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# NON-AUDITORY EFFECTS OF NOISE

## A Literature Review

NAS-NRC Committee on Hearing, Bioacoustics and Biomechanics

Working Group 63

Report of Working Group 63,
Non-Auditory Effects of Noise,
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COMMITTEE ON HEARING, BIOACOUSTICS AND BIOMECHANICS

# NON-AUDITORY EFFECTS OF NOISE


Report of Working Group 63
Karl D. Kryter
Chairman

Gerd Jansen
Donald Parker
Horace O. Parrack
George Thiessen
Harold L. Williams



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## Introduction

By and large, practical noise control is centered on noise that is a byproduct of regularly operated machinery, such as transportation vehicles, or machines in a manufacturing industry, which in and of themselves provide a wanted service and are normally not dangerous but beneficial to society. Knowledge as to the non-auditory effects of such noise is obviously necessary to permit an appropriate evaluation of the negative and positive values to society of the devices making noise.

It is the purpose of this paper to discuss, in summary fashion, research data and concepts related to what might be called the effects of such noise on non-auditiory mental and motor activity and on general health and mental well-being. Damage to the ear, the interference with the reception of wanted auditory signals (called masking), and perceived loudness or noisiness of noise will not be discussed in any detail. Furthermore, an attempt will be made to separate out, as irrelevant to the present discussion, effects that are attributable primarily to noises that are an unexpected part of a particular environment or have special meanings, such as fear of the source (be it a mosquito, a siren, or a vehicle out of control).

A secondary purpose of this paper will be to suggest areas and types of research studies that may be necessary in order to provide full answers to the

questions of why and how much noise control is required with respect to the non-auditory effects of expected, normally present noise in a living or working environment.

Physiological Effects (Non-Auditory)

It is perhaps surprising how few systematic studies of non-auditory physiological responses to relatively long-term exposure to noise have been conducted. The following general conclusions were reached from a review of the few experiments that have been done.

(1) Sudden, unexpected bursts of impulsive or steady-state noise will cause somatic responses in man and animals. Responses can include changes in cardiovascular blood pressure and volume, breathing, pulse rate, gastro-intestinal motility, endocrine gland excretions, and other neural and body activities. These responses are sometimes designated as "arousal," sometimes as "stress" responses, and are difficult to distinguish physiologically, from responses that occur in emotional states such as fear or anger.[17]

(2) With continued exposure to the noise, provided the noise connotes no harmful environmental condition or does not interfere with behavior as the result of auditory masking, man[10,15] and presumably animals (with the possible exception of special strains of laboratory bred rodents and rabbits) will adapt more or less completely, i.e., will cease to show arousal responses (see Figs. 1, 2, and 3). For example, the data in Fig. 3 suggest that the noise, like rest, caused a drop in peripheral blood circulation but, as the noise continued, the blood circulation returned to that which is normal for a given period of work or rest.

(3) Sudden noises will elicit an eye-blink response which, unlike the general somatic responses mentioned above, does not habituate with continued exposure to the noise.[15] It is possible that the relative simplicity and protective

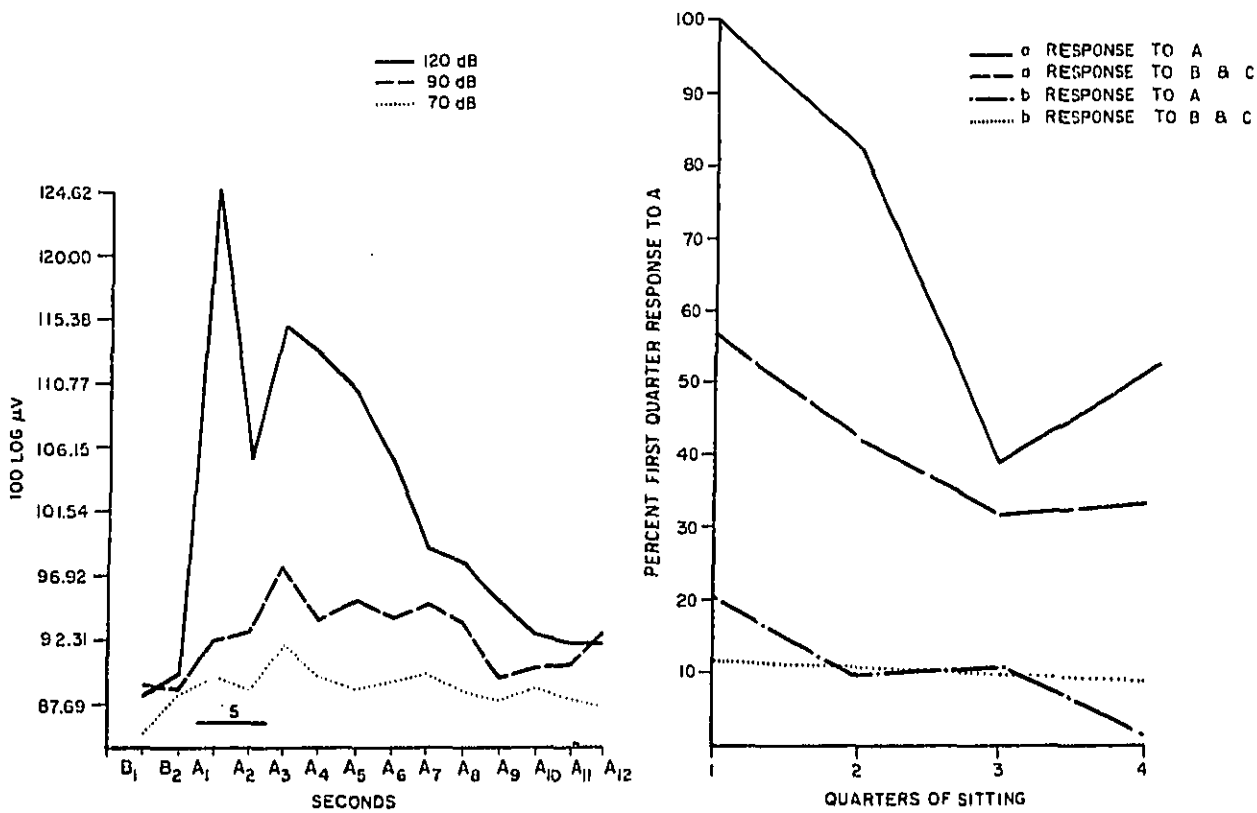



Fig. 1 Graph on Left:

Mean muscle-action potential (left forearm) response to 1000-Hz tone of varying intensities. Horizontal line indicates stimulus duration. On the abscissa, B indicates periods before, and A indicates periods during and after stimulation.

Graph on Right:

Adaptation of muscle action potential responses "a" (brief latency) and "b" (long latency) to various intensities of a 1000-Hz tone presented in mixed order during a sitting. Noise A was at 120 dB, B at 90 dB, and C at 70 dB. From Davis, Buckwald and Frankmann[8]

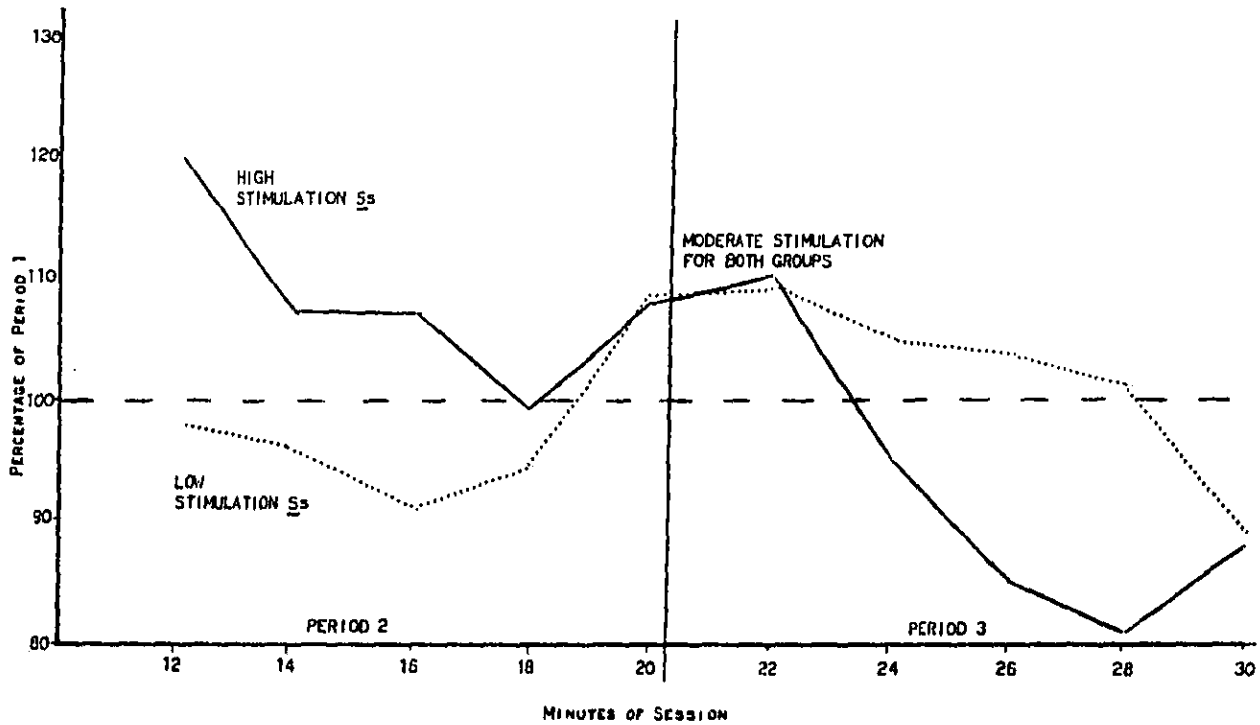
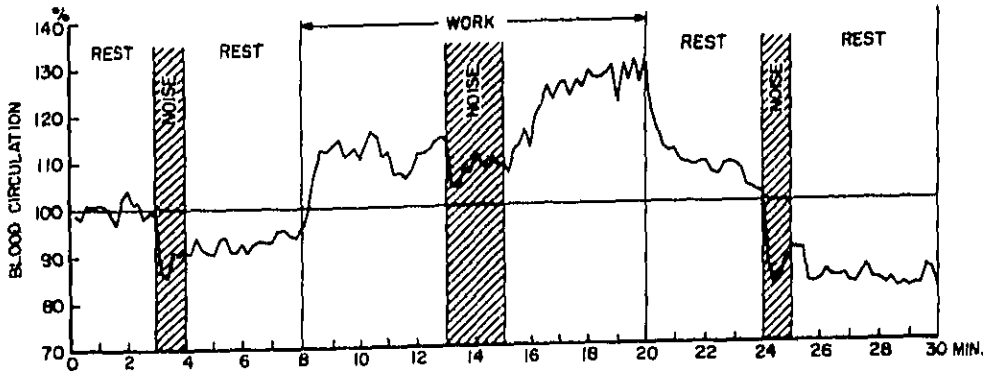
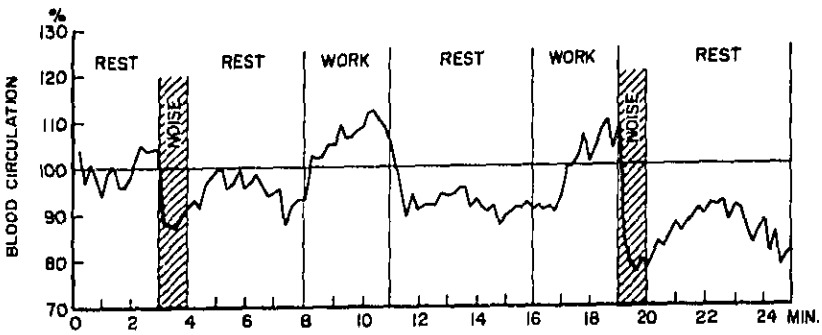


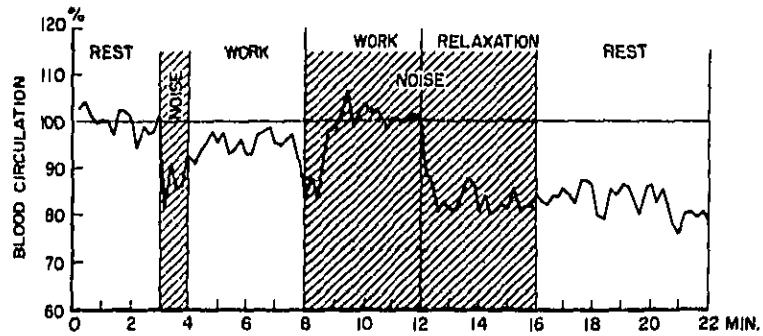

Fig. 2 Contrast in stimulation: Sliding means for amplitude of gastrointestinal motility.
High = 500 Hz tone at 70 dB and 64 millilamberts of light
Moderate = 500 Hz tone at 40 dB and 12 millilamberts of light
Low = no tone and no light. From Stern[22]




INFLUENCE OF A TWO MINUTE NOISE EFFECT DURING A TWELVE MINUTE WORK PERIOD. NOISE: WIDE-BAND 95 DIN-PHON; WORK: 5 MCP/SEC. BICYCLE ERGOMETER; 53 TESTS, 7 SUBJECTS.




INFLUENCE OF NOISE AFTER TERMINATION OF NOISELESS MANUAL WORK. NOISE: WIDE-BAND 95 DIN-PHON; WORK: 5 MCP/SEC. BICYCLE ERGOMETER; 45 TESTS, 7 SUBJECTS.




BEHAVIOR OF FINGER PULSE AMPLITUDE DURING NOISE IN A WORK PHASE AND IN A FOLLOWING REST PHASE. NOISE: WIDE-BAND 95 DIN-PHON; WORK: 5 MCP/SEC. BICYCLE ERGOMETER; 36 TESTS, 8 SUBJECTS.

Fig. 3 Showing effects of combinations of work, rest, and noise on blood circulation. A reduced percentage indicates vasoconstriction of the peripherical blood vessels. From Jansen[12]

function of the eye-blink system accounts for this phenomenon. The perserverance of the eye-blink response, unlike some of the general somatic responses, is not mentioned in the literature as being harmful or as indicating a state of somatic arousal.

Steady noise above 110 dB (approx.) can cause some temporary and permanent (after years of exposure) changes in size of visual field[4,5] and noise above 130 dB can cause mystagmus and vertigo.[2] However, these effects on the visual and vestibular systems are found under noise conditions rarely present in the environment and of sufficient intensity to cause, if exposures are continued for sufficiently long periods of time, permanent damage to the auditory system.

Effects of Arousal Responses on Health

The arousal responses of the body are normally useful in that they increase the alertness of the receptor, neural, and skeletal muscular systems that would be involved in the organism reacting to the environment in ways that would protect it from potentially harmful events. If for no other reason than to allow the organism to recover and be able to respond to a new and different stimulus that may signify some danger or threat, it is appropriate that adaptation or cessation of these responses occur to noises that, upon repetition, are shown to signify non-threatening conditions.

Also, there is evidence that continued elicitation of arousal responses is stressful, and that the organism will eventually suffer some physiological damage or dysfunction in cardio-vascular, gastro-intestinal or neurological-glandular systems. Data obtained from persons placed in what could be called stressful work situations that include noise are given in Figures 4 and 5 and Tables 1, 2, and 3, and bear upon this point. The data in Fig. 4 from Andriukin are not conclusive on this point, however, because the changes shown for hypertension could have been largely a function of age rather than the presence of noise during the person's working career.

The data in Tables 1 and 2 indicate that those men exposed to intense noise

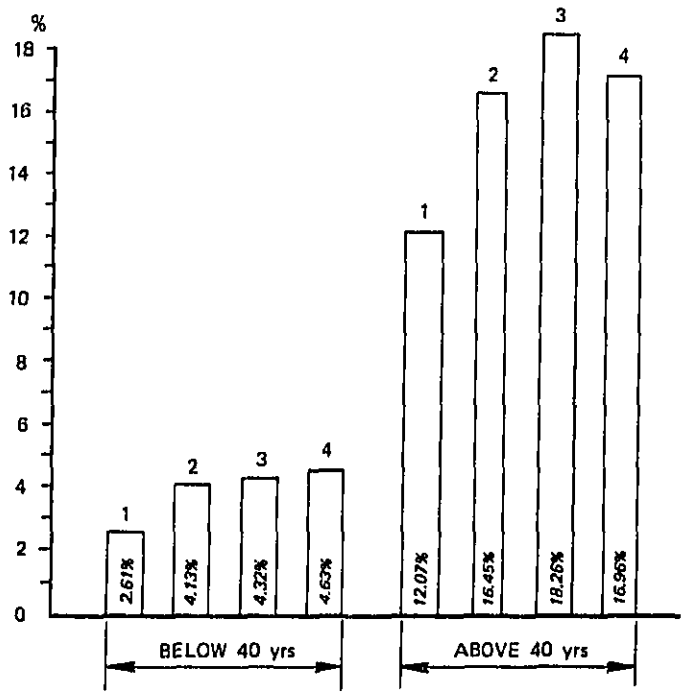



Fig. 4 Incidence of hypertension in workers of both sexes in noisy workshops in age groups under and above 40 years. 1 - tool making workshop; 2 - sorting workshop; 3 - workshop with automatic lathes; 4 - workshop producing ball bearings. From Andrukin[3]

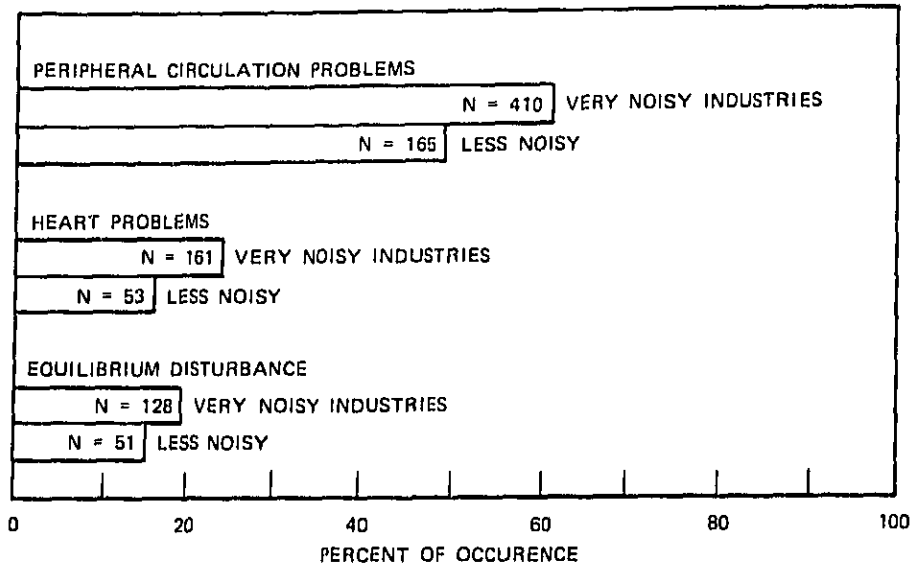



Fig. 5 Showing differences in percent of occurrence of physiological problems in 1005 German industrial workers. The differences in peripheral circulation and heart problems in the two classes of were statistically significant. After Jansen[11]

Table 1

ADJUSTED MEAN RETEST SCORES
FOR THE "MOST-EXPOSED" AND "LEAST-EXPOSED" GROUPS ON THE LARGE-SAMPLE TESTS, ANALYZED ACCORDING TO EACH OF THE CRITERIA FOR HAZARDOUS NOISE EXPOSURE

The score of the group exhibiting the poorest performance for each comparison has been underlined. From Davis[7]

| TEST | TYPE OF TEST* | CRITERION OF HAZARDOUS NOISE EXPOSURE | | | | | |
|---|---|---|---|---|---|---|---|
| | | AUDITORY THRESHOLD SHIFT | | ESTIMATE OF NOISE EXPOSURE | | SQUADRON ASSIGNMENT | |
| | | MOST-EXPOSED | LEAST-EXPOSED | MOST-EXPOSED | LEAST-EXPOSED | MOST-EXPOSED | LEAST-EXPOSED |
| Critical Flicker Frequency | H Score = N | 38.9** 7 | 40.6 30 | 40.6 15 | 41.3 12 | 40.5 24 | 39.6 54 |
| Tapping Speed | H Score = N | 20.8 7 | 20.9 30 | 19.5 14 | 20.1 12 | 20.7 24 | 20.3 54 |
| Reaction Time | L Score = N | 204.9 7 | 191.6 30 | 218.2 14 | 201.1 12 | 199.6 24 | 199.5 54 |
| Fine Hand Steadiness | L Score = N | 33.5 7 | 26.7 29 | 25.2 15 | 31.9 10 | 28.8 21 | 26.0 48 |
| Gross Hand Steadiness | L Score = N | 17.9 7 | 15.7 30 | 15.2 15 | 14.7 10 | 18.9*** 22 | 14.8 49 |
| Steadiness of Standing | L Score = N | 35.4 7 | 28.9 30 | 30.9 15 | 27.3 11 | 31.4 21 | 31.0 50 |

* For a test designated as "H", a high score indicates good performance and a low score indicates poor performance; for a test designated "L", a low score indicates good performance and a high score indicates poor performance.

** The units of measure used for each test are given in Appendix 5.2.

*** The "most-exposed" showed significantly poorer performance (5 percent level of confidence) on this comparison.

Table 2

ADJUSTED MEAN RETEST SCORES
FOR THE "MOST-EXPOSED" AND "LEAST-EXPOSED" GROUPS ON THE SMALL-SAMPLE TESTS, ANALYZED ACCORDING TO EACH OF THE CRITERIA FOR HAZARDOUS NOISE EXPOSURE

The score of the group exhibiting the poorest performance for each comparison has been underlinod. From Davis[7]

| TEST | TYPE OF TEST* | CRITERION OF HAZARDOUS NOISE EXPOSURE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ESTIMATE OF EXPOSURE | | | | SQUADRON ASSIGNMENT | | | |
| | | MOST-EXPOSED | N | LEAST-EXPOSED | N | MOST-EXPOSED | N | LEAST-EXPOSED | N |
| Tactual Threshold | L | 10.4 | 11 | 5.8 | 13 | 8.2 | 14 | 8.5 | 14 |
| Knox Cube Test | L | 2.7 | 11 | 2.4 | 13 | 2.1 | 14 | 2.1 | 14 |
| Dexterity Test | H | 15.9 | 11 | 17.4 | 13 | 16.4 | 14 | 16.8 | 14 |
| Digit Symbol Test | H | 52.6 | 11 | 52.8 | 13 | 52.3 | 14 | 50.7 | 14 |
| Taylor Anxiety Scale | L | 10.7 | 11 | 6.3 | 12 | 10.1 | 14 | 7.5 | 12 |
| Guilford Screening Inventory | L | 1.6 | 11 | 2.5 | 13 | 2.6 | 14 | 2.0 | 13 |
| Cornell Index | L | 4.7 | 11 | 3.1 | 13 | 5.1 | 14 | 3.5 | 13 |
| Visual Acuity | H | 21.1 | 11 | 21.8 | 13 | 21.0 | 14 | 20.7 | 14 |
| Visual Phoria | H | 6.8 | 11 | 5.1 | 12 | 5.1 | 14 | 6.3 | 12 |
| Depth Perception | H | 6.1 | 10 | 5.1 | 12 | 5.2 | 11 | 5.5 | 13 |

* For a test designated as "H" a high score indicates good performance and a low score indicates poor performance; for a test designated as "L", a low score indicates good performance and a high score indicates poor performance.

Table 3

PERCENTAGE OF SUBJECTS IN EACH NOISE-EXPOSURE GROUP WHO EXPRESSED NEGATIVE REACTIONS TO THEIR JOB, TO JET NOISE, AND TO SHIPYARD DUTY
From Davis[7]

| NOISE EXPOSURE | EXPRESS ANXIETY ABOUT JOB | STATE JET NOISE DISTURBING | DISLIKE SHIPBOARD DUTY |
|---|---|---|---|
| Very High | 92.3 | 53.8 | 69.2 |
| High | 61.1 | 55.5 | 55.5 |
| Moderate | 71.4 | 61.9 | 76.1 |
| Low | 21.4 | 35.7 | 42.9 |

were probably suffering some physiological effects from stress. It is possible, however, that the stress was due to the threat of bodily harm and to the nature of the job rather than to the noise. As shown in Table 3, the noise per se was not considered by the men involved as producing unusual amounts of stress. Similar factors probably apply to the data from industries shown in Fig. 4 and 5; that is, the continuing, harmful stress-producing factors were not the noise alone, but were harmful or potentially harmful environmental conditions such as excessive heat, dust in the air, and moving machinery. In addition, the possibility that the workers involved are under stress conditions outside the job (because of poor living conditions and initially poor mental or body health prior to entering into these generally low-grade occupations) cannot be overlooked as factors influencing the results found.

A recent study[21] on an African tribe living in a noise-free society revealed a lesser incidence of cardio-vascular disease and better hearing in older people than is found in persons of a similar age in a more modern society. It is possible that the lack of noise was a contributing factor to the apparent superior physiological condition of these African natives; it is perhaps more likely that these findings may be explained by the lack of other stress-inducing factors of a modern society and/or superior diet and living habits of these particular African natives.

In the studies cited above, the effects of stress on physiological and, to a lesser extent, on mental health were both evaluated, and it is probably inappropriate to consider these two aspects of health as separate. However, one recent retrospective study[1] showed that during a two-year period, a greater number of admissions to a mental hospital occurred from a residential area having the greatest amount of aircraft noise (near London's Heathrow Airport) than from adjacent residential areas receiving less exposure to aircraft noise.

Statistical analysis revealed, however, that the significant differences in admission rates occurred primarily for females over 45 years of age who were unmarried, widowed, or divorced. Rates of admission did not differ significantly for males and other females from the noisiest and the less noisy neighborhoods. The authors of the study note that the results must be interpreted with reservations because the two different residential areas may have differed to some unknown extent in environmental conditions. Information that was available with regard to these factors suggested that those persons living in the noisier neighborhoods were the more economically and socially advantaged and, presumably, should have been more resistant to "stress."

Environmental Noise and Sleep

The effects of noise on sleep are not well understood. It is known that the awakening effects of noise (sometimes measured in terms of changes in EEG activity, sometimes as conscious behavioral activity) on a sleeping person are related to the effective perceived noise level (duration and spectrum), the meaning of the noise to the person, the age of the person, and the stage of sleep the person is in.[14,18,19,24]

It appears that noise can prevent a person from going to sleep or can awaken one from sleep if it is of sufficient intensity, has important meaning, or is of unusual character. Awakening may in turn engender a typical somatic arousal response which tends to alert the individual. It appears that the threshold of "audibility" or hearing of a noise (as indicated by a change in EEG activity and, at least momentary, behavioral consciousness if the noise is continued) increases as much as 70 - 80 dB as one goes from a light to a deep stage of sleep.[14] Noise above the level of audibility during a particular stage of sleep will usually, by definition, cause some awakening, but the alerting or stress response perhaps may or may not occur depending presumably upon

the meaning or appropriateness of the noise.

It is unfortunate that more research data on the subject of noise and sleep are not available. Nevertheless, it is perhaps not unreasonable to conjecture that arousal and stress reactions to the fact of being awakened by an unfamiliar or emotion-producing noise probably serve to prevent a quick return to a given stage of sleep, but that this reaction is subject to considerable adaptation with continued exposure to the noise. One thinks, of course, of the fact that people learn to sleep in quite noisy environments such as near elevated trains, airports, aboard ships, and on trains. However, the initial awakening reaction to noise that is above the sleep threshold of audibility described above does not appear to adapt with continued exposure. This is undoubtedly a necessary protective condition for an organism in that the awakening that does occur is primarily to permit evaluation of the meaning of the noise that caused the awakening.

Some investigators[16,20] have conjectured that, because environmental noise can awaken a sleeping person or cause, without awakening, the changes in EEG activity that usually precede awakening, it is physiologically harmful, particularly to a person who is ill or recovering from undue fatigue. There are no adequate data to substantiate such conjectures, even though there are data to show that sleep deprivation can lead to harmful psychological and physiological effects.[23] If there are no harmful effects from being awakened by environmental noise to which one has become psychologically adapted, it must probably be ascribed to the cyclic nature of sleeping itself (i.e., the organism adjusts its sleeping pattern to accommodate the awakenings) or to the fact that as the needs for sleep increase (due to conditions of ill health or fatigue) the arousability of the organism decreases, thus tending to insure necessary amounts of sleep.

In any event, research and anecdotal data can be found to permit one to take either an alarmist or a more unconcerned point of view as to the "harmful" (which must be distinguished from awakening) effects of normally present environmental noise on people who are sleeping.

Other Behavioral Activities and Relation to Stress

Although, because of adaptation, normal environmental noise may not have any harmful physiological effects directly on a man's non-auditory system, noise is obviously always a potential source of stress through interference with some behavioral activities. It is appropriate, therefore, to examine the effects of environmental-type noise on other activities in attempting to assess possible physiological stress reactions indirectly due to noise; the data in Figs. 4 and 5, the hospital admission data,[1] and the results of the study of a noise-free society[21] may reflect to some extent such effects of noise.

Interference effects of noise on other activities, such as mental or motor work that does not involve auditory communications, has been studied extensively in the past. Almost without exception these studies show that the interference effects of noise are negligible. The exceptions to this general conclusion, when they occur, can usually be explained as being due to some special noise-contingent relation (i.e., the worker's motivation is improved because the reduction of industrial noise indicates a greater concern for his well-being) or because the task involved some auditory communications that the experimenter and the worker were perhaps unaware of (i.e., information obtained from the movement of machinery parts that were masked by the background noise). There is some indication that impulsive noises cause, even after continued exposure, some slight arousal response; this response appears to have a negative (for a number of seconds), then a beneficial effect on task performance.[25]

The effects of noise on auditory communication, particularly that of speech

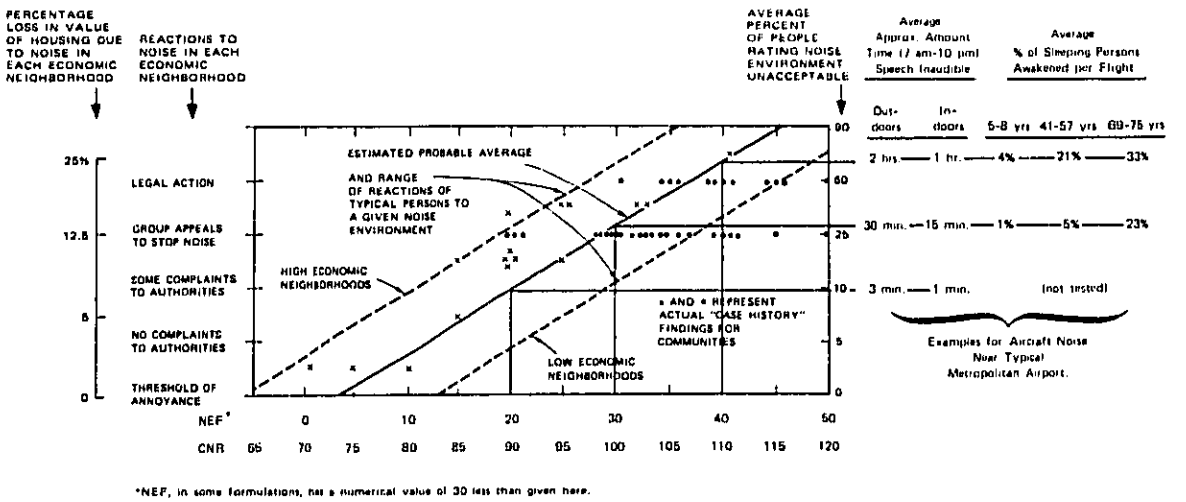
communication, have also been extensively studied and need not be discussed here. It is perhaps unfortunate that these studies have been concerned almost solely with measures of the effectiveness of communications per se in the presence of noise and have not been concerned with possible physiological stress reactions that may have occurred in the persons exposed to the noise. It would appear, however, that mental and motor work activities that do not involve auditory communication, would not be significantly interfered with by noise per se, and that the noise would not engender what might be considered disturbing and eventually harmful physiological stress reactions.

Tolerable Noise Limits as Judged by Society

The most direct, and perhaps most valid, insight into the possible presence and magnitude of stress reactions in general living environments is probably that which has been obtained from attitude surveys and real-life behavior of people. Figure 6 and Table 4 summarize much of the data obtained within the last 20 years on this problem. From an analysis of these data one may deduce what are "tolerable limits" as viewed by society or by some portion thereof on the basis of their psychological feelings and reactions to environmental noise. Whether there are physiological reactions that might suggest lower tolerable limits than those to be deduced from these psychological reactions cannot be answered unequivocally from present research data.

Insofar as noise interference effects are non-adaptive, such as in the case of masking of auditory signals, the stress reactions may be always present or may even increase with continued exposure. Furthermore, the presence pf physiological stresses, other than those indirectly due to the noise may, in concert, contribute to physiological and mental ill health.

There are, to my knowledge, no data available in the published literature which clearly demonstrate harmful physiological non-auditory or psychological




*NEF, in some formulations, has a numerical value of 30 less than given here.

ig. 6 Relation between various effects of habitual environmental noise and a composite noise rating, CNR and NEF. (CNR and NEF are common, and similar, units for measuring noise over the 24-hour day.) Percentage loss in housing values and community reactions (left-hand ordinates) are related as shown by the dashed curves to neighborhoods of different economic status. The effects of noise on attitudes, speech masking and arousal from sleep, (the right-hand ordinates) are to be related to the solid or average curve shown. The data on percentage loss in value of housing is based on a recent extensive, long range analysis of this question in England (Commission of London's Third Airport Papers and Proceedings VII, Part II, and Further Research Team Work 51, Templar House, 79/81 High Holborn, London, WC 1, England). After Kryter.[13]

Table 1

SUGGESTED TOLERABLE MAXIMUM LEVELS OR EXPOSURES IN VARIOUS ROOMS FOR MORE OR LESS CONTINUOUS NOISE FROM 7 AM TO 10 PM.

Equal Max PNLs for different noises are comparable to each other only when the noises have a broadband spectrum and do not contain any strong pure-tone or line spectrum components. Noises or noise environments of equal EPNL or equal CNR values are presumably equal in their effects on people regardless of the spectral or temporal complexities of the noises or noise environments they represent. Ref. 13

| Type of Space | Max PNL | | | EPNL | |
|---|---|---|---|---|---|
| | dB(A) | dB(D) | PNdB | EPNdB<br>EdB(D')<br>EdB(A') | CNR |
| Broadcast studios | 28 | 35 | 41 | 78 | 66 |
| Concert halls | 28 | 35 | 41 | 78 | 66 |
| Legitimate theaters (500 seats, no amplification) | 33 | 40 | 46 | 83 | 71 |
| Music rooms | 35 | 42 | 48 | 85 | 73 |
| Schoolrooms (no amplification) | 35 | 42 | 48 | 85 | 73 |
| Apartments and hotels | 38 | 45 | 51 | 88 | 76 |
| Assembly halls | 38 | 45 | 51 | 88 | 76 |
| Homes | 40 | 47 | 53 | 90 | 78 |
| Motion picture theaters | 40 | 47 | 53 | 90 | 78 |
| Hospitals | 40 | 47 | 53 | 90 | 78 |
| Churches | 40 | 47 | 53 | 90 | 78 |
| Courtrooms | 40 | 47 | 53 | 90 | 78 |
| Libraries | 40 | 47 | 53 | 90 | 78 |
| Offices - Executive | 35 | 42 | 48 | 85 | 73 |
| - Secretarial (Mostly typing) | 50 | 57 | 63 | 100 | 88 |
| - Drafting | 45 | 52 | 58 | 95 | 83 |
| Meeting rooms (sound amplification) | 45 | 52 | 58 | 95 | 83 |
| Retail stores | 47 | 64 | 60 | 97 | 85 |
| Restaurants | 55 | 62 | 68 | 105 | 93 |

Note 1: The noise levels outdoors from sources located outdoors (aircraft, road traffic, etc.) would be typically about 20 dB greater for the average house and 30 dB for masonry or well sound-insulated buildings than the levels given in the above table.

Note 2: dB(A') -13 = dB(A); dB(D') -6 = dB(D).

stress effects on man where noise per se is the sole or even the most plausible direct cause of the stress. The distinction between whether stress is induced directly or indirectly by noise is obviously of practical importance to noise control procedures, the setting of tolerable limits, and to the design of scientific experiments to study the problem.

If damage criteria were to be used for physiological (non-auditory) stress, and if physiological stress reactions resulting indirectly from interference with behavioral activities were the source of this possible damage, then it would seem reasonable to presume that the behavioral measures, such as reflected in Fig. 6, also provide, at least for "normal" people, a basis for the prevention of any such physiological harmful effects.

It has occasionally been proposed that there may be some persons who are unable to adapt (i.e., are always frightened) to noises from sources that are harmless and do not interfere with some auditory behavior; these people will, therefore, inevitably suffer from physiological stress effects indirectly induced by the noise. It is questionable, however, whether society would or could accommodate such people by restricting noise below limits that were considered very acceptable by a large percentage of people.

Use of Animals in Studies on Non-Auditory Effects of Noise

In a recent analysis of the research on noise[9] it was reasoned that human subjects may suffer physiological damage from intermittent exposure to stressful noise because (a) subendocardial hemorrhage and infarction can be induced in animals by infusion directly into the heart of catecholamines (a chemical found in the blood during arousal responses of the adrenal gland); (b) elevated catecholamine levels are found in myocardial infarction in humans; (c) elevated catecholamine levels are found in humans; and (d) some rats and rabbits show permanent vascular and central nervous system changes as the result of

exposures to noise. However, there are apparently no data available that indicate that normally present environmental noise was or is the source of the stress-causing myocardial infarction in man. What is stressful noise in man - whether noise indirectly causes stress due to frustration from the interruption of behavioral activities, or because the noise per se exceeds certain levels, was not defined in the report.[9] Presumably the author had in mind noise in excess of certain levels because the report recommends that a program of research on the effects of environmental noise on man be initiated primarily with rats as subjects, secondarily with human subjects seated in a laboratory, and thirdly with animals such as baboons.

While the proposed tests with the human subjects should be able to contribute useful data regarding the possible effects of environmental noise on man, the proposed tests with animals, particularly rats, are not likely to be constructive in this regard. If the stress of noise is indirectly due to interference with speech or other behavior, then only by studying man when engaged in these activities can one determine when and to what degree noise is stressful. Furthermore, if one accepts the possibility that there is some direct stressful effect of normal background noise independently of masking of speech or interference with other activity, the use of rats for research is counter-indicated because these animals display a type of behavior called "audiogenic."

The abnormal (with respect to its relation to man) audiogenic effects of noise on some rodents and some rabbits is attested to by the following quotations[6] (pp 24, 25, and 26):

"This type of behavior has been recognized not only in the rat, but also in mice, guinea pigs, Peromyscus, and latterly in the rabbit. In mice they may appear at any age, dependent on the strain, up to or just beyond maturity, but in Peromyscus they are confined to immature animals. Moreover they have

been found only in laboratory stocks, though in Peromyscus they appeared in the first generation removed from the wild.

"After the initial startle response to the onset of the stimulus, any of a number of patterns may appear. Some animals appear to ignore the sound source, others seek to retreat from it, a few actively attack it. Many rats crouch motionless or try to burrow beneath the floor. ....In most non-seizure trials some sort of 'substitute behavior' appears: rapid noise or ear rubbing, teeth chattering, chewing, shivering, shaking, vibrissae twitching, body cleaning, or restless head and body movements. In trials culminating in a seizure, behavior described ....as a 'motor aura' usually occurs, typically consisting of brief quick runs, jerky sidling or backward steps, or pivoting movements of the head and body. ....Most characteristically, it leads directly (after an average of 15 to 20 s) into the convulsion proper. ....The rat may continue to exhibit clonic jerks (e.g., spasmodic jumping) with decreasing frequency as long as stimulation continues, or may lapse into the phase usually described as comatose.

"Rather late in these investigations it became clear that the indicence of these seizures in laboratory stocks was hereditarily determined. In rats, dietary deficiencies play a part in determining the incidence. Vitamin B1 and B6 deficiencies are especially important. Magnesium deficiency is likewise effective in guinea pigs.

...."Otitis media has been found to be a factor in the occurrence of audiogenic seizures in rats, and has been seized on by some who claim it to be the sole cause of the incidence; but ....this is not so for mice (at least).

...."Provided the auditory stimulus is applied in an enclosure with an escape hole, rats run for shelter and do not develop the seizure. This suggests that the initial response to the sound is escape in flight to some form of

refuge. ....Not only did the mouse fail to develop a seizure if it entered the (plasticene) hut, but that if it subsequently came out while the stimulus was proceeding it did not develop a seizure. ....Moreover, it was shown that the hut need not possess a roof to be effective in this way. Contact with the walls of the hut was sufficient to suppress a convulsion."

Behavior of this sort has never been reported in man or other animals as the result of exposure to noise, although, noise or startling visual or tactile stimuli may trigger fits in some persons with epilepsy. Indeed, continued exposure to intense noise will lead to partial or complete deafness in man and other non-audiogenic animals usually with no apparent indication of any other harmful physiological effect. For this reason and because all degrees (from incipient to overt) audiogenic seizures can occur in laboratory rodents and in rabbits, it seems obvious that the results of experiment with these animals on the effects of noise cannot be generalized to other species.

The notion, as is implied in some studies of the effects of noise on animals, that the exposure of the (human) organism to any practically available amount of environmental noise can cause adverse physiological effects (other than damage to the ear-receptor mechanism is not logical from a body stimulation point of view and appears to have no basis in fact. Possibly heating of the skin or internal organs by means of ultrasonics or harmful vibrations induced in organs of the body by lower or infra frequency sound is not possible from noises to be found in typical working or living environments.[13]

Conclusions and Recommendations for Research

1. So-called stress reactions in the human organism when continued for sufficiently long periods can be physiologically harmful. However, it appears that the psychological and physiological responses to noise (excluding changes in hearing) are transitory, that they adapt out with continued

exposure to the noise, and therefore do not constitute harmful physiological stress.

This conclusion is deduced from a relatively small amount of research and incompletely tested concepts. For these reasons, research involving at least weeks or months of psychological and physiological testing with human subjects exposed, when awake, to quiet and to both low-level background and higher-level intermittent noise is needed. Further laboratory and field research on the effects of noise on sleep should be undertaken.

2. Physiological stress reactions that sometimes appear in certain noisy environments are likely to be the result of frustration or anger that occurs when the noise interferes with the reception of a wanted auditory signal or when the noise distracts from some other activity. Setting tolerable limits for environmental noise in terms of its subjective acceptability to people and its damaging effects on the inner ear would appear to provide levels of normally present environmental noise that are lower than those which can directly cause harmful non-auditory physiological stress conditions in man.

It is recommended that laboratory studies be undertaken to study individual differences in sensitivity of humans to noise and to multiple stress conditions, including the performance of tasks requiring use of auditory cues and tasks not requiring such cues. Some real-life situations may be found in industries or in various societies that permit useful research studies in this problem area; however, these studies must be undertaken with considerable caution because conditions may be present in these situations that have effects that outweigh those the noise may have on the psychological and physiological conditions of the people involved.

3. Because non-auditory physiological stress responses in an organism to normally present environmental noise are often the result primarily of interactions between specific behavioral activities and the noise rather than the noise per se, research on the effects of noise on lower animals cannot usually be generalized to man. Therefore, research aimed at understanding of the non-auditory effects of noise on man should, under most circumstances, not involve lower animals. Rodents and rabbits in particular should not be used for this purpose because of the presence in some of these animals of so-called audiogenic behavior.

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13. ABSTRACT

This report is a summary and evaluation of research findings that relate to any effects of noise other than to the ear and related structures. For example, included herein are research efforts concerned with psychological effects of noise, effects on task performance, effects on the cardio-vascular system, and on general health. This report also presents areas and types of research studies that may help to provide full answers to questions on the degree of noise control desirable with respect to the non-auditory effects of noise normally present in living and working environments.

| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
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