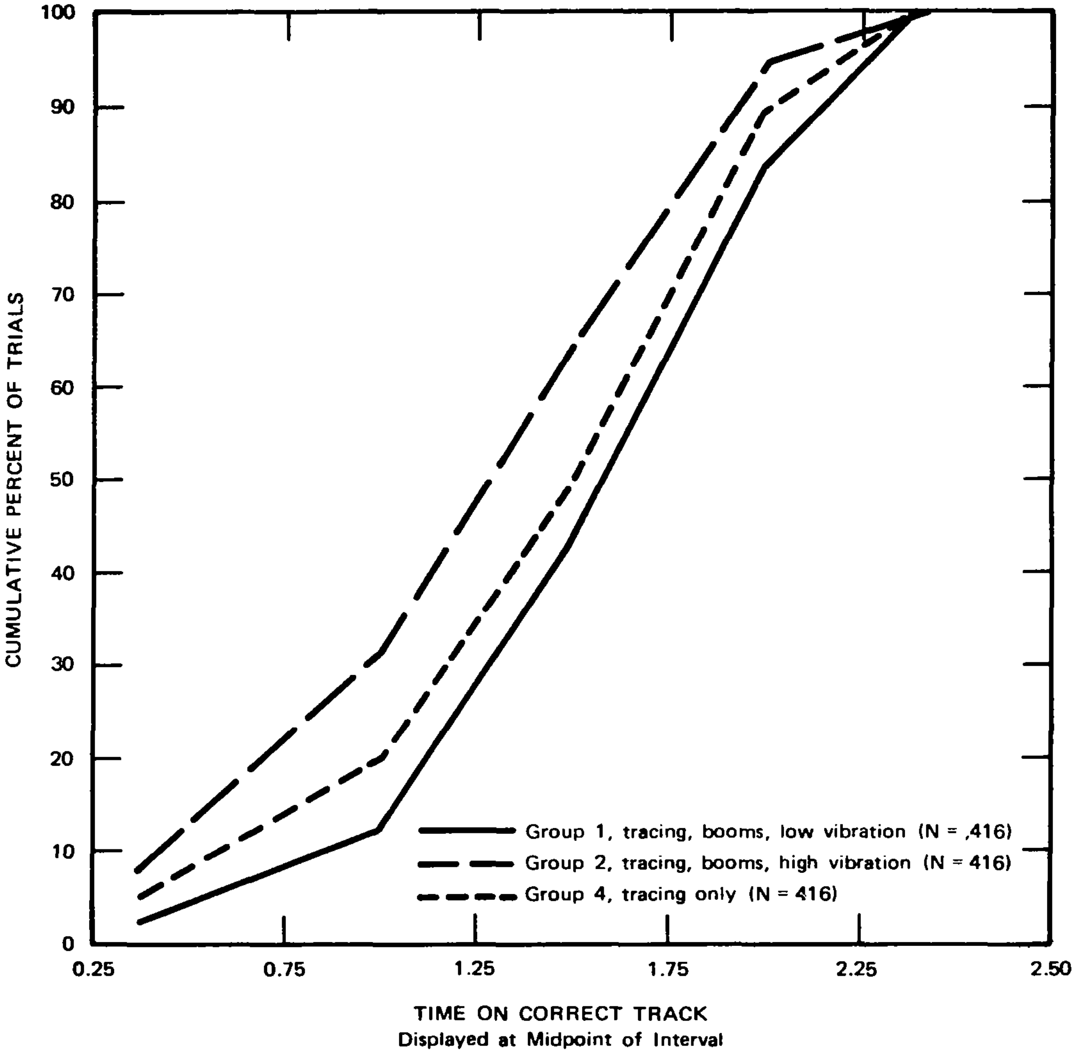

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FIGURE 3 INITIAL GROUP DIFFERENCES IN TIME-ON-TRACK DURING NO-BOOM TRIALS OF SESSION 1

Table VI

NUMBER AND PERCENT OF TIME-ON-TRACK

OF DIFFERENT DURATIONS OBTAINED ON BOOM AND NO-BOOM TRIALS

DURING SEVEN SESSIONS BY THE HIGH AND LOW VIBRATION INTENSITY GROUPS

Group	Trials	Number (N) and Percent	Time-On-Track Interval (Seconds)				
			2.50-2.26	2.25-1.76	1.75-1.26	1.25-0.76	0.75-0
1. Tracing task, booms,	No Boom	N	355	610	315	109	15
		%	25.3	43.4	22.4	7.8	1.1
Low intensity vibration*	Boom	N	65	137	89	29	4
		%	20.1	42.3	27.5	8.9	1.2
2. Tracing task, booms,	No Boom	N	131	514	440	221	98
		%	9.3	36.7	31.3	15.7	7.0
High intensity vibration†	Boom	N	22	103	119	59	23
		%	6.7	31.6	36.5	18.1	7.1

* $X^2 = 6.42$, 4 df, $0.10 > p > 0.05$, N.S. (not significant)

† $X^2 = 6.95$, 4 df, N.S.

Table VII

NUMBER AND PERCENT OF TIME-ON-TRACK OF DIFFERENT DURATIONS OBTAINED ON "BOOM" AND NO-BOOM TRIALS DURING SEVEN SESSIONS BY GROUP 4

Group	Trials	Number (N) and Percent	Time-on-Track Interval				
			2.50-2.26	2.25-1.76	1.75-1.26	1.25-0.76	0.75-0
4. Tracing only	No Boom	N %	300 21.4	637 45.4	320 22.8	119 8.5	27 1.9
	"Boom"	N %	64 19.8	152 47.0	59 18.3	31 9.6	17 5.3

$X^2 = 14.79$, 4 df, $0.01 > p > 0.005$

the 1.25-0.76 and 0.75-0.0 intervals. If booms have an effect on performance, changes in these directions are to be anticipated. Table VI shows for Groups 1 and 2 the effects of booms were in the anticipated direction: a decrease in the relative number of long TOTs and an increase in the relative number of short TOTs. In this case, however, the shifts were statistically insignificant and on the basis of the Group 4 findings, they probably are of little consequence.

Effect of Simulated Sonic Booms on Performance Errors

To compare equitably the number of errors made during the 12 trials of each session in which booms occurred versus those trials during which booms did not occur, an equivalent number (12) of no-boom trials was selected randomly from among the 52 no-boom trials of each session for each subject. These no-boom trial error frequencies provide the basis for the comparison that follows. Table VIII shows that the number

Table VIII

NUMBER AND PERCENT OF ERRORS MADE DURING BOOM AND NO-BOOM TRIALS

Group	Number (N) and Percent	Trials	
		Boom	No-Boom
1. Tracing task, booms, low intensity vibration	N %	1180 49.7	1195 50.3
2. Tracing task, booms, high intensity vibration	N %	1431 50.5	1401 49.5
4. Tracing task only	N %	1070 50.1	1064 49.9

$X^2 = 0.37$, 2 df, N.S.

of errors made did not increase or decrease significantly during those trials that contained booms as compared to the number of errors during trials that did not include booms. Group 2 also committed more errors during both boom and no-boom trials, a finding consistent with those reported above, that Group 2 had the poorest time-on-track scores of the groups compared.

Supplementary Study

To verify the lack of a significant effect due to a reduction of the intensity of the vibrational component of simulated booms, the subjects of Groups 1 and 2 were tested for four additional sessions about eight months after completion of the study reported above. The stimuli, subject's tasks, and measures were identical to those used previously, but the procedure was modified: throughout the first study Group 1 subjects were tested with vibrational components of reduced intensity, but during the first two sessions of the supplementary study they were tested at the relatively intense vibrational levels, and then for two more sessions at the relatively low vibrational levels. Group 2, in contrast, throughout the first study worked at the higher vibrational levels, while in the second they worked with low vibrational levels for two sessions and then were switched to the relatively high vibrational level for the last two sessions.

The results are essentially identical to those obtained in the first study. For example, with respect to electromyographic potentials, it will be seen, in Table IX, that whether the vibration levels were of high or low intensity had little effect on the performance of the subjects in Groups 1 and 2. In fact, for Group 1 reducing the intensity of vibrations appears to have reduced the mean electromyographic response to booms, while for Group 2 a similar reduction in the vibration

Table IX

MEAN ELECTROMYOGRAPHIC CHANGES TO SIMULATED SONIC BOOMS WITH RELATIVELY HIGH AND LOW VIBRATIONAL COMPONENTS

Group	Session Number	Relative Vibration Intensity	Mean	Standard Deviation
1	8 & 9	High	0.82	2.25
	10 & 11	Low	0.42	1.14
2	8 & 9	Low	0.79	1.82
	10 & 11	High	0.18	2.40

components of booms appears to have increased muscular responses to those booms.

With respect to time-on-track, it will be seen in Table X, that in general Group 2 performed poorly (as indicated by the smaller percentage of T.O.T.'s in the 2.50-2.26 second range and a larger percentage of T.O.T.'s in the 0.75-0 range) as compared to Group 1. These results are consistent with those reported above. Note that Group 1 during boom trials with relatively high vibration (Sessions 8 and 9) obtained fewer scores in the 2.50-2.26 second range, and more in the 0.75-0 range than they obtained during boom trials with low vibration (Sessions 10 and 11), while just the opposite effect was found in Group 2. The trend of the data for both groups, it can be seen, is identical during those trials in which booms did not occur. Clearly, the implication of these data, at least for this particular group of subjects, is that neither the acoustical nor the vibrational components of simulated sonic booms at the level tested here has a large or consistent effect on performance.

Table X

NUMBER AND PERCENT OF TIME-ON-TRACK OF DIFFERENT DURATIONS OBTAINED DURING SESSIONS WITH BOOM TRIALS OF RELATIVELY LOW AND HIGH VIBRATION INTENSITY AND DURING NO-BOOM TRIALS

Group	Trials	Session Number	Relative Vibration Intensity	Number (N) and Percent	Time-on-Track Interval (Seconds)				
					2.50-2.26	2.25-1.76	1.75-1.26	1.25-0.76	0.75-0
1	Boom (a)	8 & 9	High	N	32	36	17	3	7
				%	33.7	37.9	17.9	3.2	7.4
		10 & 11	Low	N	38	41	12	5	0
				%	39.6	42.7	12.5	5.2	0
	No Boom (b)	8 & 9	High	N	124	164	65	30	34
				%	29.7	39.3	15.6	7.2	8.2
		10 & 11	Low	N	174	175	51	15	1
				%	41.8	42.1	12.3	3.6	0.2
2	Boom (c)	10 & 11	High	N	20	36	29	7	4
				%	20.8	37.5	30.2	7.3	4.2
		8 & 9	Low	N	9	31	25	17	14
				%	9.4	32.3	26.0	17.7	14.6
	No Boom (d)	10 & 11	High	N	94	188	87	26	21
				%	22.6	45.2	20.9	6.3	5.0
		8 & 9	Low	N	43	138	92	73	70
				%	10.3	33.2	22.1	17.5	16.8

(a) $X^2 = 9.19$, 4 df, N.S.

(b) $X^2 = 46.83$, 4 df, $p < 0.001$

(c) $X^2 = 14.06$, 4 df, $0.01 > p > 0.005$

(d) $X^2 = 75.49$, 4 df, $p < 0.001$

Analysis of errors leads to a conclusion similar to that above, i.e., the acoustical and vibrational components had little effect on performance errors. The data supporting this conclusion are shown in Table XI, where it will be seen that the frequency of errors during trials with or without booms and trials with relatively high or low vibrational components are all approximately equivalent.

Table XI

NUMBER AND PERCENT OF ERRORS MADE BY GROUPS 1 AND 2 DURING BOOM AND NO-BOOM TRIALS OF RELATIVELY LOW AND HIGH INTENSITY VIBRATION SESSIONS

Group	Session Number	Relative Vibration Intensity	Number (N) and Percent	Trials	
				Boom	No-Boom
1 (a)	8 & 9	High	N %	483 50.3	477 49.7
	10 & 11	Low	N %	450 50.2	447 49.8
2 (b)	8 & 9	Low	N %	504 49.9	507 50.1
	10 & 11	High	N %	545 50.0	545 50.0

(a) $X^2 = 0.004$, 1 df, N. S.

(b) $X^2 = 0.005$, 1 df, N. S.

V DISCUSSION

On the basis of previous studies conducted in this laboratory (Ref 1, 4), detrimental effects on performance and increases in muscle tension were expected to result from booms with an intensity of 2.5 psf (as measured outdoors). This intensity was equivalent to that used in one of the previous studies (Ref 1) and double that used in the other (Ref 4). An explanation for the lack of any statistically significant effect of the simulated sonic booms on either of the two performance measures or skeletal muscle tension, as reported herein, is not readily available.

Numerous other investigators have shown that noise may have an effect on performance and certain physiological measures (Ref 8,9,10, 11,12,13). Common to these studies was the use of vigilance or target detection tasks such as detecting an odd letter such as a C in a background of many Os (Ref 10), or detecting movement of a clock hand that was double its usual excursion as required in the Mackworth-type clock test (Ref 9). Clearly, the task in the present study was different in that the subjects were required to follow a thin line with a stylus, a task requiring a good deal of perceptual-motor coordination, but little vigilance-like activity. In part, this task difference may explain the lack of detrimental effects of simulated booms.

More importantly, however, is the need to explain positive findings in the first two of our studies and their lack in the third. It may be that a peculiar collection of individuals were selected and assigned to the different groups of the third study. Hence, because of their inherent variability with respect to the EMG and performance measures and because of the relative grossness of the measurement technique, the groups would appear not to be affected by the simulated sonic booms (or other noises, for that matter) regardless of the other experimental concerns (high or low intensity vibrational components).

On the other hand, Woodhead (Ref 12) and Warner (Ref 10) emphasize, to some extent, that the response to noise may depend on the sensitivity of the individual to noise. Herein may lie an explanation for the different results obtained in the three studies conducted in this laboratory. The subjects of the first study were college students who usually work in a relatively quiet environment similar to that of the professional and technical personnel used in the second study, whose offices and electronic shops also tend to be relatively quiet, estimated at 60 dB SPL or less (Ref 14). In contrast, the subjects of the third study were tool and die makers and machinists whose usual working environment tends to be noisy; estimated peaks near 100 dB between 600-4800 Hz when air hoses are used, but average about 85 dB when the drills, borers, and mills are used (Ref 14,15). It is suggested, therefore, that impulse noises such as sonic booms may not be too different in intensity or periodicity from the noises commonly found in machine shops. Consequently, simulated sonic booms had little effect on the performance or skeletal muscle potentials of the subjects accustomed to working in such noise environments.

VI CONCLUSION

Among machinists and tool and die makers who normally work in noisy environments, the periodic occurrence of the noise and vibration associated with simulated sonic booms, of an outdoor intensity of 2.5 psf, had no statistically significant effect on performance of a tracing task requiring a fair degree of perceptual-motor coordination, or on skeletal muscle tension.

REFERENCES

1. Lukas, J. S., D. J. Peeler, and K. D. Kryter, "Effects of Sonic Booms and Subsonic Jet Flyover Noise on Skeletal Muscle Tension and a Paced Tracing Task," National Aeronautics and Space Administration, Report No. CR-1522, February 1970

2. Kryter, K. D., P. J. Johnson, and J. R. Young, "Psychological Experiments on Noise from Subsonic Aircraft and Sonic Booms at Edwards Air Force Base," Final Report NSBEO-4-67, Stanford Research Institute, Menlo Park, California, August 1968

3. Lukas, J. S. and K. D. Kryter, "Awakening Effects of Simulated Sonic Booms and Subsonic Aircraft Noise on Six Subjects, 7 to 72 Years of Age," National Aeronautics and Space Administration, Report No. CR-1599, May 1970

4. Lukas, J. S. and K. D. Kryter, "A Preliminary Study of the Awakening and Startle Effects of Simulated Sonic Booms," National Aeronautics and Space Administration, Report No. CR-1193, September 1968, pp 2-18

5. Teichner, W. H., E. Arees, and R. Reilly, "Noise and Human Performance, A Psychophysiological Approach," Ergonomics, Vol. 6, No. 1 (January 1963) pp 83-97

6. Davis, R. C., M. Buchwald, and R. W. Frankmann, "Autonomic and Muscular Responses, and Their Relation to Simple Stimuli," Psychol. Monographs, Vol. 69, No. 20, Whole No. 405 (1955), p. 25

7. Walker, Helen M. and J. Lev, Statistical Inference, Henry Holt and Co., New York, 1953, pp 191-194

8. Broadbent, D. E., "Effects of Noise of High and Low Frequency on Behaviour," Ergonomics, Vol. 1 (1957), pp 21-29

9. Jerison, H. J., "Effects of Noise on Human Performance." J. Applied Psychol., Vol. 43 (1959), pp 96-101

10. Warner, H. D., "Effects of Intermittent Noise on Human Target Detection," Human Factors, Vol. 11 (June 1969), pp 245-250

11. Woodhead, Muriel M., "Effects of Bursts of Loud Noise on a Continuous Visual Task," Brit. J. of Industrial Med., Vol. 15 (1958), pp 120-125

12. Woodhead, Muriel M., "Effects of Bursts of Noise on an Arithmetic Task," Amer. J. Psychol., Vol. 77 (1964), pp 627-633

13. Gogan, P., "The Startle and Orienting Reactions in Man. A Study of Their Characteristics and Habituation," Brain Research, Vol. 18 (1970), pp 117-135

14. "Noise: Its Effect on Man and Machine," Report of the Committee on Science and Astronautics, U. S. House of Representatives, House Report No. 2229, 86th Congress, 2nd Session, 1960, p 9

15. Bonvallet, G. L., "Noise Sources in Modern Industry," Noise Control, Vol 1 (1955), pp 30-33

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