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Final Report

EFFECTS OF AIRCRAFT NOISE ON HUMAN ACTIVITIES

(Project NAG-1-22)

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Summary

The goal of this project was to investigate the effects of aircraft noise on human activities by developing a battery of tasks (1) representative of a range of human activities and (2) sensitive to the disruptive effects of noise. The noises used were recordings of jet aircraft and helicopter sounds at three levels of loudness--60, 70, and 80 dB(A).

Experiment 1 investigated 12 different cognitive tasks, along with two intelligibility tasks included to validate that the noises were being effective. Interference with intelligibility was essentially the same as found in the research literature, but only inconsistent effects were found on either accuracy or latency of performance on the cognitive tasks. When the tasks were grouped into four categories (Intelligibility, Matching, Verbal, and Arithmetic), reliable differences in rated annoyingness of the noises were related to the task category and to the type of noise (jet or helicopter).

In Experiment 2 the battery of tasks was reduced to seven, and each task was revised in a way designed to reduce variability of performance. There were even fewer differences in the performance measures. There were still reliable differences in rated annoyingness associated with task category, but the difference in annoyingness due to type of noise was reversed; that is, in this experiment the jet noise was rated as more annoying.

In Experiment 3 the battery of cognitive tasks was reduced to four and a perceptual-motor task (Rotary Tracking) was introduced. In addition, the noises were presented on a quasi-

random intermittent basis at one loudness level (80 dB). No significant differences in performance were found, except that improvement on the Rotary Tracking had a significantly lower slope in the helicopter noise condition than in the other two conditions. As in Experiment 2, the jet noise was consistently rated as more annoying than the helicopter noise, but this difference did not achieve statistical significance. Finally, the subjects were administered a questionnaire in which they were asked to respond to a number of statements concerning the effects of noise on their performance and were asked to rate the suitability of a number of one-word descriptors of the noises. There were no differences in the questionnaire responses between the group exposed to jet noise and the group exposed to helicopter noise.

It was concluded that the failure of the research to produce more substantial results was due primarily to the use of college students as subjects. The upper limit of 80 dB(A) on loudness probably prevented the appearance of any significant interference due to the noise. Also it is doubtful that these subjects were as motivated to perform well as would be the case in a real-world situation.

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Introduction

In determining the effects of noise on human behavior, a wide variety of factors must be considered. In addition to variables associated with the noise source itself, consideration must be given to characteristics of the individual and characteristics of the total environmental situation (Dempsey and Cawthorne, 1979).

Among the relationships needing investigation is that between noise and the kind of activity being engaged in at the time the noise occurs, since it may be expected that some noise/activity combinations will produce a higher level of annoyingness than others (Gunn, Shepherd, and Fletcher, 1975; Wilshire and Powell, 1981; Key and Powell, 1980). There are several difficulties, however, that are intrinsic to the investigation of this problem. First, the variety of human activities is so great that to attempt to investigate all of them would be an impossible task. Second, subjective ratings cannot be generalized beyond the experimental conditions used in a given investigation; consequently, the numerical values for "annoyingness" that are obtained for one set of noise/activity combinations cannot be compared with the values obtained with some other set of noise/activity combinations in a separate investigation.

The present research proposed to circumvent these difficulties by an approach that attacks the problem at a more fundamental and generalizable level. The rationale for the research rested on two explicit considerations:

1. It was assumed that a wide variety of human activities

can be represented by a limited number of psychological tasks that embody a broad range of behavioral processes. On the one hand, there is the spectrum of human activities, involving such behaviors as reading, conversing, watching television, performing routine intellectual tasks (e.g., bookkeeping), performing tasks requiring close attention and skilled movements (e.g., sewing or model building), and tasks requiring problem solving or creative thinking. On the other hand, there is the list of fundamental behaviors traditionally investigated by psychologists, involving such processes as detection, discrimination, recognition, identification, matching, remembering, imagery, and thinking. The goal of this research, therefore, was to develop a reliable set of tasks through which the relevant human activities could be represented by an appropriate set of fundamental processes. Each task was selected to embody one or more of the behavioral processes involved in one or more everyday human activities. Taken as a whole, the entire battery of tasks should be representative of a broad spectrum of human activities.

2. Most of the available data on the relationship between annoyingness and noise indicates that the level of annoyingness is closely related to the loudness of the noise and, at least in the case of aircraft noises, not as closely related to differences in qualitative aspects of the noise (Patterson, Schomer, and Camp, 1977; Powell, 1978; Dempsey and Cawthorne, 1979; Powell and McCurdy, 1982). There is also evidence that the relationship between annoyingness and aircraft noise is very similar to the relationship between annoyingness and the extent to which the

noise interferes with performance on a task (Arnoult and Voorhees, 1980).

The present research proposed to establish a quantitative relationship between interference and annoyingness for each of the tasks in the experimental battery. Since the interference scores are less dependent upon stimulus context effects than are annoyingness ratings, the battery of tasks might function as a set of reference points for future investigations of the annoyingness of other samples of noise. That is, even though the rated annoyingness of two noises may not be directly comparable because the ratings were obtained in different contexts, a comparison of the interference scores for the two noises would assist in evaluating the annoyingness scores. Also, if there are cases in which rated annoyingness and interference are not closely related, this result may indicate that the qualitative properties of the noise need additional investigation.

Experiment 1

The first experiment was designed as an initial screening of tasks selected as potential measures of the effects of aircraft noise on cognitive processes. The tasks selected for screening were chosen on the basis of a thorough coverage of the research literature and were designed to represent, insofar as possible, the range of cognitive factors that had received substantial empirical support. In addition to the cognitive tasks selected for evaluation, two intelligibility tasks were also included. Since the aircraft noises were to be presented by headphones rather than by loudspeakers, performance on the intelligibility tasks would indicate whether this change from the usual procedure had any significant effect on performance in and of itself.

The research was carried out in the Cognitive Research Laboratory at Texas Christian University. This laboratory consists of a 6.7 m by 7.3 m room containing six semi-isolation booths, each 0.76 m by 0.91 m in size. Midway in the row of booths, which are arranged in a shallow arc, is a projection booth from which images can be projected to a screen 4.3 m away. Each booth is equipped with headphones and with an intercom station.

Apparatus. The equipment utilized in the research can be described in terms of four subassemblies: the control center, the relay rack, the audio rack, and the response keyboards.

A. The Control Center. An Apple II Plus microcomputer and disk drive were used to control the sequence of stimulus events and to record the responses. A micromodem permitted the transfer of data to the University's mainframe computer for purposes of data analysis. Two locally-designed circuit boards were added to the microcomputer, one to control the relay rack and one to control the response keyboards.

B. The Relay Rack. The microcomputer was used to select positions on a special I/O board which operated a stepper that determined which noise condition was sent to each of the six booths in which the subjects were located. Operation of the stepper at the end of each noise segment automatically set the noise conditions for the next segment. The relay rack also controlled the operation of the slide projectors.

C. The Audio Rack. This equipment consisted of a reel-to-reel tape deck, a cassette deck, four stereo/audio amplifiers, and a group of potentiometers. The two sound sources (jet aircraft and helicopter) were recorded on the two tracks of the reel-to-reel tape deck. The six channels of three amplifiers were used to establish three levels of each source, with the appropriate loudness levels (60, 70, and 80 dB) for each source determined by the potentiometers. On the intelligibility tasks, the speech component was produced on a cassette deck, and its loudness level was set by means of the fourth amplifier. These acoustic signals were presented to the subjects by means of headphones, and each booth was associated with a different sequence of the seven noise stimuli (two aircraft sources each at three levels of loudness, plus silence). By systematic reassignment of subjects to booths after each task, the order of noise conditions was effectively randomized.

D. The Response Keyboards. The keyboards provided buttons for four different modes of responding: True-False, Same-Different, Multiple-choice, and Numerical. Each keyboard was also provided with red and green indicator lights. When an item was presented and the keyboard had been activated by the computer, the green light was illuminated, along with a similar green light located at the top of the projection screen. When the subject responded and the response had been recorded by the computer, the red light on the keyboard was illuminated. In addition, there was an amber light at the top of the projection screen, and this light was illuminated two seconds prior to the expiration of the response period. The subjects were instructed that, when the amber light comes on, they should respond by guessing rather than omitting the item. Scoring of the responses was in terms of accuracy and in terms of latency.

Subjects. The subjects (19 men and 39 women) were undergraduate Psychology students who volunteered to participate and received academic credit.

Procedure. Subjects were run in groups of six. There were four one-hour sessions spaced over a period of about ten days. In each session the subjects performed two of the tasks in the battery. The fourteen tasks were divided into two comparable sets of seven tasks each, and these sub-batteries were administered to independent sets of subjects (N = 29 in each case).

In subset 1 were the following tasks: Word Intelligibility, Number Comparisons, Mathematical Estimation, Anagrams, Verbal Analogies, Cube Comparisons, and Area Estimation. Subset 2 consisted of: Sentence Intelligibility, Arithmetic Checking, Delta Vocabulary, Nonsense Syllogisms, Form Rotation, Length Estimation, and Necessary Arithmetic. In addition to Intelligibility, which was included for "marker" purposes, the sub-batteries were designed to include Clerical tasks, Overlearned tasks, Verbal Reasoning tasks, Arithmetic Reasoning tasks, Manipulative Visualization tasks, and Visualization/Estimation tasks.

The tasks were constructed in modular form such that each of the noise conditions was presented for 2.5 min, during which time 10 to 21 items were presented, depending on the nature of the task. Each noise was initiated 10 sec before the first item in a task segment and continued for 10 sec after the last item in that segment. There was a one-minute period of silence between noise conditions, during which the subjects rated the "annoyingness" of the noise and the "difficulty" of the task on 7-point scales ranging from "Not at all annoying" (or "difficult") to "Extremely annoying" (or "difficult").

The order of presentation of the noise conditions was different in each of the six subject booths. As the subjects progressed through the tasks they were moved systematically through the booths. This procedure distributed any effects that may have been due to the order of noise conditions or to the angular relationship of the subject to the projection screen.

The last 30-min period of the experiment involved no noise presentations and was devoted to completing the following measures of individual differences: The Group Embedded-figures Test, the Rotter Locus-of-Control Test, a locally developed Test Anxiety Inventory, and a brief questionnaire concerning the subject's reactions to noise.

Instructions. When the subjects arrived for each session they were assigned to the appropriate booths and care was taken to insure that their identification numbers and booth numbers (i.e., order of noise conditions) were correctly communicated to the computer.

The subjects were then instructed as to the nature of the task and were shown one or two sample items. When it was certain that all subjects understood the task and how to respond, the collection of data began. The presentation of the noise conditions, the sequencing of the slides containing the task items, and the recording of the subjects' responses were all controlled by a microcomputer. The experimenter monitored the subjects visually through the glass fronts of the booths and auditorially through open intercom stations, but there was normally no communication between the experimenter and the subjects during the experiment itself. Because the room was dark and the booths were lit, the subjects could not see the experimenter during the trials.

The Task Battery

I. Intelligibility Tasks

A. Word Intelligibility. This task consists of a series of color slides of everyday scenes. As each slide is in view a speaker pronounces three words at five-second intervals. Each word either clearly describes some aspect of the visual scene or clearly does not. As each word is presented, the subject must indicate whether it is "True" or "False" with respect to the scene.

B. Sentence Intelligibility. This task consists of a series of short declarative sentences presented aurally at the rate of one sentence every nine seconds. Each sentence is obviously true or false, if it can be heard clearly. The subject's task is to indicate "T" or "F" as soon as the sentence is completed.

II. Clerical Tasks

A. Number Comparisons. This task consists of a number of slides, each of which contains a pair of numbers that are either identical or differ in one digit. The numbers range in length from eight to fourteen digits and a response must be made within four seconds. The subjects indicate whether the numbers are "Same" or "Different."

III. Overlearned Tasks

A. Arithmetic Estimation. A slide is presented showing a numerical problem in addition, subtraction, multiplication, or division. After six seconds this slide is replaced with one showing four numbers, one of which is closest to the correct answer to the problem. The subject has five seconds to choose the correct number.

B. Arithmetic Checking. Each slide contains an addition problem involving summing four four-digit numbers to produce a five-digit total. On half of the problems there is an error in the sum in the third or fourth digit. The subject has ten seconds to determine whether the problem as shown, is correct or incorrect.

C. Delta Vocabulary. This is a standard multiple-choice vocabulary test. A target word is shown for three seconds, followed by a slide containing four words. The subject has nine seconds to choose the word most similar in meaning to the target word.

D. Anagrams. A slide containing six letters in scrambled order is shown for two seconds, followed by a slide containing a six-letter target word. The subject has five seconds in which to determine whether the scrambled letters are identical to the letters in the target word.

IV. Verbal Reasoning Tasks

A. Analogies. Each slide contains a pair of words that demonstrate a semantic relationship, followed by four pairs of words having various semantic relationships. The subject's task is to determine within thirteen seconds which of the four pairs has the same relationship as the target pair.

B. Nonsense Syllogisms. Each slide contains one of the standard forms of syllogistic reasoning, including both the correct logical forms and the common errors of logic. However, the terms in the propositions are selected to be nonsensical (e.g., All horses are mushrooms). The subject has thirteen seconds in which to determine whether the form of the syllogism is correct, independently of its content.

V. Arithmetic Reasoning Tasks

A. Necessary Arithmetic. Each slide contains a "word problem" in arithmetic, followed by four choices specifying either single or successive arithmetic operations. In thirteen seconds the subject must decide which arithmetic operations would be the proper ones to follow in order to solve the problem.

VI. Manipulative Visualization Tasks

A. Form Rotation. A slide containing a "nonsense" form is shown for two seconds, followed by a slide showing four forms. Three of these forms are planar rotations of the target form, and one is a form that could be obtained only by mirror-image rotation of the target form. The subject has ten seconds to identify the mirror-image rotation.

B. Cube Comparisons. The subjects are shown a slide containing two cubes marked with letters, numbers, and other symbols in the fashion of children's blocks. Three faces of each cube are visible. The task is to determine, from the symbols in view on each block, whether the two blocks could be two orientations of a single block or would have to be two different blocks. The subjects are required to respond "S" or "D" within thirteen seconds.

VII. Visualization/Estimation Tasks

A. Line Estimation. A slide is shown for three seconds containing a straight line of some length in some orientation. It is followed by a slide showing four lines of different lengths and orientations. The task is to select the line that is equal in length to the target line, despite variations in orientation. The subject has eight seconds in which to choose.

B. Area Estimation. A single slide is shown which has a common geometric figure in the top half and four different geometric figures in the bottom half. The subject has eleven seconds to choose from the bottom set the figure that is equal in area to the figure in the top half of the slide.

VIII. Individual Differences Tasks

In addition to the intelligibility and cognitive tasks described above, the subjects were given three tests which were hypothesized to reflect individual differences in performance under noise conditions. These tests were given at the end of the last experimental period, and utilized the standard paper-and-pencil format under normal (no noise) conditions.

A. Rotter Locus-of-Control Test. This test assesses the degree to which an individual perceives himself or herself as being in control of the circumstances of life as opposed to being the relatively helpless victim of circumstance.

B. Group Embedded Figures Test. This test is based on the Gottschalk demonstrations and requires the subject to find a simple geometric form embedded in a complex form. The test is a measure of the Field-independence - Field-dependence dimension.

C. Test Anxiety Scale. This is a self-description inventory designed to reflect the extent to which the person develops anxiety in formal measurement situations.

The data concerning individual differences were collected in connection with a different investigation and will not be considered in this report.

Results

Description of the data

The preliminary battery of fourteen cognitive and intelligibility tasks was administered to a total of 58 subjects. Because some subjects missed some sessions, there were small variations in the number of subjects in each task. The criterion variables were performance scores and latencies to respond; also, mean Annoyingness ratings and Difficulty ratings were calculated.

Since the maximum scores achievable on the different tasks differed because the numbers of items were not equal, error performance is reported in terms of the percent correct responses by task and noise level, as shown in Table 1. The actual means and standard deviations for the Accuracy scores can be found in Table 1A in Appendix A. To facilitate comparisons among the tasks they have been grouped according to the general behavioral requirement involved; that is, there were two intel-

Table 1

Percent correct responses by loudness level and noise type for each task

NOISE LEVEL AND TYPE

TASK	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	88.1	84.2	76.2	61.4	78.1	75.2	52.4
Sentence Intelligibility	97.1	97.8	85.2	66.3	91.1	88.5	42.2
Number Comparisons	58.9	57.2	52.2	57.2	51.2	52.7	54.0
Cube Comparisons	59.7	57.6	62.8	65.2	54.5	62.4	60.7
Area Estimation	47.4	53.3	45.6	50.5	48.1	46.3	47.8
Form Rotation	64.1	65.2	64.4	66.3	65.2	66.3	66.3
Line Estimation	60.7	64.1	63.0	60.0	58.5	58.9	59.6
Anagrams	75.2	73.3	77.8	72.2	70.0	76.7	78.1
Verbal Analogies	47.8	49.3	41.5	45.2	45.9	48.1	50.1
Delta Vocabulary	62.5	67.0	61.0	61.0	64.5	60.5	55.5
Nonsense Syllogisms	61.2	58.0	46.9	58.8	53.6	62.8	51.2
Arithmetic Estimation	56.8	50.7	57.5	50.7	58.9	52.9	54.3
Arithmetic Checking	54.0	52.7	51.2	49.6	48.8	47.7	56.9
Necessary Arithmetic	37.4	37.0	37.8	39.3	36.3	29.3	34.4
Mean	62.2	61.9	58.8	57.4	58.9	59.2	54.5
Std. Dev.	15.7	15.4	14.1	9.2	14.2	14.9	10.4

ligibility tasks, five tasks that required some form of matching of responses to stimuli, four tasks that required verbal processing, and three tasks that were numerical, or arithmetic, in nature. It can be seen from Table 1 that there were considerable variations in level of performance between tasks, ranging from better than 90% correct under some conditions for the intelligibility tasks to less than 40% correct under all conditions for the Necessary Arithmetic task. It can also be observed that, except for the intelligibility tasks, there was only small variation in performance across the various levels of aircraft noise.

Table 2 shows the same data averaged across types of tasks. It can be seen that the best performances were on the intelligibility tasks and poorest performances were on the Arithmetic tasks. Only the intelligibility tasks showed a consistent decrement in performance related to increasing noise levels. Finally, there was a small but generally consistent tendency for performance to be better in the presence of helicopter noise than at comparable levels of jet aircraft noise.

Table 3 shows the mean response latencies for each task calculated as a percent of the available response time per item (LAT%). The actual means and standard deviations for the latency scores are shown in Table 2A in Appendix A. In terms of percent of available time used in responding, the subjects responded, on the average, most quickly in the Sentence Intelligibility task and most slowly in the Arithmetic Checking task. Only in the intelligibility tasks was there any consistent tendency for latency to increase with increasing noise level.

Table 2

Mean percent correct responses by task category
for loudness level and type of noise

NOISE LEVEL AND TYPE

CATEGORY	N	ZERO	H-60	H-70	H-80	H-All	J-60	J-70	J-80	J-All
Intelligibility	2	92.6	91.0	80.7	63.8	78.5	84.6	81.8	47.3	71.2
Matching	5	58.2	59.5	57.6	59.8	59.0	55.5	57.3	57.7	56.8
Verbal	4	61.7	61.9	56.8	59.3	59.3	58.5	62.0	58.7	59.7
Arithmetic	3	49.4	46.8	48.8	46.5	47.4	48.0	43.3	48.5	46.6

Table 3

Mean latencies as a percent of available response time (LAT%) by loudness level and noise type for each task

NOISE LEVEL AND TYPE

TASK	TIME	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	3	43.0	46.7	53.3	63.3	51.7	37.7	73.3
Sentence Intelligibility	9	32.2	33.3	34.3	39.2	33.6	38.4	46.0
Number Comparisons	4	85.0	82.5	82.5	80.0	84.3	84.5	80.8
Cube Comparisons	13	59.3	60.6	57.6	57.4	58.4	59.6	55.8
Area Estimation	11	56.3	55.9	54.4	53.1	54.8	53.0	54.0
Form Rotation	10	69.5	69.7	70.1	69.0	71.6	71.5	66.5
Line Estimation	8	55.5	53.6	55.9	50.9	54.3	55.5	52.6
Anagrams	5	74.6	72.8	74.4	71.4	74.8	74.2	73.4
Verbal Analogies	13	62.5	64.5	64.6	64.2	64.9	61.6	65.3
Delta Vocabulary	9	63.1	63.4	64.3	64.7	63.3	64.2	65.0
Nonsense Syllogisms	13	76.4	72.8	72.1	72.4	73.8	72.7	71.7
Arithmetic Estimation	5	69.2	71.2	70.2	69.6	69.8	72.0	68.8
Arithmetic Checking	10	84.3	86.6	86.4	86.1	87.6	86.5	86.7
Necessary Arithmetic	13	78.2	77.2	78.7	78.7	80.2	79.0	79.2
Mean		64.9	65.1	65.6	65.7	65.9	65.0	67.1
Standard Deviation		15.1	14.4	13.8	12.6	14.6	15.2	11.7

Table 4 shows the same data averaged across types of task. In the intelligibility tasks LAT% was slightly smaller in the presence of helicopter noise than for jet noise, whereas for the other categories of tasks LAT% was essentially the same under both conditions.

Table 5 shows the mean Annoyingness rating (7-point scale) by task and by noise condition. (These same values, along with the associated standard deviations, are shown in Table 3A in Appendix A.) It can be seen that, for all tasks, there was a tendency for rated Annoyingness to increase with increased noise, although, inexplicably, for six tasks the jet noise at 70 dB(A) was rated as less annoying than the same noise at 60 dB(A). Table 6 shows the same data averaged across type of task. It can be seen that the subjects tended to find the aircraft noises less annoying while performing the matching tasks than in the context of the other kinds of tasks. Also, the helicopter noises were rated as more annoying than the jet aircraft noises on all types of tasks. This result may be contrasted with the results shown in Table 2, in which there was a slight tendency for performance to be better under helicopter noise than under jet noise.

There were inconsistencies among the mean annoyingness ratings given to the zero noise condition in the various tasks. For example, the mean annoyingness of this condition across all tasks was 1.75, with a range from 1.30 to 2.20. This variability can be reduced by expressing the mean annoyingness under each of the noise conditions as a ratio of the mean annoyingness under the zero noise condition for each task.

Table 4

Mean LAT% by task category for loudness level and type of noise

NOISE LEVEL AND TYPE

CATEGORY	N	ZERO	H-60	H-70	H-80	H-All	J-60	J-70	J-80	J-All
Intelligibility	2	37.6	40.0	43.8	51.3	45.0	42.7	38.1	59.7	46.8
Matching	5	53.9	64.5	64.1	62.1	63.6	64.7	64.8	61.9	63.8
Verbal	4	69.2	68.2	68.9	68.2	68.4	69.2	68.2	68.9	68.8
Arithmetic	3	77.2	78.3	78.4	78.1	78.3	79.2	79.2	78.2	78.9

Table 5

Mean annoyingness ratings by loudness levels and type of noise for each task

NOISE LEVEL AND TYPE

TASK	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	1.90	3.18	3.03	5.10	3.00	2.91	5.21
Sentence Intelligibility	1.30	3.33	4.90	6.25	3.91	3.25	5.33
Number Comparisons	1.96	3.18	3.36	5.12	3.04	3.22	5.21
Cube Comparisons	1.75	2.92	4.04	5.12	3.04	3.23	4.88
Area Estimation	1.52	2.79	3.32	5.12	3.04	2.62	4.70
Form Rotation	2.20	2.76	3.88	4.87	2.96	2.85	4.77
Line Estimation	1.64	2.71	3.33	4.50	2.42	2.88	4.31
Anagrams	1.76	3.00	4.00	5.23	3.05	3.45	4.62
Verbal Analogies	1.67	2.72	4.12	5.00	2.84	3.16	4.88
Delta Vocabulary	2.14	3.69	4.14	5.17	3.50	3.57	4.62
Nonsense Syllogisms	1.72	2.64	3.56	5.00	2.52	3.00	4.48
Arithmetic Estimation	1.36	2.87	3.79	4.81	2.82	2.81	4.93
Arithmetic Checking	1.72	3.21	3.59	5.09	3.36	3.17	4.96
Necessary Arithmetic	1.92	3.33	4.50	5.32	3.71	4.04	4.79
Mean	1.75	3.02	3.83	5.12	3.09	3.15	4.84
Standard Deviation	0.26	0.30	0.51	0.38	0.42	0.36	0.29

Table 6

Mean annoyingness ratings by task category
for loudness level and type of noise

NOISE LEVEL AND TYPE

CATEGORY	N	ZERO	H-60	H-70	H-80	H-All	J-60	J-70	J-80	J-All
Intelligibility	2	1.60	3.26	3.97	5.68	4.30	3.46	3.08	5.27	3.94
Matching	5	1.81	2.87	3.59	4.95	3.80	2.90	2.96	4.77	3.54
Verbal	4	1.82	3.01	3.96	5.10	4.02	2.98	3.30	4.65	3.64
Arithmetic	3	1.67	3.14	3.96	5.07	4.06	3.30	3.34	4.89	3.84

This transform produces a value that can be called "Adjusted Annoyingness" (A_A). The results of this transform can be seen in Table 7 and Figure 1. For both types of noise (jet and helicopter) there was a consistent ranking of the four categories of tasks in relation to perceived annoyingness. The sounds were regarded as most annoying in the context of intelligibility tasks, followed in order by matching tasks, verbal tasks, and arithmetic tasks.

The means and standard deviations for the Difficulty ratings are shown in Table 4A in Appendix A. No major or consistent differences were found among the tasks or the noise conditions on this measure. By a small margin the Sentence Intelligibility task was rated as overall the easiest and the Arithmetic Checking task was rated as overall the most difficult. Also, 10 of the 14 tasks were rated as more difficult under helicopter noise than jet noise.

Analysis of the data

The accuracy scores and latency scores for all 14 tasks were subjected to an analysis of variance using the regression model. The complete results of that analysis are shown in Table 5A and Table 6A in Appendix A. The three components of the analysis were; Subjects (Ss), Loudness (L_A), and jet vs. helicopter noise (J/H). A hierarchical approach was used, with the variables entered in the order Ss, L_A, J/H.

Intelligibility tasks. For both of these tasks both L_A and J/H were significant variables by the $p = .05$ criterion of significance. In terms of the accuracy measure, Ss was not a significant source of variance, but it was significant for the

Table 7

Adjusted annoyingness (A_A). Mean annoyingness ratings expressed as ratios of the mean ratings under zero noise for each task and task category.

NOISE LEVEL AND TYPE

TASK	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	1.67	1.59	2.68	1.58	1.53	2.74
Sentence Intelligibility	2.56	3.77	4.81	3.01	2.50	4.10
Number Comparisons	1.62	1.71	2.61	1.55	1.64	2.66
Cube Comparisons	1.67	2.31	2.92	1.74	1.84	2.79
Area Estimation	1.84	2.18	3.37	2.00	1.72	3.09
Form Rotation	1.25	1.76	2.21	1.34	1.29	2.17
Line Estimation	1.65	2.03	2.74	1.48	1.76	2.63
Anagrams	1.70	2.27	2.97	1.73	1.96	2.62
Verbal Analogies	1.63	2.47	2.99	1.70	1.89	2.92
Delta Vocabulary	1.72	1.93	2.42	1.64	1.67	2.16
Nonsense Syllogixms	1.53	2.07	2.91	1.46	1.74	2.60
Arithmetic Estimation	2.11	2.79	3.54	2.07	2.07	3.62
Arithmetic Checking	1.87	2.09	2.96	1.95	1.84	2.88
Necessary Arithmetic	1.73	2.34	2.77	1.93	2.10	2.49
CATEGORY						
Intelligibility	2.12	2.68	3.74	2.30	2.02	3.42
Matching	1.61	2.00	2.37	1.62	1.65	2.67
Verbal	1.64	2.18	2.82	1.63	1.82	2.57
Arithmetic	1.90	2.41	3.09	1.98	2.00	3.00

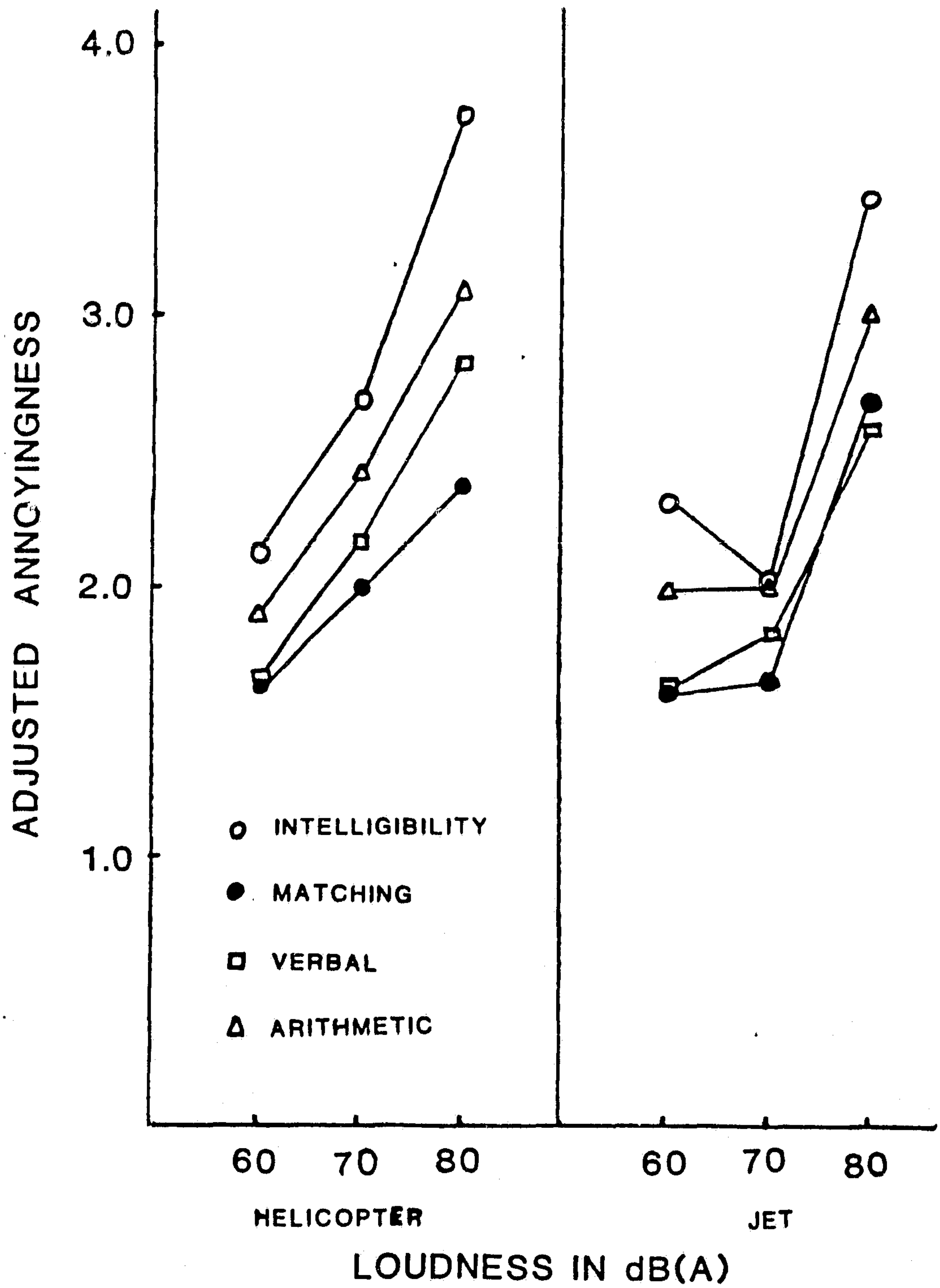

Figure 1. Adjusted Annoyingness by task category, noise type, and loudness level.

latency measure. Also, the contribution of J/H did not reach significance for the latency measure on the Sentence Intelligibility task. The significant role of the L_A and J/H variables on these two tasks was important because intelligibility tasks were included originally as "marker" tasks to demonstrate whether well-established research results could be duplicated with the method of noise production used in this experiment.

Cognitive tasks. In all of the remaining tasks there were only occasional relationships that achieved statistical significance, although the individual differences among subjects (Ss) was by far the major component of variance, exceeding the $p = .01$ level of confidence for both measures on all tasks.

Because this first experiment was exploratory in nature, it was decided that consideration should be given to all relationships that exceeded the $p = .20$ level. By this criterion, the L_A variable reached significance for the accuracy measure on the Number Comparisons task and for the latency measure on Area Estimation, Form Rotation, Line Estimation, Nonsense Syllogisms, and Arithmetic Checking. The J/H variable reached significance for the accuracy measure on Anagrams and Necessary Arithmetic and for the latency measure on Mathematical Estimation.

Since there was a small but consistent tendency for performance to be poorer under jet noise than helicopter noise, relative difficulty of the noise conditions was compared across tasks using the nonparametric sign test. Performance under jet noise was poorer than performance under helicopter noise in 9 of the 14 tasks ($p > .05$); performance under helicopter noise was poorer than under no noise on 8 tasks ($p>.05$); and performance under jet noise was poorer than under no noise on 11 tasks ($p>.05$) (Table 8).

Annoyingness and Difficulty. Overall, the helicopter noises were rated as more annoying than the jet noises on all 14 tasks. Although the mean difference in rated annoyingness was not significant ($.10>p>.05$), the difference between the noise sources was significant by the Sign test ($p<.01$) (see Table 9).

Likewise, the subjects tended to perceive the tasks as more difficult under helicopter noise than under jet noise. Under helicopter noise the subjects rated 10 of the 14 tasks as more difficult, an outcome that was marginally significant by the Sign test ($p<.10$) (Table 10). In general, then, although the subjects tended to perform slightly more poorly under jet noise than under helicopter noise, they perceived the tasks to be more difficult under helicopter noise and rated that noise as more annoying.

Discussion

Experiment 1 was undertaken with two objectives: first, to determine whether the experimental conditions were comparable to those used in other research involving aircraft noise, and second, to provide an initial screening of a battery of cognitive tasks that might be useful in investigating the effects of aircraft noise.

The results obtained with the two intelligibility tasks show that the first objective was successfully achieved. Both accuracy and latencies varied systematically with both L_A and J/H. In addition, the rated annoyingness of the aircraft noises

Table 8

Percent correct responses by task and type of noise

TYPE OF NOISE

TASK	ZERO	HELICOPTER	JET
Word Intelligibility	88.1	73.9	68.6
Sentence Intelligibility	97.1	83.1	73.9
Number Comparisons	58.9	55.5	52.6
Cube Comparisons	59.7	61.9	59.2
Area Estimation	47.4	49.8	47.4
Form Rotation	64.1	65.3	65.9
Line Estimation	60.7	62.4	59.0
Anagrams	75.2	74.4	74.9
Verbal Analogies	47.8	45.3	48.0
Delta Vocabulary	62.5	63.0	60.2
Nonsense Syllogisms	61.2	54.6	55.9
Arithmetic Estimation	56.8	53.0	55.4
Arithmetic Checking	54.0	51.2	51.1
Necessary Arithmetic	37.4	38.0	33.3

Table 9

Mean annoyingness ratings by task, task category, and type of noise

TASK	TYPE OF NOISE HELICOPTER	JET	COMBINED
Word Intelligibility	3.77	3.71	3.74
Sentence Intelligibility	4.83	4.16	4.50
Number Comparisons	3.89	3.82	3.86
Cube Comparisons	4.03	3.72	3.87
Area Estimation	3.74	3.45	3.60
Form Rotation	3.84	3.53	3.68
Line Estimation	3.51	3.20	3.36
Anagrams	4.08	3.71	3.89
Verbal Analogies	3.95	3.63	3.79
Delta Vocabulary	4.33	3.90	4.11
Nonsense Syllogisms	3.73	3.33	3.53
Arithmetic Estimation	3.86	3.52	3.69
Arithmetic Checking	3.96	3.83	3.90
Necessary Arithmetic	4.38	4.18	4.28
CATEGORY			
Intelligibility	4.30	3.94	4.12
Matching	3.80	3.54	3.67
Verbal	4.02	3.64	3.83
Arithmetic	4.07	3.84	3.96

Helicopter vs. Jet

t test:

$M_D = .301$

$S_D = .157$

$t = 1.92$

$.10 > p > .05$

Sign test:

$Z = 13/3.60$

$Z = 3.61$

$p < .01$

Table 10

Mean difficulty ratings by task, task category, and type of noise

TYPE OF NOISE

TASK	HELICOPTER	JET	COMBINED
Word Intelligibility	4.46	3.32	3.89
Sentence Intelligibility	3.77	2.27	3.02
Number Comparisons	4.00	3.80	3.90
Cube Comparisons	3.56	3.56	3.56
Area Estimation	3.29	3.20	3.24
Form Rotation	3.27	3.38	3.38
Line Estimation	3.46	3.15	3.30
Anagrams	3.28	3.16	3.22
Verbal Analogies	3.98	3.59	3.79
Delta Vocabulary	4.06	3.57	3.81
Nonsense Syllogisms	3.86	3.62	3.74
Arithmetic Estimation	3.43	3.26	3.34
Arithmetic Checking	4.88	4.96	4.92
Necessary Arithmetic	4.86	4.91	4.88
CATEGORY			
Intelligibility	4.12	2.80	3.46
Matching	3.52	3.42	3.47
Verbal	3.80	3.48	3.64
Arithmetic	4.39	4.38	4.38

<u>Helicopter vs. Jet</u>

t test:

$M_D = .315$

$S_D = .466$

$t = .676$

$p > .05$

Sign test:

$Z = 10/3.46$

$Z = 2.89$

$.10 > p > .05$

varied in a fashion consistent with previous research in that area. The results obtained with the cognitive tasks, then, could not be attributed to a failure to provide the necessary conditions under which aircraft noise might affect behavior.

In general, the results with the cognitive tasks were disappointing. It should be remembered, however, that these tasks were screened under conditions designed to provide a stringent test of the sensitivity of each task to the effects of noise. The highest value of L_A used was 80 dB, and the noise was continuous. That is, each component in the series of noises was initiated prior to the presentation of the first item in that section of the task, and the noise continued without interruption until after the last item in that series had been presented. Under these conditions the subjects had maximum opportunity to adapt to the presence of the noise.

Although the statistically significant differences found in the cognitive tasks were marginal and scattered, it was nevertheless possible to choose from among the tasks those that appeared to have the greatest promise for further investigation. Consideration was also given to such factors as the absolute difficulty of the task and to the representation of a variety of cognitive factors. The following tasks were chosen to be dropped from the battery; Sentence Intelligibility, Word Intelligibility, Number Comparisons, Area Estimation, Arithmetic Checking, Delta Vocabulary, and Line Estimation. The tasks retained for further investigation were: Nonsense Syllogisms, Form Rotation, Necessary Arithmetic, Mathematical Estimation, Anagrams, Cube Comparisons, and Verbal Analogies. Those seven

Experiment 2

On the basis of the results obtained in Experiment 1, seven tasks were selected for further investigation. Although the most significant relations among noise level, noise type, annoyingness, and difficulty were obtained in the two intelligibility tasks, those tasks were dropped from the battery because they had been included originally only as "marker" tasks used to evaluate the effectiveness of the method of noise presentation. The other tasks dropped were: Number Comparisons, Delta Vocabulary, Arithmetic Checking, Line Estimation, and Area Estimation.

The tasks retained for Experiment 2 were: (1) Matching Tasks: Cube Comparison and Form Rotation; (2) Verbal Tasks: Anagrams, Verbal Analogies, and Nonsense Syllogisms; (3) Arithmetic Tasks: Arithmetic Estimation and Necessary Arithmetic. Most of these tasks were revised in one or more of the following ways: instructions were modified; more, or different, practice items were provided; items were eliminated or revised; and the amount of time allowed for responding was changed.

Subjects. The subjects (33 men and 57 women) were undergraduate psychology students who volunteered to participate and received academic credit.

Apparatus and Procedure. The apparatus and procedure were the same as were used in Experiment 1.

Results

Description of the data

The data from the seven tasks in the revised battery were analyzed in terms of accuracy scores (ACC), latency to correct response (LAT), rated Annoyingness, and rated Difficulty. In addition, an attempt was made to account for the variance in Annoyingness ratings on the basis of Performance (Accuracy and latency), noise level (L_A), and noise type (J/H).

Means and standard deviations for number of correct responses in each task for each noise level and each noise type are shown in Table 1B. Comparable data for latencies to correct responses are shown in Table 2B. In Table 11 are shown the mean percent correct responses for each task at each noise level and for each type of noise. Examination of this table reveals that there were no consistent differences with respect to either noise level or noise type. However, from Table 12 it can be seen that there were consistent differences in level of performance associated with the three categories of tasks represented in the battery.

Comparisons among the tasks on the latency measure are complicated by the fact that different amounts of time were allowed for responding. These differences can be reduced by calculating the mean percentages of the available time used on each task (LAT%). These data are shown in Table 13, and it can be seen that there were no consistent differences in mean LAT% associated with the various noise conditions. Table 14, however, shows that there were consistent differences among the categories of tasks. On the average, subjects responded most promptly on the matching tasks and least promptly on the arithmetic tasks. These differences reflect differences

Table 11

Mean percent correct responses by loudness level and noise type for each task

NOISE LEVEL AND TYPE

TASK	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	61.6	65.5	63.8	62.8	61.1	63.0	63.0
Form Rotation	59.1	56.0	53.9	62.3	59.1	56.6	59.1
Anagrams	34.7	32.5	36.7	42.6	59.6	42.4	37.5
Verbal Analogies	48.7	47.8	50.7	47.0	48.7	48.4	49.6
Nonsense Syllogisms	51.2	51.3	49.2	49.1	50.4	51.8	50.1
Arithmetic Estimation	55.6	55.5	55.4	53.5	55.4	54.9	54.4
Necessary Arithmetic	40.9	43.5	42.6	44.0	43.5	43.9	42.2
Mean	50.3	50.3	50.3	51.6	54.0	51.6	50.8
Std. Dev.	9.7	10.5	8.8	8.2	6.6	7.2	9.0

Table 12

Mean percent correct responses by task category for loudness levels and type of noise

NOISE LEVEL AND TYPE

CATEGORY	N	ZERO	H-60	H-70	H-80	H-All	J-60	J-70	J-80	J-All
Matching	2	60.4	60.8	58.8	62.4	60.7	60.1	59.8	61.1	60.3
Verbal	3	44.9	43.9	45.5	46.2	45.2	52.9	47.5	45.7	48.7
Arithmetic	2	48.3	49.5	49.0	48.8	49.1	49.4	49.4	48.4	49.1

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Table 13

Mean latencies as a percent of available response time (LAT%) by loudness level and noise type for each task.

NOISE LEVEL AND TYPE

TASK	TIME	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	13	69.2	65.2	66.0	65.3	67.0	65.1	65.8
Form Rotation	10	66.9	65.8	66.3	65.8	66.5	66.3	64.2
Anagrams	5	73.2	74.2	72.4	72.2	73.0	72.8	72.4
Verbal Analogies	13	83.5	83.9	81.2	81.6	83.0	84.0	81.8
Nonsense Syllogisms	13	85.5	83.2	80.0	83.9	83.7	81.5	80.2
Arithmetic Estimation	5	71.6	74.4	74.6	71.0	73.8	72.0	72.0
Necessary Arithmetic	13	95.2	95.5	96.3	96.2	94.6	95.9	96.2
Mean		77.8	77.4	76.7	76.5	77.4	76.8	76.1
Std. Dev.		10.4	10.8	10.5	11.2	10.2	11.0	11.0

Table 14

Mean LAT% by task category for loudness level and type of noise

CATEGORY	N	ZERO	H-60	H-70	H-80	H-All	J-60	J-70	J-80	J-All
Matching	2	68.1	65.5	66.2	65.6	65.8	66.8	65.7	65.0	65.8
Verbal	3	80.7	80.4	77.9	79.2	79.2	79.9	79.4	78.1	79.1
Arithmetic	2	83.4	85.0	85.4	83.6	84.7	84.2	84.0	84.1	84.1

in the rates at which the information in the item can be registered and can be processed.

Means and standard deviations for the annoyingness ratings by task and noise condition are shown in Table 3B in Appendix B. As was the case in Experiment 1, the subjects' mean annoyingness ratings for the zero noise condition varied from task to task, with an overall average rating of 1.52 and a range from 1.31 to 1.70. Table 15 shows the mean annoyingness rating as a ratio of the rating given in the zero noise condition for that task, and the same data are depicted graphically in Figure 2. It can be seen that, as in Experiment 1, there were consistent differences related to noise level and to task category.

Means and standard deviations for ratings of Difficulty by task and noise condition are shown in Table 4B in Appendix B. While there were consistent differences in rated Difficulty between tasks, there were no consistent differences related to type of noise or noise level.

Analysis of the data.

The accuracy scores and latency scores were subjected to a repeated measures multiple regression Analysis of Variance in which the variables were subjects (Ss), noise level (L_A), noise level squared (L^2_A), and type of noise (J/H). The results of this analysis are shown in Table 16 and Table 17.

For both measures on all tasks the major part of the variance was accounted for by the variance among subjects, with the amount of variance accounted for ranging from 21.4% to 72%. Except for the Anagrams task, there were only occasional

Table 15

Adjusted Annoyingness (A_A). Mean annoyingness ratings expressed as ratios of the mean ratings under zero noise for each task and task category.

TASK	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	2.65	2.85	3.79	2.66	2.96	4.06
Form Rotation	2.28	2.38	3.22	2.18	2.49	3.18
Anagrams	2.46	2.54	3.72	2.52	2.73	3.64
Verbal Analogies	2.22	2.29	3.06	2.27	2.35	3.13
Nonsense Syllogisms	2.46	2.35	3.26	2.40	2.64	3.39
Arithmetic Estimation	2.17	2.24	3.12	2.14	2.39	3.12
Necessary Arithmetic	2.26	2.39	3.23	2.25	2.53	3.28
CATEGORY						
Matching	2.46	2.62	3.51	2.42	2.72	3.62
Verbal	2.38	2.39	3.35	2.40	2.57	3.39
Arithmetic	2.22	2.32	3.18	2.20	2.46	3.20

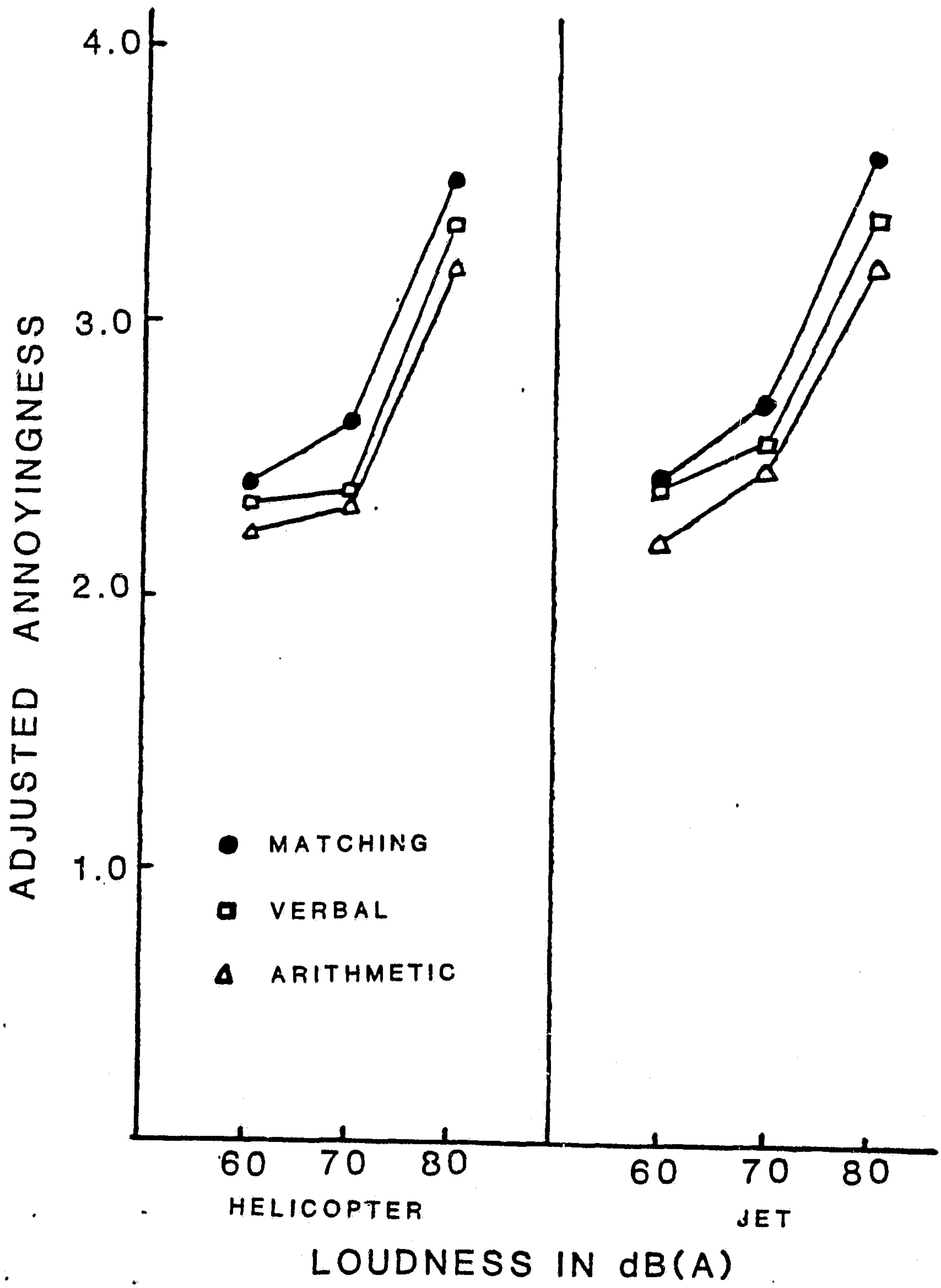

Figure 2. Adjusted Annoyingness by task category, noise type and loudness level.

Table 16

Multiple regression analysis of variance of accuracy scores.

TASK	SOURCE	F	P	R^2_{mult}
Cube Comparisons	Subjects (Ss)	3.54	<.01	.413
	Loudness (L_A)	0.12	n.s.	.413
	Loudness^2 (L_A^2)	0.06	n.s.	.413
	Type (J/H)	1.69	n.s.	.415
Form Rotation	Ss	12.87	<.01	.720
	L_A	2.59	.10	.722
	L_A^2	6.03	.01	.727
	J/H	0.03	n.s.	.727
Anagrams	Ss	1.52	<.01	.214
	L_A	12.74	<.01	.234
	L_A^2	5.89	.02	.244
	J/H	42.71	<.01	.312
Verbal Analogies	Ss	8.26	<.01	.634
	L_A	0.00	n.s.	.634
	L_A^2	2.34	n.s.	.636
	J/H	0.63	n.s.	.636
Nonsense Syllogisms	Ss	3.27	<.01	.395
	L_A	0.90	n.s.	.397
	L_A^2	0.10	n.s.	.397
	J/H	0.95	n.s.	.398
Arithmetic Estimation	Ss	4.60	<.01	.480
	L_A	0.39	n.s.	.481
	L_A^2	0.13	n.s.	.481
	J/H	0.01	n.s.	.481
Necessary Arithmetic	Ss	5.82	<.01	.542
	L_A	0.14	n.s.	.542
	L_A^2	0.01	n.s.	.542
	J/H	0.00	n.s.	.542

Table 17

Multiple regression analysis of latency scores

TASK	SOURCE	F	P	R^2mult
Cube Comparisons	Subjects (Ss)	11.65	<.01	.699
	Loudness (L_A)	0.29	n.s.	.699
	Loudness^2 (L_A^2)	0.13	n.s.	.699
	Type J/H	0.30	n.s.	.699
Form Rotation	Ss	12.14	<.01	.706
	L_A	1.79	n.s.	.707
	L_A^2	0.75	n.s.	.707
	J/H	0.20	n.s.	.707
Anagrams	Ss	10.56	<.01	.676
	L_A	2.31	n.s.	.678
	L_A^2	0.28	n.s.	.678
	J/H	0.14	n.s.	.678
Verbal Analogies	Ss	10.57	<.01	.676
	L_A	2.34	n.s.	.678
	L_A^2	0.00	n.s.	.678
	J/H	0.64	n.s.	.679
Nonsense Syllogisms	Ss	6.47	<.01	.560
	L_A	1.21	n.s.	.561
	L_A^2	3.31	.07	.565
	J/H	0.31	n.s.	.565
Arithmetic Estimation	Ss	4.53	<.01	.470
	L_A	5.21	.02	.477
	L_A^2	0.28	n.s.	.477
	J/H	0.56	n.s.	.478
Necessary Arithmetic	Ss	7.24	<.01	.590
	L_A	0.97	n.s.	.591
	L_A^2	0.24	n.s.	.591
	J/H	0.17	n.s.	.591

significant relationships to be found; L^2_A was significant at the .01 level for error scores on the Form Rotation task and L_A was significant at the .02 level for latency scores on the Arithmetic Estimation task.

On the Anagrams task there were consistent significant relationships among the predictor variables for the analysis of accuracy scores. L_A and J/H were significant at the .01 level, and L^2_A was significant at the .02 level. Altogether, these three variables accounted for 9.8% of the variance, but it should be noted that, overall, only 31.2% of the variance was accounted for by all variables, the smallest value obtained in the analyses.

As was the case in Experiment 1, type of noise (J/H) was related to the Annoyingness and Difficulty ratings by means of the Sign test. Table 18 shows that, in the case of Annoyingness, the jet noise was judged to be more annoying on the six of the seven tasks ($P > .05$). Also (Table 19), six of the seven tasks were judged to be more difficult under the jet noise condition ($p > .05$). Both of these results were opposite to the results obtained in Experiment 1.

Finally, an analysis was performed to determine the amount of variance in the Annoyingness ratings that could be accounted for by the independent variables of the experiment. A hierarchical multiple regression technique was used in which the "Performance" measures, Accuracy (ACC) and Latency-to-correct-response (LAT) were entered first, and the "Stimulus" variables, loudness (L_A) and type (J/H) were entered second. The variance attributable to individual differences among the subjects (Ss)

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Table 18

Mean annoyingness ratings by task, task category, and type of noise.

TASK	HELICOPTER	JET	COMBINED
Cube Comparisons	4.06	4.23	4.14
Form Rotation	4.07	4.06	4.06
Anagrams	3.89	3.97	3.93
Verbal Analogies	4.29	4.39	4.34
Nonsense Syllogisms	4.20	4.38	4.29
Arithmetic Estimation	3.97	4.03	4.00
Necessary Arithmetic	4.33	4.43	4.38
CATEGORY			
Matching	4.06	4.12	4.10
Verbal	4.13	4.25	4.19
Arithmetic	4.15	4.23	4.19

Table 19

Mean difficulty ratings by task, task category, and type of noise.

TASK	HELICOPTER	JET	COMBINED
Cube Comparisons	5.59	5.62	5.60
Form Rotation	3.41	3.57	3.49
Anagrams	2.76	2.66	2.71
Verbal Analogies	3.45	3.65	3.55
Nonsense Syllogisms	3.04	3.05	3.05
Arithmetic Estimation	2.82	2.90	2.86
Necessary Arithmetic	4.28	4.29	4.29
CATEGORY			
Matching	4.50	4.60	4.55
Verbal	3.08	3.12	3.10
Arithmetic	3.55	3.60	3.58

was removed initially. The results of this analysis can be seen in Table 5B in Appendix B. For all tasks, individual differences in the performances of subjects accounted for the major portion of explainable variance. Performance measures (ACC and LAT) accounted for significant amounts of variance on four tasks (Form Rotation, Anagrams, Verbal Analogies, and Arithmetic Estimation), but only on the Anagrams task was the amount of variance accounted for greater than 1% of the total. The Stimulus variables (L_A and J/H) accounted for significant proportions of variance on all tasks, with the actual amount ranging from 12.9% to 24.8%. The coefficients of the Stimulus variables show that in every case the greater proportion of stimulus-related variance could be attributed to the loudness of the sound.

Of more direct interest for this research is the proportion of variance in the Annoyingness ratings accounted for by the Performance and Stimulus variables after the variance due to subjects is removed. Table 20 shows the proportion of the remaining variance accounted for by these variables for each task. The amount of remaining variance accounted for by Performance variables ranged from 0.3% (Nonsense Syllogisms) to 3.5% (Anagrams). For the Stimulus variables the range was from 36.4% (Arithmetic Estimation) to 50.9% (Necessary Arithmetic).

Discussion

The results of Experiment 2 would have to be judged as disappointing in that there was no significant improvement over the results obtained in Experiment 1. Only on the Anagrams task were there consistent significant relationships between a

Table 20

Percent of non-Ss variance in annoyingness ratings accounted for by Performance variables (ACC and LAT) and stimulus variables (L_A and J/H) for each task.

TASK	VARIANCE[a]	PERFORMANCE[b]	STIMULUS[c]
Cube Comparisons	43.1	0.4	44.4
Form Rotation	40.3	1.7	40.2
Anagrams	42.6	3.5	40.6
Verbal Analogies	39.2	1.4	43.6
Nonsense Syllogisms	40.8	0.3	39.5
Arithmetic Estimation	35.4	1.7	36.4
Necessary Arithmetic	48.7	0.4	50.9

[a] Proportion of variance remaining after variance due to Ss is removed.

[b] Proportion of remaining variance accounted for by ACC and LAT.

[c] Proportion of remaining variance accounted for by L_A and J/H.

performance measure (ACC) and the stimulus variables (L_A and J/H). Only occasional and scattered significant values of F were found among the other tasks. As before, there were significant differences among the tasks in terms of the Annoyingness and Difficulty ratings in relation to the type of noise (jet vs. helicopter), but unfortunately, these differences were opposite in direction to the differences found in Experiment 1. In relating the judged Annoyingness to the various tasks it was found that the stimulus properties, especially L_A, accounted for substantial proportions of the variance in every task, but only for the Anagrams task was a substantial proportion of the variance related to the characteristics of the task itself, as reflected by the measures of performance.

It would seem that the marginal results obtained in Experiment 2 were due to the same factors that limited the results obtained in Experiment 1. The highest noise level permissible to use with college student subjects (80dBA) was probably not sufficient to produce large amounts of interference with the subjects' ability to perform the task. Second, the fact that the noise was continuous during the performance of the task items allowed the subjects the opportunity to adapt to the presence of the noise. Although it was not possible to increase the maximum noise level, it was decided that Experiment 3 could incorporate two changes. First, the noise would be presented intermittently on a nonpredictable schedule and, second, a new task requiring precise eye-hand coordination would be introduced.

tasks formed the basis for the research conducted in Experiment 2.

Experiment 3

For the third experiment a number of changes were made in the battery of tasks. First, the number of cognitive tasks was reduced to four: Number Comparisons, Cube Comparisons, Anagrams, and Verbal Analogies. Second, a new perceptual-motor task, called Rotary Tracking, was introduced. Third, the noise was presented on an intermittent rather than continuous basis. Finally, the subjects were asked to complete a detailed questionnaire on their perceptions of the noise and its effects on performance.

Procedure

Apparatus. For this experiment Apple II+ computers with 12 in. color monitors were installed in four of the six subject booths. For the cognitive tasks these devices were only used for recording the Ss' responses, while the task items were displayed on the projection screen, as before. For the Rotary Tracking task, however, the entire task was run on the individual computers, with the master computer used only to insure that all subjects began and ended at the same time. In addition, each of the subjects' computers was equipped with a standard (TG Products) joystick controller.

Tasks. The four cognitive tasks were modified so that the items were presented continuously rather than in modular groups. For the Cube Comparisons, Anagrams, and Verbal Analogies tasks a total of 70 items was presented per task, with the items occupying 15 seconds each, making the entire task last a total of 17.5 minutes. The Number Comparisons task involved a total of 116 items, with each item requiring 9 seconds.

The display for the Rotary Tracking task consisted of a white rectangular box having outside dimensions of 4 cm (horizontal) by 3 cm (vertical) and inside dimensions of 2.75 cm by 1.5 cm. The center of the box followed an elliptical path having a horizontal diameter of 15.5 cm and a vertical diameter of 8.5 cm. The cursor, which was controlled by the joystick, was a solid red rectangle having a horizontal extent of 1.25 cm and a vertical extent of 0.75 cm. The box made one complete loop every 10 sec, and the total path was divided into 31 scoring "windows". The subject could score one point by placing any part of the cursor inside of the inner boundary of the box, so that possible scores ranged from 0 to 31 on each loop. At the completion of each loop, the S's score for that loop was displayed in the lower right-hand corner of the screen. The task was run continuously for a total of 95 loops, which required 16 min. Because the cursor was quite difficult to control, the task required a high level of concentration and delicate manipulation of the joystick.

At the completion of each task the Ss rated the Annoyingness of the noise on the same seven-point scale used in previous experiments. During the final experimental session the Ss were asked to complete an 18-item questionnaire concerning their perceptions of the effects of the noise on their performance on the tasks. Following the questionnaire they were given a list of 10 adjectives which were to be rated on a seven-point scale with respect to their "appropriateness" as descriptors of the noise. A copy of the questionnaire is included in Appendix C.

Noise. The experiment involved three noise conditions, each of which utilized a separate group of Ss: Group 1 (N = 29) received jet aircraft noise at 80 dB(A); Group 2 (N = 31) received helicopter noise at 80 dB(A); Group 3 (N = 28) was a Silence condition.

The pattern of alternating noise and silence was established by a quasi-random sequence based on a modular duration. Table 21 shows that for the cognitive tasks the module was 6 sec, and the durations ranged from 6 sec to 30 sec with the frequencies shown. Altogether, there were 34 periods of noise and 34 periods of silence. For the Rotary Tracking task the modular duration was 10 sec, and the durations ranged from 10 sec to 50 sec with the frequencies shown. There were 17 periods of noise and 17 periods of silence. For both kinds of tasks the pattern of noise was counterbalanced across the first and second halves of the tasks.

Subjects. The subjects were 32 male and 56 female undergraduate Psychology students at Texas Christian University. They volunteered to participate as partial completion of a course requirement. Because not all subjects appeared at every session, the number of subjects per condition in the cognitive tasks ranged from 20 to 30. An error in the computer program led to the loss of additional data in the Rotary Tracking task, so that the number of usable subjects in that task ranged from 14 to 16.

Results

Description of the data.

The data were examined, first, with respect to the accuracy of performance on all tasks under the three noise conditions.

Table 21

Durations of noise and silence used in the quasi-random intermittent presentation of noise

COGNITIVE TASKS		ROTARY TRACKING	
Duration (in sec)	Frequency of Occurrence	Duration (in sec)	Frequency of Occurrence
6	8	10	4
12	28	20	12
18	24	30	10
30	8	40	2
		50	6

Table 22

Mean percent correct by type of noise for each task

		HELICOPTER			JET		
TASK	SILENCE	NOISE	SILENCE	MIXED	NOISE	SILENCE	MIXED
Number Comparisons	42.91	44.95	42.07	43.19	46.14	46.31	46.22
Cube Comparisons	46.90	43.20	46.91	45.93	49.0	52.80	50.90
Anagrams	57.67	53.59	50.17	51.04	51.45	53.89	52.11
Verbal Analogies	31.31	27.23	28.48	27.76	31.20	27.31	29.26
Rotary Tracking[1]	19.35	23.0	24.41	23.68	19.78	20.65	20.42

[1] Percent of total possible score

Second, the Annoyingness ratings were compared by task and by noise condition. Finally, the responses to the Questionnaire items were considered.

Accuracy. Means and standard deviations for number of correct responses by task and type of noise are shown in Table 1C in Appendix C. Since the maximum possible score was not the same for all tasks, the data are shown in terms of mean percent correct in Table 22. Within each noise condition the data are also separated according to whether or not the noise was actually present. It can be seen that on the Matching tasks performance was essentially unaffected by the noise. On the Verbal tasks performance tended to be better in the Silence condition than in the noise conditions, but this difference did not hold up within the intermittent noise conditions. On the Rotary Tracking task there was no consistent pattern of differences. On all of the cognitive tasks performance under jet noise was superior to performance under helicopter noise, but this was not the case for the Rotary Tracking task.

It may be noted that the Ss found all of the tasks to be quite difficult. On both of the matching tasks performance was generally slightly below chance levels (50%). On the Verbal Analogies task chance performance was 25%, so performance slightly exceeded chance on both of the verbal tasks. Chance performance could not be calculated for the Rotary Tracking task, but performance was well below the maximum possible score. The Ss did, however, show improvement in performance on that task as a consequence of practice. Figure 3 and Table 23 show performance for the three groups in relation to successive

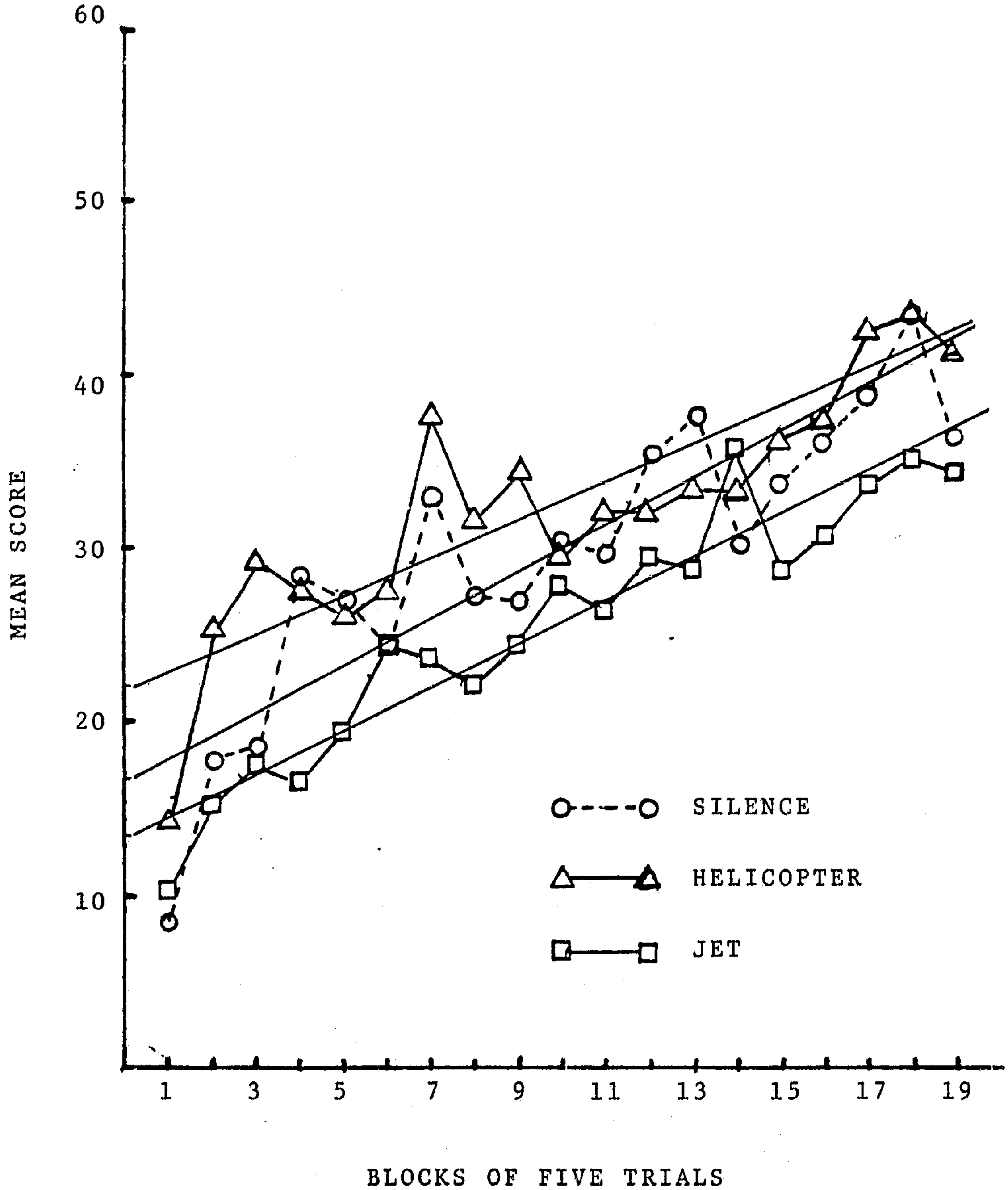

Figure 3. Scores on the Rotary Tracking task by groups across blocks of five trials.

Table 23

Mean performance scores on the Rotary Tracking task for each noise group. The 95 trials have been grouped into 19 blocks of 5 trials each.

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SILENCE	8.4	17.7	18.7	28.2	27.0	24.5	32.9	27.1	26.7	30.2	29.8	35.3	37.6	30.2	33.8	36.1	38.8	43.2	36.4
HELICOPTER	14.3	25.2	29.2	27.9	26.5	27.5	37.6	31.5	34.2	29.6	32.1	32.1	33.2	33.4	36.5	37.4	42.5	43.4	41.1
JET	10.2	15.2	17.5	16.7	19.3	24.2	23.1	22.0	24.7	27.9	26.5	29.3	28.9	35.9	28.8	30.7	33.7	35.1	34.7

Table 24

Linear regression of performance on blocks of trials for the Rotary Tracking task

GROUP	R	R^2	SLOPE	INTERCEPT
SILENCE	.872	.760	1.288	16.72
HELICOPTER	.857	.734	1.046	21.92
JET	.952	.906	1.237	13.12

Table 25

Mean annoyingness ratings by type of noise for each task

TASK	HELICOPTER	JET
Number Comparisons	3.65	3.95
Cube Comparisons	3.24	3.71
Anagrams	2.80	2.92
Verbal Analogies	4.03	4.04
Rotary Tracking	2.43	2.52
Mean	3.23	3.43
Std. Dev.	0.64	0.67

blocks of five trials. On the first block of trials scores were around 7% of maximum, whereas on the final block of trials scores were about 24% of maximum. The data in Table 24 show that all three performance curves could be rather closely fitted with a linear regression model, with some suggestion that the rate of improvement for the Helicopter group was less steep than for the other two groups.

Annoyingness. Annoyingness ratings were collected at the completion of each task. Table 25 shows the mean annoyingness rating for each task and for each type of noise. (Ratings were not collected from the Silence group.) The Jet Noise was consistently rated as more annoying than the Helicopter Noise, a result that is consistent with the results obtained in Experiment 2.

Questionnaire. Table 26 shows the mean rating assigned to each questionnaire item and each descriptor by each of the noise groups. Certain items, as indicated, have been reflected so that high ratings consistently indicate negative feelings about the noise.

On the questionnaire both groups gave the highest rating to Item 15, indicating agreement with the statement, "The noise would probably have bothered me more if it had been louder." In rating the descriptors the Helicopter group gave the highest rating to Item 20, rejecting the description of the noise as "soothing", and the second highest rating to Item 28, rejecting the description of the noise as "stimulating". The Jet group also gave these items the two highest average ratings, but in opposite order.

Table 26

Means and standard deviations for rating responses to the questionnaire. For items 1 through 18 the anchor points of the 7-point scale were "Disagree-Agree"; for items 19 through 28 the anchor points were "inappropriate-Appropriate". Items 2, 5, 6, 7, 17, 18, 20, 21, 24, 26, and 28 have been reflected so that high scores consistently indicate negative feelings about the noise.

STATEMENTS

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
HELICOPTER	5.44	3.48	3.50	4.12	4.85	4.89	5.67	5.23	3.26	4.59	3.00	2.48	3.73	4.56	5.74	4.22	2.81	3.52
	1.55	1.67	1.84	1.77	1.92	1.58	1.18	2.02	1.93	1.98	1.44	1.12	1.95	1.85	1.77	1.65	1.82	2.06
JET	5.54	3.77	3.46	4.08	4.88	4.65	5.54	5.23	3.31	5.15	3.19	3.12	3.81	5.54	5.85	4.23	2.38	3.69
	1.60	1.61	1.72	1.57	1.63	1.57	1.10	1.53	1.78	1.76	1.55	1.58	1.96	1.75	1.32	1.53	1.33	1.59

DESCRIPTORS

GROUP	19	20	21	22	23	24	25	26	27	28
HELICOPTER	4.67	6.44	4.69	4.30	4.89	5.89	4.89	5.78	3.85	6.11
	1.98	1.01	1.49	1.26	1.78	1.58	1.80	1.60	1.92	1.42
JET	4.69	5.77	4.67	4.12	4.65	5.58	4.58	5.15	4.12	5.96
	1.32	1.45	1.37	1.37	1.50	1.55	1.39	1.89	1.36	1.22

Analysis of the data.

Performance. Analysis of the performance data obtained on the four cognitive tasks revealed no significant differences among the three noise conditions.

Although there appeared to be differences between the groups on the Rotary Tracking task (see Figure 3), analysis of the data revealed no differences achieving statistical significance. The large amount of within-group variance suggested that there were substantial differences among the Ss with respect to such factors as initial aptitude, past experience with such tasks, and motivation. Two procedures were adopted in an attempt to reduce this variance. First, atypical subjects were identified by correlating the scores of each individual with the average scores for all subjects. Those subjects whose correlations were either zero or negative were dropped. This procedure eliminated one subject from each of the noise groups and five subjects from the Silence group. Second, each subject's scores were fitted to a linear regression model and the resulting regression equations used to generate adjusted scores for all subjects. These adjusted scores were then subjected to a repeated measures Analysis of Variance. The results of the ANOVA showed no significant differences among the group means ($F = 1.06$, $p > .05$), significant differences across trial blocks ($F = 107.72$, $p < .01$), and a significant Trials by Groups interaction ($F = 2.49$, $p < .01$). The significant interaction was related to a slower rate of improvement for the Helicopter group than for the other two groups. The adjusted means, slopes, and intercepts are shown in Table 27.

Table 27

Means, standard deviations, slopes, and intercepts for adjusted performance scores on the Rotary Tracking task

GROUP	MEAN	STD. DEV.	SLOPE	INTERCEPT
SILENCE	32.97	10.5	1.834	14.72
HELICOPTER	38.90	6.11	1.08	22.05
JET	25.82	8.57	1.523	10.59

Annoyingness. Although the Jet noise was consistently rated as more annoying than the Helicopter noise on all tasks (see Table 25), the mean differences were not significant by either parametric or nonparametric tests.

Questionnaire. Analysis of the responses to the questionnaire items revealed that the subjects in the two noise groups responded in very similar fashion. In rating the statements (Items 1 through 18) the ratings of the two groups correlated highly ($r = .949$). In rating the appropriateness of the descriptive terms (Items 19 through 28) the correlation was even higher ($r=.961$).

Discussion

This experiment introduced two new features: the noise was presented in a quasi-random intermittent fashion and a new task, Rotary Tracking, was included in the battery. The introduction of intermittent noise had no significant effect on performance in the cognitive tasks. In fact, the differences between performance under noise and in silence were even smaller than in the previous experiments. On the Rotary Tracking task, even though the differences in mean performance were not significant, analysis showed that the subjects performing under helicopter noise improved at a significantly slower rate than the subjects experiencing intermittent jet noise or silence. However, the number of subjects in each group was small enough that it was not possible to rule out the possibility that the result was due to sampling differences.

As was the case in Experiment 2 the average annoyingness ratings were higher for the Jet noise condition than for the Helicopter condition on all tasks, but these differences were not statistically significant. It is worth noting, perhaps, that the lowest ratings of annoyingness occurred on the perceptual-motor task. The Questionnaire results were generally in accord with *a priori* expectations with regard to the reactions of the subjects to the noise, but they did not produce any significant differences between the types of noise.

Conclusions

It is clear that the primary goal of the research project was not achieved. While a number of interesting results were obtained and a substantial amount of information was gathered that would be useful in planning future research, the research program did not result in a battery of tasks that are sensitive to possible disrupting effects of aircraft noise on human activities.

Experiment 1 demonstrated, in the context of the intelligibility tasks, that the technique used to present the aircraft noises to the subjects was effective; that is, in those tasks essentially the same results were obtained as in other research using different means of providing the noise stimuli. Also, this experiment showed that there appeared to be differences in the rated annoyingness of the two kinds of noise as a function of the class of tasks used. It was tentatively concluded that failure to get significant differences in performance was due, first, to unreliability of the tasks and, second, the fact that the noise was continuous rather than intermittent.

Experiment 2 was designed primarily to overcome the first of these problems, so most of the tasks retained in the battery were revised in ways designed to improve the stability of the subjects' performances. The results showed even fewer differences by task, noise level, and noise type than had occurred in Experiment 1. Again, however, there were reliable differences in the annoyingness ratings related to the categories of tasks, but the results were opposite to those obtained in Experiment 1, in that the Jet noise was now regarded as more annoying.

In Experiment 3 the battery of cognitive tasks was reduced even further, the noise was presented intermittently, and a new kind of task, Rotary Tracking, was introduced. Even the occasional performance differences that had occurred on the cognitive tasks in the previous experiments failed to materialize under intermittent noise. In the new task there was evidence that the subjects practicing under the helicopter noise condition improved at a significantly slower rate than the subjects working under the other two conditions, but that result needs replication before it can be accepted with assurance. As in Experiment 2, the Jet noise was consistently rated as more annoying than the Helicopter noise, but the differences were not statistically significant.

When the research program was undertaken it was considered that there were two primary bases on which it might be plausibly expected that noise would interfere with cognitive processes. It is possible that a loud noise might so dominate the sensorium that there would literally be less "cortical machinery" to be used for covert processing of information. If this process were to occur, its effects should be most evident in tasks requiring covert auditory processing; that is, tasks involving the covert manipulation of verbal or mathematical symbols should show the greatest interference. Tasks requiring covert manipulation of visual imagery should be less affected. The other basis on which interference might be expected would be as a secondary effect of the emotional disturbance produced by the annoyingness of the noise. If this effect were occurring, it should affect all tasks to about the same extent.

The results of the research failed to support either of these expectations, and it is the opinion of the investigators that the major reason for the failure, in retrospect, was the nature of the subject population used. It is quite possible that either or both of the kinds of interference postulated do occur in noisy situations, but the level of noise required is higher than the highest level used.

The current requirements for safeguarding the health of student subjects, although very commendable in principle, can have the effect of unnecessarily limiting the range of aversive stimulus conditions to which subjects can be exposed. In terms of the exposure durations used in the present research, loudnesses of 90 dB(A), or even 95 dB(A), would have been within acceptable limits from the point of view of industrial standards, whereas the upper limit actually used, 80 dB(A), was probably too low to generate the kinds of interference expected under either of the proposed mechanisms.

Another significant factor, probably related to the population from which the subjects were drawn was the subjects' attitudes toward the noise and toward the tasks. Although the subjects expressed some annoyingness toward the noises, individuals in that age group are regularly exposed voluntarily to much high loudness levels and are probably able to tolerate loud sounds with more equanimity than older age groups. Furthermore, since the subjects did not have a large motivational stake in performing well on the tasks, the presence of the noise did not generate any substantial emotional consequences based on perceiving oneself as doing poorly.

In summary, it is the investigators' opinion that the research approach used in this project can be a productive way to investigate the effects of aircraft noise on human activities, but the research needs to be performed with higher loudness levels and with a more mature subject sample highly motivated to perform well on the tasks.

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Appendix A

Table 1A

Means and standard deviations for accuracy scores by type of noise (helicopter or jet) and loudness level (L_A) for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	Mean	18.50	17.70	16.00	12.90	16.40	15.80	11.00
	Std. Dev.	2.43	3.70	2.98	3.57	3.54	4.17	3.40
Sentence Intelligibility	Mean	14.56	14.67	12.78	9.94	13.67	13.28	6.33
	Std. Dev.	0.50	0.47	1.44	2.44	1.37	2.42	2.52
Number Comparisons	Mean	10.60	10.30	9.40	10.30	9.21	9.48	9.72
	Std. Dev.	2.74	3.30	2.99	3.52	3.78	3.75	3.53
Cube Comparisons	Mean	5.97	5.76	6.28	6.52	5.45	6.24	6.07
	Std. Dev.	1.83	1.99	1.96	2.01	2.34	1.94	2.15
Area Estimation	Mean	4.74	5.33	4.56	5.05	4.81	4.63	4.78
	Std. Dev.	1.88	2.00	2.02	1.69	1.68	2.39	2.42
Form Rotation	Mean	6.41	6.53	6.44	6.63	6.52	6.63	6.63
	Std. Dev.	2.68	2.35	2.23	2.39	2.32	2.15	2.48
Line Estimation	Mean	6.07	6.41	6.30	6.00	5.85	5.89	5.96
	Std. Dev.	1.49	1.73	2.03	1.63	1.63	1.85	1.91
Anagrams	Mean	7.52	7.33	7.78	7.22	7.00	7.67	7.81
	Std. Dev.	1.77	1.72	1.93	1.99	1.66	1.78	1.54
Verbal Analogies	Mean	4.78	4.93	4.15	4.52	4.59	4.81	5.07
	Std. Dev.	2.69	2.37	2.55	2.01	2.30	2.09	1.80
Delta Vocabulary	Mean	6.25	6.70	6.10	6.10	6.45	6.05	5.55
	Std. Dev.	1.92	2.05	1.97	2.14	1.66	1.88	1.69
Nonsense Syllogisms	Mean	6.12	5.80	4.69	5.88	5.36	6.28	5.12
	Std. Dev.	1.70	1.55	2.09	1.68	1.44	1.78	1.68
Arithmetic Estimation	Mean	5.68	5.07	5.75	5.07	5.89	5.29	5.43
	Std. Dev.	2.07	2.09	2.15	2.03	2.02	2.17	2.03

Table 1A (Continued)

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Arithmetic	Mean	5.40	5.27	5.12	4.96	4.88	4.77	5.69
Checking	Std. Dev.	1.80	1.77	1.97	1.83	1.50	1.60	1.61
Necessary	Mean	3.74	3.70	3.78	3.93	3.63	2.93	3.44
Arithmetic	Std. Dev.	1.92	1.88	1.71	1.65	1.59	1.59	1.66
All	Mean	7.60	7.54	7.08	6.79	7.12	7.12	6.33
Tasks	Std. Dev.	4.17	2.74	3.48	2.55	3.64	3.52	1.99

Table 2A

Means and standard deviations for latency scores by type of noise (helicopter or jet) and loudness level (L_A) for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word Intelligibility	Mean	1.29	1.40	1.60	1.90	1.55	1.13	2.20
	Std. Dev.	0.44	0.50	0.42	0.79	0.47	0.61	0.72
Sentence Intelligibility	Mean	2.90	3.00	3.09	3.53	3.02	3.46	4.14
	Std. Dev.	0.33	0.29	0.37	0.84	0.38	0.87	1.89
Number Comparisons	Mean	3.40	3.30	3.30	3.20	3.37	3.38	3.23
	Std. Dev.	0.67	0.25	0.67	0.72	0.70	0.68	0.69
Cube Comparisons	Mean	7.71	7.88	7.49	7.46	7.59	7.75	7.25
	Std. Dev.	2.33	1.79	2.35	2.40	2.12	2.24	2.27
Area Estimation	Mean	6.19	6.15	5.98	5.84	6.03	5.83	5.94
	Std. Dev.	1.40	1.43	1.61	1.34	1.48	1.40	1.46
Form Rotation	Mean	6.95	6.97	7.01	6.90	7.16	7.15	6.65
	Std. Dev.	1.15	1.05	1.01	1.12	1.13	1.08	1.10
Line Estimation	Mean	4.44	4.29	4.47	4.07	4.34	4.44	4.21
	Std. Dev.	0.71	0.60	0.67	0.66	0.76	0.78	0.69
Anagrams	Mean	3.73	3.64	3.72	3.57	3.74	3.71	3.67
	Std. Dev.	0.35	0.42	0.42	0.56	0.38	0.34	0.41
Verbal Analogies	Mean	8.13	8.39	8.40	8.35	8.44	8.01	8.49
	Std. Dev.	4.02	4.03	4.15	4.10	4.17	3.96	4.16
Delta Vocabulary	Mean	5.68	5.71	5.79	5.82	5.70	5.78	5.85
	Std. Dev.	0.79	0.97	0.84	0.87	0.60	0.69	0.78
Nonsense Syllogisms	Mean	9.93	9.47	9.37	9.41	9.59	9.45	9.32
	Std. Dev.	1.16	1.38	1.39	1.25	1.46	1.37	1.26
Arithmetic Estimation	Mean	3.46	3.56	3.51	3.48	3.49	3.60	3.44
	Std. Dev.	0.54	0.48	0.45	0.52	0.50	0.51	0.53

Table 2A (Continued)

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Arithmetic	Mean	8.43	8.66	8.64	8.61	8.76	8.65	8.67
Checking	Std. Dev.	0.91	0.52	0.57	0.70	0.56	0.68	0.70
Necessary	Mean	10.17	10.04	10.23	10.23	10.42	10.27	10.29
Arithmetic	Std. Dev.	1.01	1.65	0.98	1.19	0.74	1.35	1.24
All	Mean	5.89	5.89	5.90	5.88	5.96	5.90	5.95
Tasks	Std. Dev.	2.77	2.74	2.69	2.65	2.77	2.72	2.56

Table 3A

Means and standard deviations for Annoyingness ratings by type of noise (helicopter or jet) and loudness level (L_A) for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word	Mean	1.90	3.18	3.03	5.10	3.00	2.91	5.21
Intelligibility	Std. Dev.	1.03	1.54	1.64	1.59	1.37	1.51	1.42
Sentence	Mean	1.30	3.33	4.90	6.25	3.91	3.25	5.33
Intelligibility	Std. Dev.	0.46	1.41	1.37	1.30	1.24	1.71	2.05
Number	Mean	1.96	3.18	3.36	5.12	3.04	3.22	5.21
Comparisons	Std. Dev.	1.09	1.58	1.60	1.65	1.43	1.42	1.53
Cube	Mean	1.75	2.92	4.04	5.12	3.04	3.23	4.88
Comparisons	Std. Dev.	1.09	1.38	1.78	1.45	1.29	1.58	1.67
Area	Mean	1.52	2.79	3.32	5.12	3.04	2.62	4.70
Estimation	Std. Dev.	0.98	1.15	1.80	1.48	1.12	1.44	1.46
Form	Mean	2.20	2.76	3.88	4.87	2.96	2.85	4.77
Rotation	Std. Dev.	1.57	1.58	1.69	1.90	1.60	1.79	1.74
Line	Mean	1.64	2.71	3.33	4.50	2.42	2.88	4.31
Estimation	Std. Dev.	1.13	1.67	1.89	1.93	1.75	1.87	2.11
Anagrams	Mean	1.76	3.00	4.00	5.23	3.05	3.45	4.62
	Std. Dev.	1.27	1.66	1.48	1.56	1.16	1.47	1.70
Verbal	Mean	1.67	2.72	4.12	5.00	2.84	3.16	4.88
Analogies	Std. Dev.	0.94	1.46	1.39	1.52	1.08	1.22	1.56
Delta	Mean	2.14	3.69	4.14	5.17	3.50	3.57	4.62
Vocabulary	Std. Dev.	1.55	1.90	1.92	2.07	2.03	1.76	2.13
Nonsense	Mean	1.72	2.64	3.56	5.00	2.52	3.00	4.48
Syllogisms	Std. Dev.	1.43	1.69	1.81	1.67	1.70	1.85	2.02
Arithmetic	Mean	1.36	2.87	3.79	4.81	2.82	2.81	4.93
Estimation	Std. Dev.	0.62	1.30	1.47	1.64	1.34	1.52	1.63

Table 3A (Continued)

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Arithmetic	Mean	1.72	3.21	3.59	5.09	3.36	3.17	4.96
Checking	Std. Dev.	1.40	1.87	1.90	1.98	1.76	1.88	1.71
Necessary	Mean	1.92	3.33	4.50	5.32	3.71	4.04	4.79
Arithmetic	Std. Dev.	1.58	1.93	2.34	1.85	1.99	1.81	2.14

Table 4A

Means and standard deviations for Difficulty ratings by type of noise (helicopter or jet) and loudness level (L_A) for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Word	Mean	3.67	4.18	4.81	4.40	3.70	2.86	3.39
Intelligibility	Std. Dev.	2.25	1.80	2.30	2.22	1.90	1.69	1.74
Sentence	Mean	3.10	3.30	4.78	3.22	1.73	2.18	2.91
Intelligibility	Std. Dev.	2.39	2.33	2.15	2.70	1.14	1.70	1.88
Number	Mean	3.63	3.72	4.33	3.96	3.76	3.48	4.15
Comparisons	Std. Dev.	1.47	1.46	1.47	1.65	1.41	1.34	1.41
Cube	Mean	3.41	3.50	3.67	3.52	3.29	3.69	3.70
Comparisons	Std. Dev.	1.64	1.67	1.84	1.79	1.67	1.68	1.70
Area	Mean	3.22	3.08	3.42	3.37	3.16	3.23	3.21
Estimation	Std. Dev.	1.31	1.30	1.53	1.41	1.25	1.45	1.41
Form	Mean	3.56	3.11	3.12	3.59	3.42	3.19	3.54
Rotation	Std. Dev.	1.70	1.79	1.61	1.79	1.78	1.57	1.62
Line	Mean	3.32	3.20	3.59	3.58	3.04	3.12	3.30
Estimation	Std. Dev.	1.62	1.41	1.68	1.78	1.31	1.80	1.46
Anagrams	Mean	2.95	3.24	3.38	3.21	3.10	3.14	3.24
	Std. Dev.	1.43	1.63	1.84	1.61	1.54	1.55	1.57
Verbal	Mean	3.67	3.64	4.04	4.26	3.59	3.32	3.87
Analogies	Std. Dev.	1.46	1.61	1.85	1.29	1.64	1.43	1.51
Delta	Mean	3.71	4.46	4.08	3.64	3.86	3.15	3.69
Vocabulary	Std. Dev.	1.48	1.50	1.64	1.44	1.41	1.51	1.43
Nonsense	Mean	3.80	3.62	4.08	3.87	3.52	3.43	3.92
Syllogisms	Std. Dev.	1.72	1.84	1.74	1.92	1.68	1.84	1.57
Arithmetic	Mean	2.96	3.44	3.42	3.42	3.22	3.12	3.44
Estimation	Std. Dev.	1.07	1.06	1.34	1.36	1.29	1.01	1.07

Table 4A (Continued)

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Arithmetic	Mean	5.08	4.62	5.31	4.72	4.88	4.92	5.08
Checking	Std. Dev.	1.66	1.80	1.46	1.87	1.80	1.64	1.75
Necessary	Mean	4.56	4.65	4.92	5.00	4.96	4.65	5.12
Arithmetic	Std. Dev.	1.89	1.69	1.71	1.63	1.74	1.80	1.65

Table 5A

Regression analysis of accuracy scores. The variables were entered in the order: Subjects (Ss), Loudness (L_A), Noise Type (J/H).

TASK	SOURCE	F	P	R^2_{mult}
Word Intelligibility	Ss	1.08	n.s.	.099
	L_A	68.68	<.01	.384
	J/H	7.65	<.01	.448
Sentence Intelligibility	Ss	1.21	n.s.	.064
	L_A	136.42	<.01	.487
	J/H	30.54	<.01	.677
Number Comparisons	Ss	5.62	<.01	.478
	L_A	2.54	.11	.487
	J/H	0.32	n.s.	.490
Cube Comparisons	Ss	5.89	<.01	.488
	L_A	1.34	n.s.	.493
	J/H	1.23	n.s.	.503
Area Estimation	Ss	4.85	<.01	.448
	L_A	0.13	n.s.	.449
	J/H	0.67	n.s.	.454
Form Rotation	Ss	10.72	<.01	.640
	L_A	0.01	n.s.	.640
	J/H	0.19	n.s.	.642
Line Estimation	Ss	2.67	<.01	.298
	L_A	0.00	n.s.	.298
	J/H	1.40	n.s.	.316
Anagrams	Ss	14.14	<.01	.693
	L_A	0.33	n.s.	.694
	J/H	2.33	.10	.704

Table 5A (Continued)

TASK	SOURCE	F	P	R^2mult
Verbal Analogies	Ss	9.64	<.01	.611
	L_A	0.12	n.s.	.611
	J/H	1.25	n.s.	.617
Delta Vocabulary	Ss	7.12	<.01	.525
	L_A	0.17	n.s.	.526
	J/H	1.54	n.s.	.545
Nonsense Syllogisms	Ss	3.50	<.01	.364
	L_A	0.67	n.s.	.368
	J/H	0.15	n.s.	.370
Arithmetic Estimation	Ss	6.32	<.01	.507
	L_A	0.89	n.s.	.510
	J/H	0.74	n.s.	.515
Arithmetic Checking	Ss	3.85	<.01	.382
	L_A	0.00	n.s.	.382
	J/H	0.98	n.s.	.393
Necessary Arithmetic	Ss	2.62	<.01	.296
	L_A	1.10	n.s.	.303
	J/H	2.05	.13	.330

Table 6A

Regression analysis of latency scores. The variables were entered in the order: Subjects (Ss), Loudness (L_A), Noise Type (J/H).

TASK	SOURCE	F	P	R^2mult
Word Intelligibility	Ss	2.85	<.01	.279
	L_A	21.47	<.01	.375
	J/H	3.67	.03	.408
Sentence Intelligibility	Ss	6.70	<.01	.485
	L_A	4.41	.04	.531
	J/H	0.68	n.s.	.545
Number Comparisons	Ss	6.77	<.01	.532
	L_A	1.06	n.s.	.535
	J/H	1.08	n.s.	.543
Cube Comparisons	Ss	24.75	<.01	.802
	L_A	5.79	.02	.810
	J/H	0.39	n.s.	.812
Area Estimation	Ss	20.14	<.01	.766
	L_A	1.74	.19	.769
	J/H	0.29	n.s.	.770
Form Rotation	Ss	8.13	<.01	.553
	L_A	4.65	.03	.571
	J/H	1.62	.20	.584
Line Estimation	Ss	8.01	<.01	.546
	L_A	5.82	.02	.579
	J/H	0.03	n.s.	.580
Anagrams	Ss	6.79	<.01	.526
	L_A	0.05	n.s.	.526
	J/H	0.87	n.s.	.532

Table 6A (Continued)

TASK	SOURCE	F	P	R^2mult
Verbal Analogies	Ss	10.13	<.01	.630
	L_A	0.88	n.s.	.633
	J/H	0.39	n.s.	.635
Delta Vocabulary	Ss	10.56	<.01	.621
	L_A	1.41	n.s.	.628
	J/H	0.96	n.s.	.637
Nonsense Syllogisms	Ss	9.31	<.01	.588
	L_A	6.23	.01	.611
	J/H	0.31	n.s.	.614
Arithmetic Estimation	Ss	11.75	<.01	.654
	L_A	0.62	n.s.	.656
	J/H	1.61	.20	.664
Arithmetic Checking	Ss	5.30	<.01	.458
	L_A	1.64	.20	.467
	J/H	0.46	n.s.	.471
Necessary Arithmetic	Ss	4.14	<.01	.402
	L_A	0.12	n.s.	.403
	J/h	0.30	n.s.	.406

Appendix B

Table 1B

Means and standard deviations for accuracy scores by loudness level (L_A) and type of noise (J/H) for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	Mean	6.16	6.55	6.38	6.26	6.11	6.30	6.30
	Std. Dev.	1.62	1.71	1.69	1.64	1.71	1.73	1.52
Form Rotation	Mean	5.91	5.60	5.39	6.23	5.91	5.66	5.91
	Std. Dev.	2.54	2.46	2.53	2.48	2.52	2.74	2.58
Anagrams	Mean	3.47	3.25	3.67	4.26	5.96	4.24	3.75
	Std. Dev.	1.32	1.52	1.27	1.42	1.67	1.89	1.47
Verbal Analogies	Mean	4.87	4.78	5.07	4.70	4.87	4.84	4.96
	Std. Dev.	2.06	2.03	1.94	1.96	2.18	2.23	1.98
Nonsense Syllogisms	Mean	5.12	5.13	4.92	4.91	5.04	5.18	5.01
	Std. Dev	1.33	1.31	1.50	1.53	1.34	1.36	1.33
Arithmetic Estimation	Mean	5.56	5.55	5.54	5.35	5.54	5.49	5.44
	Std. Dev.	1.55	1.62	1.55	1.57	1.56	1.62	1.57
Necessary Arithmetic	Mean	4.09	4.35	4.26	4.40	4.35	4.39	4.22
	Std. Dev.	1.46	1.90	1.72	1.56	1.44	1.67	1.70
All Tasks	Mean	5.02	5.03	5.03	5.16	5.40	5.16	5.08
	Std. Dev.	0.97	1.05	0.88	0.82	0.66	0.73	0.88

Table 2B

Means and standard deviations for latency scores by loudness level (L_A) and type of noise (J/H) for each task.

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	Mean	8.99	8.48	8.58	8.49	8.71	8.46	8.56
	Std. Dev.	1.97	1.87	1.96	1.98	1.98	2.01	1.87
Form Rotation	Mean	6.69	6.58	6.63	6.58	6.65	6.63	6.42
	Std. Dev.	1.28	1.30	1.34	1.18	1.23	1.24	1.24
Anagrams	Mean	3.66	3.71	3.62	3.61	3.65	3.64	3.62
	Std. Dev.	0.50	0.57	0.57	0.56	0.55	0.57	0.61
Verbal Analogies	Mean	10.85	10.91	10.55	10.61	10.79	10.92	10.64
	Std. Dev.	2.51	2.23	2.49	2.37	1.97	1.98	2.05
Nonsense Syllogisms	Mean	11.12	10.82	10.40	10.91	10.88	10.59	10.42
	Std. Dev.	1.98	2.03	2.23	2.08	1.91	2.07	1.94
Arithmetic Estimation	Mean	3.58	3.72	3.73	3.55	3.69	3.60	3.60
	Std. Dev.	0.54	0.70	0.65	0.52	0.58	0.56	0.69
Necessary Arithmetic	Mean	12.38	12.41	12.52	12.50	12.30	12.47	12.51
	Std. Dev.	2.25	2.22	2.01	1.86	2.19	1.72	2.13
All Tasks	Mean	8.17	8.09	8.00	8.04	8.10	8.04	7.97
	Std. Dev.	3.62	3.53	3.47	3.58	3.52	3.55	3.52

Table 3B

Means and standard deviations for annoyingness ratings by loudness level and type of noise for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	Mean	1.31	3.47	3.74	4.96	3.49	3.88	5.32
	Std. Dev.	0.78	1.71	1.61	1.84	1.70	1.73	1.77
Form Rotation	Mean	1.55	3.54	3.69	4.99	3.38	3.86	4.93
	Std. Dev.	1.05	1.63	1.62	1.81	1.46	1.65	1.87
Anagrams	Mean	1.34	3.29	3.41	4.98	3.38	3.66	4.88
	Std. Dev.	0.58	1.53	1.55	1.89	1.61	1.70	1.91
Verbal Analogies	Mean	1.70	3.78	3.90	5.20	3.86	4.00	5.32
	Std. Dev.	1.07	1.73	1.62	1.84	1.87	1.76	1.87
Nonsense Syllogisms	Mean	1.56	3.84	3.67	5.09	3.74	4.12	5.29
	Std. Dev.	0.89	1.69	1.53	1.91	1.71	1.70	1.83
Arithmetic Estimation	Mean	1.58	3.44	3.54	4.93	3.38	3.77	4.93
	Std. Dev.	1.16	1.90	1.61	2.00	1.85	1.75	1.90
Necessary Arithmetic	Mean	1.65	3.73	3.94	5.33	3.71	4.18	5.41
	Std. Dev.	1.00	1.67	1.37	1.51	1.71	1.53	1.71

Table 4B

Means and standard deviations for difficulty ratings by loudness level and type of noise for each task

NOISE LEVEL AND TYPE

TASK	MEASURE	ZERO	H-60	H-70	H-80	J-60	J-70	J-80
Cube Comparisons	Mean	5.66	5.51	5.54	5.72	5.63	5.57	5.65
	Std. Dev.	1.40	1.48	1.30	1.22	1.31	1.21	1.34
Form Rotation	Mean	3.62	3.38	3.35	3.49	3.45	3.64	3.62
	Std. Dev.	1.76	1.67	1.57	1.48	1.47	1.73	1.66
Anagrams	Mean	2.38	2.66	2.78	2.84	2.62	2.75	2.60
	Std. Dev.	1.39	1.38	1.52	1.66	1.46	1.57	1.57
Verbal Analogies	Mean	3.28	3.53	3.35	3.48	3.49	3.88	3.57
	Std. Dev.	1.45	1.70	1.52	1.51	1.54	1.64	1.72
Nonsense Syllogisms	Mean	3.21	2.95	2.86	3.31	3.08	3.24	2.84
	Std. Dev.	1.50	1.44	1.29	1.51	1.57	1.52	1.49
Arithmetic Estimation	Mean	2.62	2.72	2.76	2.98	2.84	3.08	2.77
	Std. Dev.	1.69	1.56	1.52	1.66	1.46	1.57	1.57
Necessary Arithmetic	Mean	4.08	4.35	4.31	4.18	4.31	4.17	4.40
	Std. Dev.	1.46	1.45	1.61	1.67	1.88	1.66	1.57

Table 5B

Hierarchical multiple regression analysis of the predictability of annoyingness ratings from performance measures (Accuracy and Latency) and stimulus measures (loudness and type) with the variance due to subjects removed initially

TASK	SOURCE	PROPORTION OF VARIANCE	BETA COEFFICIENT	F	P
Cube Comparisons	SUBJECTS (Ss)	56.9			
	PERFORMANCE	0.17		1.47	n.s.
	Accuracy (ACC)		-.05		
	Latency (LAT)		-.01		
	STIMULI	19.13		164.2	<.01
	Loudness (L_A)		.45		
	Type (J/H)		.03		
	TOTAL	76.2		145.0	<.01
Form Rotation	Ss	59.7			
	PERFORMANCE	0.7		4.64	.01
	ACC		.07		
	LAT		.02		
	STIMULI	16.2		107.12	<.01
	L_A		.42		
	J/H		.06		
	TOTAL	76.6		14.5	<.01
Anagrams	Ss	57.4			
	PERFORMANCE	1.5		12.1	<.01
	ACC		-.06		
	LAT		-.01		
	STIMULI	17.3		138.8	<.01
	L_A		.44		
	J/H		.04		
	TOTAL	76.2		14.1	<.01

Table 5B (Continued)

TASK	SOURCE	PROPORTION OF VARIANCE	BETA COEFFICIENT	F	P
Verbal Analogies	Ss	60.8			
	PERFORMANCE	0.54		4.77	<.01
	ACC		.08		
	LAT		-.03		
	STIMULI	17.1		150.6	<.01
	LA		.43		
	J/H		.04		
	TOTAL	78.4		15.6	<.01
Nonsense Syllogisms	Ss	59.2			
	PERFORMANCE	0.12		0.87	n.s.
	ACC		.01		
	LAT		.05		
	STIMULI	16.2		115.2	<.01
	L_A		.42		
	J/H		.05		
	TOTAL	75.4		13.3	<.01
Arithmetic Estimation	Ss	64.6			
	PERFORMANCE	0.61		4.73	<.01
	ACC		.02		
	LAT		-.05		
	STIMULI	12.9		99.9	<.01
	L_A		.37		
	J/H		.06		
	TOTAL	78.1		15.9	<.01
Necessary Arithmetic	Ss	51.3			
	PERFORMANCE	0.2		1.77	n.s.
	ACC		-.05		
	LAT		-.07		
	STIMULI	24.8		221.0	<.01
	L_A		.51		
	J/H		.07		
	TOTAL	76.3		14.4	<.01

Appendix C

Subjective Questionnaire: NASA III

Instructions

The purpose of this questionnaire is to draw on your experiences in general and in this experiment to help evaluate the results of this study. The statements below are statements that a participant in this experiment might make. Please read all of the following items carefully.

Some of the statements may involve judgments on your part of an "as if" kind. In these cases we understand that you are replying only in terms of your best guess as to what would be the case.

Please answer all the items. If for some reaon you cannot answer an item, please draw a line through the entire question so that we will know that you did not just skip the item by mistake.

For those items that are relevant please indicate how strongly you disagree or agree by picking the response from 1 to 7 which best reflects your judgment on that statement. A (1) indicates that you strongly disagree with the statement. A (7) indicates that you strongly agree with the statement. Please answere all items. Room has been left at the end for any additional comments you may want to make.

Your responses to this questionnaire will be used for evaluating certain parts of this experiment. All information will be kept confidential. Your responses will not be used to evaluate intelligence, personality, etc, but only to help interpret the results of the study.

Please respond by circling the appropriate number for each statement. Answer the questions in the order given and don't backtrack.

	Disagree			-			Agree
1. When I study, I prefer to be in an area that is very quiet.	1	2	3	4	5	6	7
2. Having the aircraft noise on while I was performing in this experiment didn't bother me very much.	1	2	3	4	5	6	7
3. Because the noise was on, I picked the wrong answer on several occasions.	1	2	3	4	5	6	7
4. Because the noise was on, it took me longer to answer some of the test questions than it normally would have if it had been quiet.	1	2	3	4	5	6	7

	Disagree			-			Agree
5. Having the noise on helped me to concentrate during some of the tasks.	1	2	3	4	5	6	7
6. Because the noise was in the background, I think I answered more quickly than I would have if it had been quiet.	1	2	3	4	5	6	7
7. I was able to answer questions more accurately because the noise was there.	1	2	3	4	5	6	7
8. The noise bothered me most when it came on.	1	2	3	4	5	6	7
9. The noise bothered me the most when it went off.	1	2	3	4	5	6	7
10. I found that I had more trouble answering a question if the noise came on in the middle of the problem, than if it came on at the beginning or end of the probblem.	1	2	3	4	5	6	7
11. I found that I had more trouble answering a question if the noise came on at the beginning of a problem, than if it came on in the middle.	1	2	3	4	5	6	7
12. I found that I had more trouble answereing a question if the noise came on at the end of the problem than if it came on in the middle.	1	2	3	4	5	6	7
13. The noise bothered me because I couldn't predict when it would come on or go off.	1	2	3	4	5	6	7
14. The noise would have bothered me more if it had come on and off more frequently.	1	2	3	4	5	6	7
15. The noise would probably havve bothered me more if it had been louder.	1	2	3	4	5	6	7
16. At times, the noise seemed to interfere with my memory for the problem.	1	2	3	4	5	6	7

	Disagree - Agree
17. The noise would have been less bothersome if it had been on constantly.	1 2 3 4 5 6 7
18. I was less bothered by the noise toward the end of the task than at the beginning.	1 2 3 4 5 6 7

If you were trying to describe this experiment and how you felt about it to someone else, there are a number of possible words that you might use to tell about how you felt abbout the noise. Please indicate how appropriate each of the following words would be.

	Innappropriate - Appropriate
19. Annoying	1 2 3 4 5 6 7
20. Soothing	1 2 3 4 5 6 7
21. Unobtrusive	1 2 3 4 5 6 7
22. Pesky	1 2 3 4 5 6 7
23. Bothersome	1 2 3 4 5 6 7
24. Helpful	1 2 3 4 5 6 7
25. Irritating	1 2 3 4 5 6 7
26. Interesting	1 2 3 4 5 6 7
27. Troublesome	1 2 3 4 5 6 7
28. Stimulating	1 2 3 4 5 6 7

In the space below, please add any other words that you can think of that might describe this noise that you heard.

Comments

In the space below, please add any of your own comments. Of particular interest are: (1) any questions which you found to be confusing or ambiguous; (2) any comments about the experiment which you feel are important and which were not covered in this questionnaire; (3) comments on any of the specific tasks.

Table 1C

Means and standard deviations of accuracy scores by task and type of noise

TASK	MEASURE	SILENCE	HELICOPTER	JET
Number Comparisons	Mean	50.11	50.80	53.62
	Std. Dev.	8.66	9.40	8.57
Cube Comparisons	Mean	32.84	32.15	36.69
	Std. Dev.	8.48	6.04	8.05
Anagrams	Mean	40.04	35.73	36.48
	Std. Dev.	15.94	13.78	13.46
Verbal Analogies	Mean	22.46	19.43	20.48
	Std. Dev.	10.36	6.25	7.32
Rotary Tracking	Mean	561.80	590.94	509.57
	Std. Dev.	277.08	322.34	182.24