EFFECTS OF HIGH SPEED DENTAL DRILL NOISE ON HEART RATE IN NORMAL HEARING ADULT MALES

BY

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THESIS

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Introduction and Rationale

Noise is probably the original form of air pollution (Ward and Fricke, 1969). Throughout history man has been exposed to noise from one source or another. It has only been in the past few years that the organic effects of noise have been measured (Kryter, 1969). Fosbroke recorded the first hearing loss attributable to noise, in blacksmiths, in 1831 (Glorig, 1969). As industry has grown, noise has been recognized as a major contributing factor in hearing losses among workers (Studebaker and Brandy, 1971).

Hearing losses caused by noise can be placed in two broad categories; acoustic trauma and noise-induced hearing loss (Davis, 1970). Davis (1970) defines acoustic trauma as an injury to the ear by a single brief exposure to sound, such as an explosion or gun blast. He reports that hearing will return to normal within forty-eight hours. Davis further indicates that acoustic trauma may also be caused by a blow to the head in the area of the ear.

Noise-induced hearing losses are those that are found most often among military and/or industrial workers (Studebaker and Brandy, 1971). They also report that such loss results from daily exposure to intense sound over a long period of time, even though these noises are not sufficient in intensity to produce acoustic trauma. Noise may cause a temporary threshold shift (TTS) which may be described as a diminuation of the ability to detect weak auditory signals (Ward, 1969). Although TTS causes a depression in all of the higher frequencies, the 4000 through 6000 Hertz (Hz) hearing threshold are those which are most often permanently damaged (Davis, 1970).

While most attention has been focused on noise-induced hearing losses in military and industrial environments (Eldredge, 1960; Fox, 1965; Glorig, 1971), another area that has recently been under investigation has been the noise emitted by modern dental drills (Cantwell et al., 1965; Von Kramer, 1965; Weatherton et al., 1972).

In 1957 the high speed air turbine dental drill was introduced and is now in wide use throughout this country (Taylor et al., 1965). These new drills emit a high pitch noise resulting from rotational speeds which may reach as high as 500,000 revolutions per minute (r.p.m.). Although manufacturers indicate that the high speed drill is at a safety intensity level in accordance with Occupational Health and Safety Act standards (1969), numerous studies have been done in determining effects of the high speed dental drill noise on hearing (Cantwell et al., 1960; Hopp, 1962; Weston, 1962; Wark, 1967). These researchers have found no conclusive evidence that the noise produced by high speed dental drills results in hearing loss in dentists.

A number of studies (Ward and Holmberg, 1969; Skurr and Bulteau, 1970; Taylor et al., 1965; Weatherton et al., 1972), on the other hand have been done which suggest that the high speed dental drill noise will cause hearing impairment. Taylor et al., (1965) revealed that dentists showed a significantly greater hearing loss than did non-dentists who had matched non-noise exposure backgrounds.

Ward and Holmberg (1969) tested the hearing of 164 non-dentists and 156 dentists. His findings did not show a significant difference in hearing between the groups, however, a trend of poorer hearing at 6000 Hz was noted in the dentist's group.

Skurr and Bulteau (1970) compared the hearing of third year dental students and fifth year medical students. The dental students were retested after two years of working with the high speed dental drill. Of these students retested, five of the 17 who had previously had normal hearing showed a deterioration of hearing, even though there was no history of excessive noise exposure noted. In addition, 14 subjects who had a hearing loss in the initial test displayed greater losses at the end of the two year period.

Weatherton et al., (1972) compared the hearing of beginning and advanced dental students against the hearing of dental faculty members. Their findings indicated, that although there was not a significant difference between the two groups of students, there was a significant difference between the students and faculty members' hearing. The loss of hearing for faculty members was greater than that which is attributable to the aging process (presbycusis).

Effects of Noise Apart From Hearing Loss

Although noise-induced hearing loss is a handicap, there can be other detrimental effects of noise. Noise can be considered an overall health hazard when intensities are excessive (Rosen, 1970).

Noise can act as a form of stress: that is, an effective, behavioral and physiological response to aversive stimuli (Glass and Singer, 1972). These researchers conclude that in most situations man is able to adapt to this stress, but they also feel that the body must be subjected to harmful effects due to the changes necessary for adaptation. The effects of noise other than auditory may be broadly classified as psychological, efficiency-performance, and physiological.

Psychological. Noise can directly affect feelings and attitudes (Cohen, 1969; Jansen, 1961). Jansen (1961) found that those steel workers exposed to the noisiest work environments had the highest frequency of social conflicts.

Very often the amount of annoyance from noise depends upon the listener and the situation in which the listener is placed (Broadbent, 1957). Cohen (1969) reports that: (1) Annoyance grows with the increasing intensity of sounds, (2) Annoyance is greater for those sounds of higher frequency, (3) Sounds which are variable in nature are judged to be more annoying than those which are unchanging.

Efficiency-Performance. Contradictory results have been found in terms of the effects of noise on work performance. It is difficult to separate the annoyance effects from effects on work performance.

Kryter (1970) suggests that specific noise levels found unnacceptable depend upon the activity in which the individual is engaged. An individual working in noise is able to adapt to his environment to some extent, which may in turn reduce the detrimental effects of noise on performance.

Cohen (1969) reports that the effects of noise should be considered. It appears that noise is more inclined to disturb the quality rather than the quantity of work. He further concludes that performance under noise is subject to marked fluctuations, periods of poor performance being interwoven with periods of heightened effort and that noise is more likely to impair performance of those tasks that place extreme demands on the worker.

Noise also has positive effects on performance (Cohen, 1969). He also suggests that rythmic noise occurrences may pace work efforts and may be beneficial to jobs which are simple and repetitive. Cohen (1969) further reports that noise can mask out other distracting noise if the masking noise is not distracting. He also concludes that performance can be effected by the feelings of the individual about his work and any noise associated with his job.

Physiological. The physiological organization of the auditory pathways to the brain has two distinct systems: a direct pathway called the specific auditory system, and another pathway branching off from the main auditory system to the activating system in the reticular formation of the brain stem (Grandjean, 1969). Grandjean also postulates that auditory stimuli spreading out into the entire cortex creating an arousal or generalized alerting response.

The auditory system and the activating system are the primary alerting system for the human organism 24 hours a day making it the primary protection system for all higher level organisms (Grandjean, 1969).

The findings for studies of the physiological effects of noise on man have not been in full agreement. Jansen (1961) studied the long term effects of noise on industrial workers. These studies indicated that industrial workers tend to have greater circulatory, heart, and equilibrium problems than do workers in quieter environments. Kryter (1970) reasons that other factors (poor ventilation, anxiety over job security, danger from accidents) may be responsible for many presumably noise-induced health problems.

Rosen (1969) summarizes some non-auditory reactions to loud noise:

> The blood vessels constrict, the skin pales, the pupils dilate, the eyes close, one winces, holds the breath, and the voluntary and involuntary muscles tense. Gastric secretion diminishes and the diastolic pressure increases. Adrenaline is suddenly injected into the blood stream ...

Jansen (1969) found that a 92 decibel (dB) noise to which subjects were accustomed, effected changes in the peripheral vegatative system functions, including the peripheral circulatory system and the pupillary function. Rosen (1970) reported that when subjects were exposed to noise, constriction of the blood vessels begin to disappear after five minutes, but this action may persist for as long as 25 minutes before disappearing completely.

Arguelles et al., (1967) reports hypertensive and psychotic patients were shown to have endocrine disturbances, blood pressure increases, and general stress when exposed to a 30 minute tone of 2000 Hz at 90 dB. These researchers feel that some of this physiological reaction may be due to the annoyance attitudes involved which may be more pronounced in persons with mental disturbances.

Kryter (1970) suggests that although there is little evidence to connect noise with identifiable physical disease, the possibility cannot be completely dismissed at this time. Cohen (1969) warns that even if intense noise does not produce measurable effects on health, it does induce stress under certain conditions, with a resultant increase in autonomic reactions, irritability, and social conflicts at home and work. It is generally felt that physiological arousal will not occur to noise below 60 to 65 dB (Kryter, 1970). Kryter also reports that above this level, there are definite arousal effects, and at levels exceeding 130 dB we begin to feel pain.

Rosen et al., (1964) did comparative studies of peoples of Western Europe and Africa to determine the effects of environmental noise on health. Their findings indicated that the people in the quieter environments had fewer health problems.

Statement of the Problem

Noise is being recognized as a problem in our industrial environment. Governmental and insurance investigators have begun to monitor levels of industrial noise in regard to new state and national regulations.

High speed dental drills are tested by the manufacturers in order to meet the new governmental regulations. However, no monitoring of these drill noises are performed once they are installed in the dental operatory.

Studies of dental drill noise have neither confirmed nor denied that hearing losses among dentists are attributable to such exposure. However, researchers indicate that intense noise may have physiological effects on the cardiovascular system which could be detrimental to health.

The purpose of this study will be to determine the effects of high speed dental drill noise (including operatory noise) on heart rate. An attempt will be made to answer the following question: Is heart rate significantly affected in individuals exposed to high speed dental drill noise?

Methodology

Test Site

All testing was conducted in the speech and hearing clinic at Florida Technological University at Orlando, Florida.

Subjects

20 male individuals were selected from a college population of undergraduate students as subjects in this study. Individuals qualified for utilization in this study if they had hearing no poorer than 20 dB (American National Standards Institute - ANSI - 1969) at frequencies of 250 through 8000 Hz inclusive. Subjects had not previously participated in noise experiments.

Instrumentation

Rooms. A testing suite (Industrial Acoustics Company Series 1200) was used for all audiometric tests employed in this study. The noise level in this room met the standards set down by the American Standards Association for Audiometric Testing.

Pure-tones. Pure-tone audiometrics were performed using a clinical and research audiometer (Grayson-Stadler Model 1702-A). A matched set of earphones (Telephonics TDH-39) using MX 41 AR cushions were used for all pure-tone testing.

Measurements. Measurements of heart rate were obtained using a Physio-Control Corporation Electrocardiograph using a graphic recorder.

Stimulus Presentation. Presentation of the stimulus was performed using a reel tape recorder (Akai Model M-9) at a speed of 7½ inches per second (ips) and received through a 10 inch wide frequency range speaker. The stimulus presentation was delivered at an average intensity of 86 dBA.

Procedures

A calibration check of all equipment was done prior to each testing session. All subjects utilized in this study were tested audiometrically to insure that thresholds were within the limits set for this study (see Appendix A for audiogram form used). All subjects were randomly assigned to the experimental and control groups. Instructions were read to each subject explaining the procedures to be followed (Appendix B). A three minute rest period was allowed for each subject prior to beginning the experiment. During the rest period, the electrodes from the electrocardiograph were attached to the subject. Pretest measurements of heart rate were recorded to establish a baseline for each subject. Sound level measurements of the stimulus material were taken to insure that each subject in the experiment received the correct stimulus intensity. The stimulus was high speed dental drill noise presented at an average intensity level of 86 dBA for 15 minutes. The experimental group was exposed to the drill noise for the 15 minute period. The control group was exposed to all conditions presented to the experimental group except for the noise. Four measurements of heart rate were taken on each subject, a baseline, one minute into the experiment, seven minutes into the experiment, and 14 minutes into the experiment for both groups. After completion of the experimental process each subject was thanked for his help and asked not to speak with the other subjects about the experiment.

Design

A total of 20 subjects were divided into two equal groups. The experimental group was exposed to 15 minutes of high speed dental drill noise. The control group was exposed to all procedures except the drill noise. Each subject was randomly assigned to a group through the use of a random numbers table. A 2 (control-experimental) X 4 (measurements of the dependent variable after 1, 7, and 14 minutes of stimulus exposure) design was used to assess the effects of high speed dental drill noise on heart rate.

Results

An analysis of the results of the experiment revealed that high speed dental drill noise did have an effect on heart rate.

TABLE 1

Mean Scores for Control and Experimental Groups over Time

	Base	Time 1	Time 2	Time 3
Control	78.0	78.6	75.6	76.8
Experimental	76.8	82.8	83.4	82.2

Table 1 shows the mean scores of the control and experimental groups for the base measurement and the measurements done at one minute, seven minutes and 14 minutes of elapsed time. The mean scores for the control group did not increase during the 15 minute period. The experimental group had an increase in mean score beginning at the onset of the noise. The increase reached almost seven beats per minute (bpm) after seven minutes of noise exposure and then decreased slightly by the 14th minute of exposure. This increase in the mean score for the experimental group suggests that a change did take place within the group.

Follow-up t tests were done with correlated groups. Table 2 shows the results of these t tests. The comparisons were done on the base time one pairing base to time two and base to time three pairing. In each case the t was significant beyond the .01 level. The results of these tests indicate that the drill noise produces a significant change in heart rate. The greatest affect appears to be at the second time period. While the greatest mean increase occurred at time two, an analysis between all pairs of times, excluding baseline, did not yield significant differences. It seems that the noise rather than the length of exposure to the noise is the significant factor in the increase in heart rate. An analysis of variance was done for the control group which was exposed only to the time period. Table 3 shows the results of this analysis. The control group did not attain a significant F. This lack of significance again suggests that time in and of itself is not a significant factor in heart rate increase. These results also indicate that the laboratory setting can be ruled out as a rival source of variance.

An additional method of testing the effects of the high speed dental drill noise is given in Table 4. Comparisons were done for each time interval between the experimental and control groups. The validity of this type of analysis is based on the fact that the two groups were not significantly different in their baseline.

TABLE 2

Analysis of Differences Between all Pairs of Means for the Experimental Group

Pairing	_t_	_p_ *
Base - Time 1	4.762	$< .01$
Base - Time 2	11.000	$< .01$
Base - Time 3	9.000	$< .01$
Time 1 - Time 2	NSD	
Time 1 - Time 3	NSD	
Time 2 - Time 3	NSD	

* two-tailed tests

TABLE 3

Analysis of Variance of Heart Rate as a
Function of No Noise over Time

Source of Variation	SS	DF	MS	F
Between Subjects	28.8	3	9.6	0.27[1]
Within Subjects	1281.6	36	35.6	
Total	1310	39		

[1] $F_{.95}$ (2,36) = 3.26

TABLE 4

Follow-up t Tests Analyzing Differences Between Time Period Pairings for Control and Experimental Groups

Time Period Pairings		t	P*
Control	Experimental		
Base	Base	0.452	
Time 1	Time 1	1.889	< .05
Time 2	Time 2	2.807	< .01
Time 3	Time 3	1.832	< .05

* One-tailed tests

measurements. There was a significant difference between the groups at all three time periods. The greatest difference was seen at the second time period (after seven minutes), this was followed by time one; time three showed the least difference. These results suggest that the heart rate change was caused by the noise since the base measurements yielded non-significant results.

All of the results indicate that the change in heart rate by the experimental group was due to the high speed dental drill noise rather than any intervening variable.

Discussion

The results of the experiment indicated that there is an increase in heart rate caused by exposure to high speed dental drill noise. The increase in heart rate was not a function of exposure time. There also appeared to be a minimal amount of adaption to drill noise. After the subjects made their initial increase in heart rate, the rate remained relatively stable throughout the exposure. It is not known if there would be an adaption with longer exposure time or with repeated exposures to the noise. In view of the increase in heart rate of the experimental subjects, compared to the general decrease in heart rate of the control subjects, the detrimental effects of dental drill noise on the overall physiology of the people exposed to the dental drill noise must be considered, for example, high blood pressure or other cardiovascular disorders. These elevations in heart rate have been shown (Rosen, 1970) to be medically and/or clinically significant.

The results of this study are in agreement with the research findings of Jansen (1969), Rosen (1970) and Arguelles (1967). These researchers reported that excessive noise causes changes in the cardiovascular functions of the human body.

An obvious next step in this research is to test whether dentists, who are exposed to the noise daily, react in the same manner as the subjects in this experiment. Dentists may adapt to the drill noise because there is no threat involved with the noise. It is possible that dentists may be spared certain adverse effects due to positive financial associations with the drill noise.

A second useful direction for research involves studying populations which have a sensorineural hearing loss and loudness recruitment, these individuals may have an even more pronounced response to the drill noise. Different age populations might also yield different results. For example, the aged may be more adversely affected by the noise than was the college age population used in this research.

High speed drill noise is not a continuous noise in the dental office. The noise may be heard for several minutes and then ceases momentarily, then resumes. It remains for future researchers to discuss what systemic effects this continual on-off noise may have on man.

Summary and Conclusions

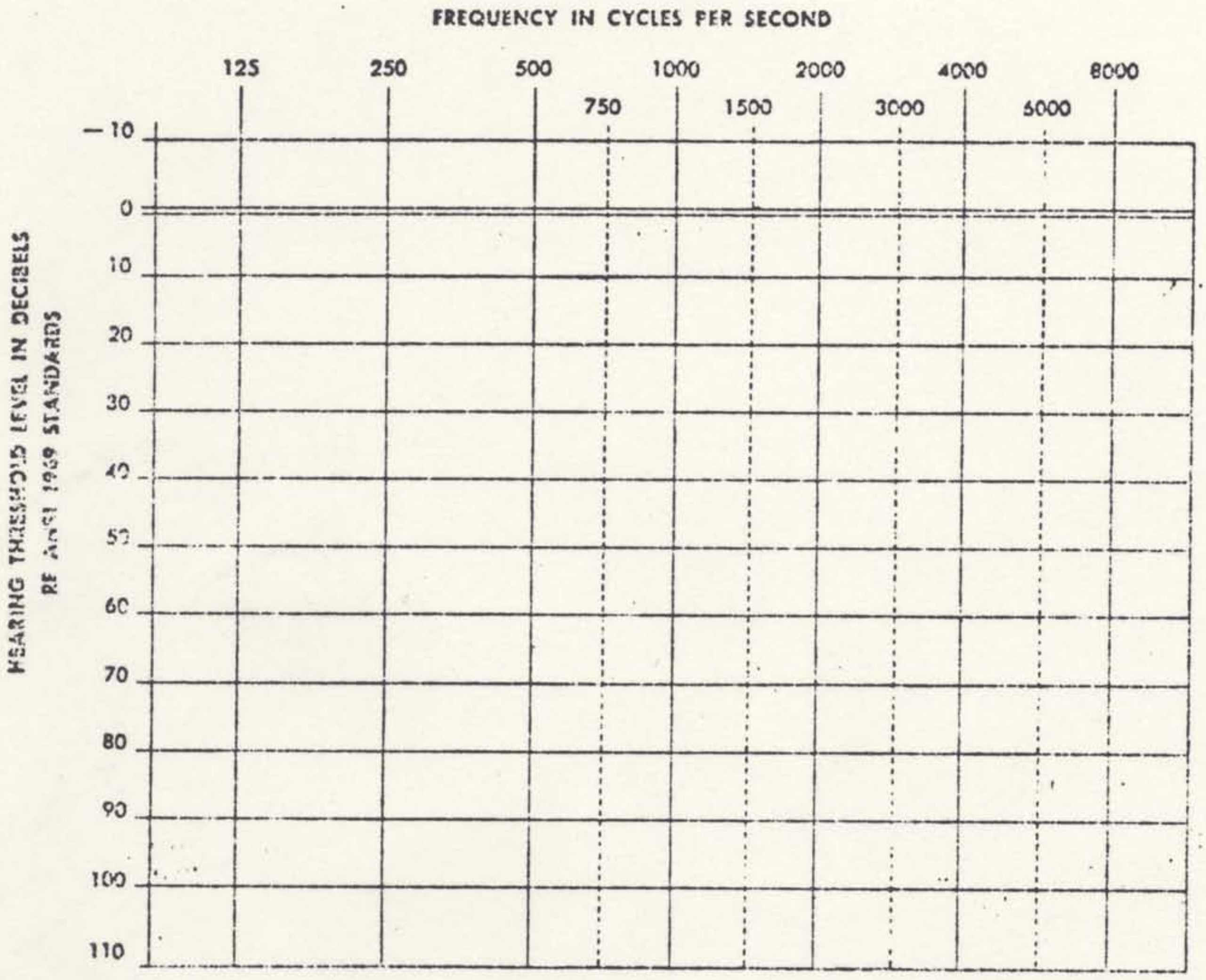
A review of the literature discloses that noise can be a threat to man both psychologically and physiologically. Large numbers of people are exposed to noise in their daily environment. Persons working in dental offices are continuously exposed to the high frequency, high intensity noise of the modern dental drill. Some researchers feel that these dental drills can cause damage to the hearing mechanisms of those persons exposed to the noise for a number of years. Little information is available on other possible effects of drill noise. It was decided to investigate one of the physiological effects, that of heart rate alterations due to the drill noise, on normal hearing adults.

An experimental group of subjects were exposed to 15 minutes of drill noise at an average intensity of 86 dBA. A control group was used in a no noise condition to correct for extraneous variance that might be caused by the experimental environment. Heart rate was measured for each group at the beginning of the procedure. The raw scores of the treatment subjects were subjected to a one-way analysis of variance and subsequent $\underline{t}$ tests on correlated groups. The results provided statistically significant evidence that dental drill noise increased heart rate for the treatment group.

Further considerations should be given to this area. Population and age differences may produce different findings. Variations in the on-off period for the drill may also yield different results.

APPENDIX A

Audiogram



APPENDIX B

Instructions

Greeting. My name is Tom Bunn and I am a graduate student at Florida Technological University. This is an experiment to determine the effects of environmental sounds. It will take approximately 30 minutes during which time I would like for you to listen and relax. First, I would like to ask you a few questions and obtain some pertinent information:

1. Name, age.
2. Phone where you can be reached during the day.
3. As far as you know, do you have any problems with your hearing?
4. Have you previously participated in any experiments dealing with noise?

Pure-tone Audiometrics

Now I would like to conduct a screening test to determine if your hearing is satisfactory for this experiment. Please take a seat inside the booth and listen to the following instructions.

You are going to be listening to some tones which will sound like short whistles. Every time you hear the whistle you are to press the button and then release it. This signifies that you have heard the tone. The whistles will get very soft in volume, but don't guess, only when you are sure you hear the whistle, press the button. We will start with your right ear and then your left ear. Do you understand?

Heart Rate Measurements

I am now going to attach some leads to your wrists and legs. These will measure your body functions during the experiment. For the next 15 minutes you may or may not be listening to some form of noise. I would like you to sit back and relax; let me assure you that there will be no discomfort at any time.

After the experiment is completed I would appreciate it if you would not discuss any information concerning this experiment. Do you have any questions? If not, we will begin.

APPENDIX C

Heart Rate for Experimental Group Subjects

Subject No.	Base Rate	Time 1	Time 2	Time 3
1	90	96	96	96
2	78	84	84	84
3	84	84	90	90
4	78	84	84	84
5	72	78	78	78
6	78	78	84	84
7	66	72	72	72
8	78	90	90	84
9	72	84	78	78
10	72	78	78	78

APPENDIX D

Heart Rate for Control Group Subjects

Subject No.	Base Rate	Time 1	Time 2	Time 3
1	78	78	78	84
2	78	78	78	78
3	84	90	78	78
4	72	66	66	66
5	84	84	84	84
6	72	72	72	72
7	78	72	72	72
8	72	72	72	72
9	84	84	84	84
10	78	72	78	78

APPENDIX E

Octave Band Analysis of High Speed Dental Drill Noise Measured in Sound Pressure Level (.0002 dynes cm^2)

Frequency (Hz)	31.5	63	125	250	500	1K	2K	4K	8K	16K
Load (dB)	64	52	56	66	66	69	77	86	83	77
No Load (dB)	60	48	51	51	52	56	62	82	76	72

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