# NON AUDITORY EFFECTS Of NOISE - A REVIEW OF LITERATURE

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AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILLMENT FOR FIRST YEAR M.Sc ( SPEECH AND HEARING ) TO THUS UNIVERSITY OF MYSORE

ALL INDIA INSTITUTE OF SPEECH AND HEARING MYSORE - 570 006

# CERTIFICATE

This is to certify that the Independent Project entitled "Non-auditory effect of noise - A review of literature" is the bonafide work on part fulfillment for the degree of Master of science (Speech and Hearing) of the student with Register No.8807.

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## CERTIFICATE

This is to certify that this Independent Project entitled "Non-auditory effects of noise - A review of literature" has been prepared under my supervision and guidance.

Dr.M.N.Vyasamurthy

## DECLARATION

I hereby declare that this Independent Project entitled "Non-auditory effects of noise - A review of literature" is the result of my own study under the guidance of Dr.M.N.vyasamurthy, Department of Audiology. All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

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1.1

# INTRODUCTION

Noise defined as unwanted sound, has bothered mankind for at least two thousand five hundred years. The ancient Greeks were disturbed by noise and about 600 bc. The syrabites banned metal work involving hammering within the city limits. Pliny the Elder was the first to report the association of noise exposure and deafness in his work "Natural History". With the advent of industries noise type, source and intensity increased and accordingly occupational hearing loss also increased. Nils Skragge (1765) stated in his thesis "Morbe Artificum" that coppermiths usually become hard of hearing as a result of hammer blow.

By 19th century effects of noise were beginning to be studied. Initially attention was directed at the auditory effects of noise. Only since the last three decades the non-auditory effects namely annoyance etc. have received attention.

Most investigation of noise effects to-date have been carried out on animals. Studies involving humans are either retrospective or prospective studies on people working in a noisy area where precise control of the character, intensity and duration of the noise exposure was lacking. Further, much of the work has involved steady-state (continuous)noise and it is on this work that the predicted traumatic effect of noise has been estimated.

Impulsive noise from gunfire, drop forges and other sources of intermittent sound has been studied less frequently. This is due to difficulties in quantifying the variable number of impulses, impulse intensity, the daily variability within an individual to temporary threshold shifts from impulse noise and the difficulty of simulating impulse noise in the lab. Davis et al (1949), Lehman (1965) Jansen (1970) and Rosen et al (l950) among others have studied various aspects of non-auditory physiological reactions in man when subjected to noise (cited by Cantrell, 1974).

It is now fairly certain that exposure to noise causes in man physiological reaction which bear on psychological reaction and physical health, and the ability of the person to perform mental motor tasks (Caatrell, R.W.1974).

According to Kryter (1970) non-auditory system responses are, for the most part, the result of the stimulation by the auditory system of three neural system that are not devoted exclusively to audition:

1. To so-called automatic nervous system which controls the general somatic responses and the state of arousal of the body - the glands, viscera, blood vessels, heart etc.
2. The so-called reticular nervous system Which appears to be involved in the state of arousal of the higher brain centres of the central nervous system with sensory inputs related to pain and pleasure.

3. The cortical and subcortical brain centres concerned with cognition, consciousness,task performance, thinking etc.

Davis et al (1955) labelled the following set of response to noise in human beings as the N-response.

1. A vascular response characterized by peripheral vasoconstriction, minor changes in heart rate and increased cerebral blood flow, since cerebral vessels show no vasoconstriction to such stimuli.
2. Slow deep breathing.
3. A change in the resistance of the skin to electricity(GSR).
4. A brief change in skeletal muscle tension.

In addition to the above (1) changes in gastrointestinal motility (2) chemical changes in blood and urine from endocrine glandular stimulatlon may be preaent (cited by Kryter,1970).

Schiff (1973) summarised the non-auditory effects of noise in man as follows:

1. Speech interference.
2. Annoyance - a) Disruption of sleep pattern. Interferenc of privacy and rest.
3. Physiological changes (a) cardiovascular (b) glandular or endocrine (c) respiratory (d) neurological and vestibular changes.
4. Psychological changes (a) Startle effect (b) Rock 'n' roll 'wayout' effect (c) Psycho-social effects (d) information content (e) attitude (f) peraonality factors.
5. Efficiency changes The tasks requiring the following skills (a) Sensory skills (b) perceptual skill (c) Manual skill (d) mental skills cited by Central, (1974).

According to Rossi , (1976) Noise is responsible for four closely linked effects in man. They relate to (1) Hearing (b) vegetative functions Which comprises, cardio-circulatory system, sleep, endocrime activity and the gastro-intestinal apparatus (c) Interperaonal relations (state of attention and wakefulness speech and behaviour (d) overall repursussion on physical and mental activity determined by the degree and type of "disturbance and annoyance ceused by the noise in question".

According to Dejoy D.M(1984) non-auditory effects refer to all the effects of noise not directly related to hearing loss. Usually -

1. Physiological responses and health outcomes other than hearing loss.
2. Performance and behavioural effects.
3. Sleep disturbance.
4. Communication Interference are considered non-auditory effects.

Since noise has the subjective quality of interaction with humans, it can be described in both physical and psychological dimensions.

The most common operational definition of noise is that it is unwanted sound.

In the audio encyclopedia noise is defined as a random sound composed of many different frequencies not harmonically related.

Noise is defined by the physicist as sound due to acoustic waves of random intensities and frequencies.As found in industry, it represents unwanted sound and wasted energy (Ballenger, 1979).

Noise is also defined as-

a) unwanted sound

b) sound not wanted by recepient

c) the wrong sound, in the wrong place, at the wrong time.

All the above definitions agree that noise is a form of sound. Noise quality of sound is as much dependent on the context as on the physical properties of the sound itself.

concern about non-auditory effects is increasing since the last dacade. This is largely due to heightened public concern ragarding environmental pollution and workplace health and safety.

Performance and communication interference have been under scientific investigation relatively longer than the other areas of non-auditory effects. This is because of the relevance of the above mentioned two areas to communication and military system development. Even in these areas there has been expansion of interest studies now include investigation of long term effects and identification of susceptible subpopulations.

The existing literature on non-auditory effects of noise on human beings is characterised by two investigative approaches (DeJoy, 1984).

1. Epidamiological or population based studies of noise exposed industrial workers or community residents.
2. Experimental or quasiexperimental human studies in either field or lab settings.

1. **Epidemiological studies**: These studies make up the largest body of research on the non-auditory physiological effects of noise. Reviewers Miller (1974), Cohen (1977), Kryter (1980) conclude that although there are evidences that noise exposure results in adverse physiological effects; generalizability of these findings is still questionable.

2. **Experimental and quasi-experimental human studies**: Several recant studies have been conducted which are best classified as chronic exposure human experimental studies. some of the studies though, could also be classified as epidemiological studies, they are included in this category because the design employed approximated that of a true experiment. A few such studies are quoted below.

Ising et a1 (19797 conducted a study in a German brevery to compare blood pressure and stress hormone levels on days in which workers did or did not wear hearing protectors. On days when the workers did not wear personal protection devices and were therefore exposed to more noise, statistically significant intra-worker elevations in blood pressure and norepineohrine levels were obtained (cited by Dejoy, 1984).

Cantrell's (1974) long-term laboratory study results indicate that exposure to short bursts of noise at 80-90dB SPL for thirty days produced elevations in cortisol and cholestrol. The levels decreased upon noise cessation suggesting that effects were noise-induced.

General recommendations for additional research on the non-auditory health effects of noise have been offered by a number of national and international scientific and medical groups (National academy of sciences, 1981; world health organization, 1980; Rassnekov, 1980). The consensus is that effort should be concentrated on the cardiovascular system; initiatives should be developed using both experimental and epidemiological approaches directed at determining whether cause-effect relationships exist between long-term noise exposure and medically significant physiological responses and related health outcomes.

Adequate studies have to be done oa another segment of the population the children. Children are exposed to high noise levels in schools and residential areas. Its been suggested that children may be hyper susceptible to the effects of noise, and that given noise levels may produce greater effects on children than would be predicted on the basis of previous studies of adults (Mills, 1975 (cited by Dejoy,1983).

Prior to 1975 most of the information about the effects of noise came from studies conducted on adults, Conclusions about chiildren were often based on extrapolations from adult data. Most of tha recent investigations have focussed on academic parformance and cognitive development effects, but some findings have also been obtained, relevant to auditory and non-auditory health effects in children. More detailed study is required in this area because it is necessary to adequately plan design and evaluate environments used by children.

The relevance and importance of the information given above and in the forthcoming chapters, in our daily life, is better understood by the following illuatration.

Diwali is one of the times when we all bacome aware of noise and its effects. Although the auditory effects of noise like temporary threshold shift noticed, not much attention may be given to the non-auditory effects. Students studying for their examinations may get annoyed by the noise around them, some of them may find noise diaturblng their concentration and some others may be unable to relax or sleep Most individuals experience inability/difficulty in communicating through speech during this time. But the people involved in berating crackers seem to be oblivious of all these effects. we also see individuals Who try to mask the outside noise by listening to music of their choice. In addition these may be physiologcial Changes due to noise, going on within the individuals who are effected and unaffected by noise,of which they are unaware. This than leads us to ask a number of questions:

1. Why is it that only some individuals are adversely affected by noise and not the others?

2. Do risk groups exist with respect to harmful aspects of sound,

3. Why does noise effect differ from individual to individual.

4. What particular conditions must be fulfilled if mound is to have a harmful non-auditory chronic effect. Can these conditions be fulfilled in real life or in the lab.

5. What could be the effects of noiae on health.

6. Are there any physical Characteristics of a sound making it particularly potent in influencing non auditory, physiological systems.

7. Do chronic alteration of the physiological homeostasis also imply a threat to health, a decrease of well being, an increasa of disease incidence or a shortened life span.

8. Does sound interact with other physical or chemical factors in the environment? Is there an additive effect,a potentiation or a partial cancelling.

9. Can the risk group be identified, example on the basis of their short term reactions.

10. What are the neuronal mechanisms responsible for the short and long term non-auditory effects of sound.

11. Does sound influence the body even when it does not convey information about anything other than its own presence.

Research studies on non-auditory effects of noise which have aimed at answering the above questions and many more will be reviewed in the forthcoming chapters.

# NOISE ANNOYANCE

Behaviour in response to noise is normally measured in three ways. They are-

1. Measurement of annoyance
2. Physiological measurements much as metabolism, rate of breathing, tension in the muscles and similar indicators of the man's bodily state.
3. Measurement of efficiency in task performance.

It is common to find that the above three measures do not agree in estimating the importance of some environmental conditions.

Eg. An individual who complains of annoyance due to certain noise may not show soy changes in the efficiency of the task he is performing.

The main effects of noise apart from the physiological effects, are the distinctive and characteristic ones variously referred to as annoyance, disturbance, bother, nuisance, intrusion, negative feelings or affects towards noise, adverse subjective response to noise, perceived noisiness. Objective end neutral terms like acceptability, unacceptability of noise or dissatisfaction have also been employed.

May (1978) defines annoyance as the overall unwantedness of sound heard in a real life situation.

Annoyance is also defined as a general feeling of displeasure or aversivenass towards a noise source believed to have a harmful effect upon a person's health and well-being (Karolinska Institute (1971) cited by Borsky (1980). Thus more than thirty English words and phrases have been grouped under the general head of annoyance (Langdon, 1985). The fact that annoyance is referred to under so many different names and descriptions points to its capability for affecting people in a wide variety of ways. Some of these are purely attitudinal, as When someone says "My neighbour's singing drives me crazy".Others are more closely related to various activities interfered with, such as reading, talking or watching television. Again it is largely the attitudinal aspect, the dissatisfaction occaaioned by this interference rather than the degree of interference itself. According to Broadbent (1957) the annoyance produced by some sounds does not mean that they are bad for health; secondlyv because annoyance is unrelated to health, it does not follow that it can be ignored.

Studies of noise annoyance have tended to rely mainly on observation through social surveys rather than on controlled experiments becauae it is difficult to have a person simulate annoyance in a lab and also because it is largely attitudinal and therefore difficult to measure. Some studies, though, have been carried out in the lab under controlled conditions (Rice, 1977; Rylander et al, 1977; Flindell, 1979; Stephens and Powell, 1980) with some degree of success. The results of these studies While comparable with those of field studies, are not in general capable of being used directly for the establishment of control norms. Surveys dealing with noise annoyance have involved rating scale, questionnaires etc, with the aim of discriminating between different aspects of the noise and the way it affects people and particularly at different levels of intensity. Lack of control in noise annoyance survey has tended to limit the general conclusion.

Annoyance response is mediated by three primary factors:

1. The inherent unpleasant characteristics of the noise.
2. The aversive meaning associated with the noise source.
3. The interference with ongoing activity.

Since the work of Laird and Coye (1929) evidence has accumulated indicating that the annoyance with noise (or preference for tones etc) can be influenced by physical aspects such aa intensity and spectrum (Reese at al. 1944; Kryter, 1948; Vits, 1966. 1972; Molino, 1974: Bryan and Tolcher, 1976; Gunn at al. 1976, 1978). Louder the sound more likely it is to produce annoyance (Broadhent, 1957). (cited by Harris 1970)

High pitched noise is more annoying than an equally loud low pitched noise (i.e. above 1500 Hz). The effect is true for both puretones and for bands of noise. Especially low pitch in a sound, in the region of 100 Hz, makes it more annoying than a noise more toward the middle of the audible spectrum (Broadbent, 1957).

Shultz (1978) developed curves representing percentage of the population "highly annoyed" as a function of various noise levels. Based on the composite results of nineteen community noise surveys, data indicates that 3-4% will be highly annoyed by noise at or below Ldn=5 dB; 16% at Ldn = 65 6B and 25% at Ldn = 70 dB.

Gunn et al (1981) also demonstrated that loudness and annoyance are directly linked phenomena. Doubling of annoyance from a score of 2 to 4 occurred when level of noise increased from 80 dB(A) to 90 dB(A).

Modulated sound in terms of intensity and frequency is found to be much more annoying and people do not become accu-stomed to such noises s0 quickly as they do to steady noises. There is evidence that complaints of aircraft noise are less frequent in the neighbourhoods which have a high permanent noise level (Broadbent, 1957). Proportion of people Who com-plain will also vary with situations in which the complaints of annoyance are recorded. In residential areas a noise level of 6O dB may produce a sizeable number of complaints. In industrial situation the level is likely to be higher.(cited by Tempest 1985).

Annoyance seems to be influenced by a member of non-acoustic variables as well. Connor and Patterson (1970) reported that the most important psychological variable influencing community annoyance reaction to aircraft noise was fear of airplane crashes in the neighbourhood. Also, those who feel that they have no control over the noise, are often more bothered by the noise than those holding the opposite views (Leonard and Brosky, 1973).

Berglund et al (1975, 1976) were of the view that significance of the noise rather than the physical parameter of the noise are important. Their study result indicated that some noises, though soft, were annoying.
Eg. When reading in the Library even Whispering annoys a person.

Uncertain localization of the sound may provoke curiosity and even feeling of insecurity Which may interfere with other occupations and prove annoying. In the case of aircraft noise, localisation provides clues to possible consequences of the situation as danger of airplane crashes and accidents in the neighbourhood. When aircraft is perceived directly overhead, it is very likely that such perception indicates immediate danger associated with aircraft accidents.

Studies indicative of an association between annoyance of aircraft noise and fear of crashes do not necessarily prove the causation of annoyance. It might occur because fear produces annoyance, or it might occur because fear and annoyance responses might both be indecative of emotional lability or lack of stoicism.

Previous studies have shown that emotional lability is involved in annoyance (Sennet, 1945; Pearson and Hart, 1969;

Vanderhei, 1976 and others). Annoyance reactions are greater in hystenic personality than in dysthymic personality (shigehisa and Gunn, 1978), annoyance increases in emotionally labill subjects where as it decreases in emotionally stable subjects whan the intensity of ambient illumination is increased (Shigehisa and Gunn, 1978).

Shigehisa and Gunn et al (1981) studied annoyance in relation to the emotional content of noise. They found that, the more anxious subjects were less annoyed by the flyover noise, than the leas anxious subjects, regardless of the judgement, situation or procedures used. These data give support to the view that emotional lability as well as the emotional content of noise may underlie annoyance reactions caused by aircraft noise. It may be because more anxious people have higher levels of emotional arousal and addition of another annoying stimulus such as aircraft noise,does not further increase the level of emotional arousal or annoyance.

Noxiousness of noise may depend on its effect in disrupting communication, sleep and other behavioral activities (Loeb, 1975). When noise interfering with auditory task is presented it is more annoying than noise which does not interfere with the task.

Evidence suggests that stimuli in various sense modalities occuring in temporal proximity influence the magnitude of response in other modalities (Symons, 1963). Gunn et al (1975) showed that annoyance to recorded aircraft noise is differentially associated with the different ongoing activities. These differences in judged annoyance suggest a possible differential basis for the sensitivity of annoyance, associatad with noise in regard to each behavioral activity, either in the same or different sensory modality. Due to the greater complexity of the perceptual aspects of annoyance, relative to loudness, it is expected that annoyance may grow differentially than loudness with changes in noise level and spectrum. It is possible that some spectra result in greater unpleasant characteristics of the noise and cause greater interference with ongoing process of perception involving more than one sense modality, such as those watching television. Gunn et al (1977) studied the annoyance response to spectrally modified recorded aircraft noise during television viewing. Results were as follows:-

1. Maximum annoyance reduction occured When a given amount of energy was removed from octave bands in the frequency range between0.8 KHz to 1.6 KHz.
2. Spectrum modification was moast effective in reducing annoyance When the overall maximum intensity ranged from 88.0 to 89.1 dB(A), and was the least effective from 83.9 dB(A) to 85.3 dB(A).
3. Annoyance reduction resulting from spectrum modification at a single octave band (centred at either 0.8 KHz or 1.6 KHz) was equivalent to that resulting from a 2.7 dB(A) overall intensity reduction.

Gunn at al (1981) studied annoyance and ongoing activities. Group-I consisted of subjects in the reverse group Who sat and listened. Group-II watched a television program, While Group-III listened to a recorded modified rhyme test (House et al 1963) over a telephone during recorded noise exposure of 6—30 minutes. Each group had 108 subjects.

Group-II showed greater annoyance than I and III. As noise levels increased the annoyance of III was significantly greater than the annoyance of others 5% of the subjects found aircraft noise to be pleasent.

Arvindson and Lindwall (1978) studied 100 male students during acute exposure to 85 dB(A) of traffic noise in a lab setting. An association was demonstrated between reported feelings of annoyance, performance efficiency and the subjects experience of the influence of the noise.On their performance In the more annoyed individuals effect of noise annoyed individuals effect of noise exposure was more negative in their per— formance.Results indicated that the annoyance-inclined individuals in a community may constitute a special risk group that will suffer more from the adverse effects of community noise.

Sreedevi (1986) conducted a community noise survey and came to the following conclusions:

1. Noise made by people and vehicular noise caused more annoyance and interference with most of the activities.
2. Annoyance and interference with different activities being affected was dependent on the type of activity at hand, kind of noise source and also related to the age, sex and occupation of the individual.

**Conclusions:**

1. Most of studies of annoyance tend to rely on surveys rather than controlled experiments. Hence the results cannot be used directly for the establishment of control norms.

2. The feeling of annoyance towards certain sounds is to some extent influenced by physical aspects much as intensity and frequency of the spectrum.

3. High pitched noise is more annoying, and loudnees and annoyance are directly linked phenomenon.

4. More than steady state noise, modulated sound in terms of intensity and frequency is much more annoying.

5. Non-acoustical variables such as the emotional cantent of the noise, significance of the noise to the individual, sometimes are more important than the physical parameters of the noise

6. Unpredictability or uncertainity in terms of localisation may also play an important roll in annoyance since it may result in curiosity or even feelings of insecurity.

7. Emotional lability of the individual is also an important factor. Annoyance increases in emotionally labile subjects.

8. Annoyance depends on the kind of activity in which the individual is involved gets interfered.

9. Noise interfering with auditory task performance is more annoying than which does not.

10. Annoyance-inclined individuals are present who form a special risk group in the community.

Individual difference in terms of the psychological factors, sensitivity of the individual, multiple stress conditions influence the annoyance felt.

Complains of annoyance varies from situation to situation.

Noise Which is annoying for one individual may be pleasant for another. Hence the definition that annoyance is the overall unwantedness of a sound is appropriate.

**Research needs:**

1. Further, studies of annoyance in a more realistic set up is warranted so that the results of it can be used directly in noise abatement programs.

2. Identification of special risk groups to annoyance should be emphasized more so that further adverse effects can be avoided.

3. Sensitivity of the individual towards other stressors, emotional lability of the individual, attitude towards noise should be considered especially when studying annoyance.

4. Contradictory to previous studies, pleasant reactions to noise have been reported which should be further investigated.

5. Indirect and direct effects of annoyance on the individuals health in terms of physiological effects caused during noise should be studied in more detail.

6. Interaction between the annoyance variables like task, physical aspects of noise and annoyance should be studied to underatand the relevance of annoyance caused by noise in an individuals day-to-day living.

7. Annoyance effects with reference to different age groups and the sex should be done to check if any difference does exist.

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## NOISE AND HEALTH

The world health organisation defines health as "the state of complete physical, mental and social well-being, and not merely an absence of disease and infirmity". Noise diminishes wall being, so in this sense health is adversely affected, and it is generally appreciated that noise can physically damage the inner ear. In this chapter physiological responses and health outcomes. Other than hearing loss will be considered.

Under the non-auditory health effects the following will be considered:

a) Physical illness

b) Psychological effects of noise

c) Sleep

d) Extra—auditory effects on the special senses.

**a) Physical illness:**

The nature of the noise effect is non-specific and human beings are rarely exposed to an acoustical stress in isolation from other stresses. Hence the exact importance of noise and its effects on health have proven difficult to delineate and specify. There has been little evidence to date that noise has been the cause of permanent physical illness apart from hearing loss (Pelman, 1985). In an attempt to demonstrate physical Changes due to noise, heart-rate, blood pressure, muscular activity, metabolic rate and other responses have been studied.

The physiological changes occur im three stages. At the sudden onset of the noise there is initially rapid tensing of the muscles. The tensing is followed by slightly slower effects, comprising changes in the heart rate, respiratory volume, blood vessel diameter, secretion etc. finally, there are the effects which are controlled largely via the pituitary adrenal axis (Stephens and Rood, 1978).

Labmann in the mid 1950s conducted the first studies on the effects of noise on the human body. His team of researchers had determined that noise has an explicit effect on the blood vessels, and especially the smaller ones known as preeaplllaries. Noise makes the blood vessels narrower thereby reducing blood supply to various aspects of the body like toes, fingers, skin and abdominal areas. This vasoconstriction is a reflex action generated by the nervous system. Peripheral vasoconstriction is thus the earliest and also the best documented effect of noise on the cardiovascular system. At moderate noise levels there is a vasodilation with an increase in the blood flow to the head. This is considered important from an evolutionary point of view, in preparing the body for avoiding action against whatever threat may be causing the noise. But at high levels of acoustic stimulations there is a reduction in the blood flow to the head along with other parts of the body due to vasoconstriction. A particularly critical aspect of this restriction is that it affects blood supply to the inner ear. Thus, at the time when the sensory calls of the inner ear are in need of blood supply to provide energy sources and remove metabolites. They are receiving an impaired blood supply which enhances their susceptibility to the damaging effects of the noise.

Studies have been carried out to learn the relationship between the peripheral vasoconstriction and the temporary threshold shift and hearing status of the individual. Example: People Who show a large fall in the blood flow to their fingers when exposed to loud noise show relatively little change in their hearing Whereas those showing less fall in their finger blood flow show large shifts in their thresholds of hearing (Stephens and Rood, 1978).

Lehmann and Tamm (1956) and Jansen (1962) found that a short or prolonged noise caused vasio-constriction of pre-capillary blood vessels which persisted for the duration of the noise and longer. After five minutes of noise the constriction of the blood vessels begin to disappear but may persist for twentyfive minutes before disappearing completely.

Jansen et al (1964) compared the vaso-constriction of the Mabaans, an isolated primitive black tribe, to that of the Dortmunders in Germany. Both the groups were exposed to identical loud noise stimuli of 90 dB puretones and 90 dB white noise vase—constriction was much greater in the Mabaans of all ages, and also disappeared much quicker. Thus persistence of vasoconstriction and previous experience of noise exposure to produce vasoconstriction may act as an important influencing factor of physical health.

Mojdehi and Wailer (1980) studied twelve normal hearing awake adult subjects to determine the minimum intensities of white noise which produce a detectable change in digital blood flow. They found that 20-60 dB HTL was the range of minimum intensities to produce the response. There was no significant variation in the mean intensity required to produce the response from trial to trial.

According to Borg (1981) during exposure to a novel sound environment a redistribution of blood from skin and certain inner organs to muscles occurs. The adjustments depends on the features and timing of the sound and are sensitive to habituation. Although vasoconstriction is a part of a normal physiological response to a novel stimulus, it may relate to hypertension end coronary heart disease.

Ickes at al (1979) demonstrated that male subjects with personality A (stress prone) exhibited peripheral vasoconstriction than subjects with pattern B personality.

Heart rate is perhaps the earliest cardiovascular parameter recorded and consequantly the most widely used for study of non—auditory responses to sound. Phasic changes in heart rate are usually seen at the onset of an unexpected sound (Borg,198l).

Sokolov (1963), Graham and Slaby (1963) demonstrated that low level stimuli give a decaleration (orienting reflex) and high level stimuli an acceleration (defence reaction) in heart rate. The change is usually small in humans. It is less than 5 beats per minute. Lazettat et al (1979) supported the view that heart rate increased during occupational noise exposure.

Clocte (1979) differntiated between stress sensitive and stress-resistant individual with respect to heart rate reaction to 85 dB(A) noise. The stress sensitive subjects showed a significantly larger reaction Which habituated at a slower rate than in the stress-resistant subjects. (cited by Borg 1982)

Andren et al (1980) reported of no changes in heart rate on short-term exposure to modulated industrial noise at 95 dB(A).

Blood pressure (BP) has a close relationship to cardio-vascular pathology. Hence it is the most important parameter to observe in the analysis of non-audlitory effects in the acoustic environment.

Lehmann and Tamm (1955) obtained a minimal effect on the systolic blood pressure, but a slight rise of the diastolic blood pressure when they used octave band noise upto 90 phon. A clearest decline of total peripheral resistance and an increase of stroke volume was, however, observed. Habituation in most of the cases and a delayed rise in peripheral resistance was noted in several cases.

Steinmann et al (1955) reported of am immediate rise in the symbolic blood pressure of 5-20 mm Hg during exposure to high frequency metallic sounds. They emphasized that effect was dependent in a qualitative way on the type of sound used, and on the emotional value of the stimulus. Classical music usually produced a drop in the systolic pressure. whereas oriental music caused a rise in pressure. They interpreted that the emotional reaction to oriental was stronger than it was to the more familiar European music.

Schulte et al (1977) obtained a significant rise in systolic BP in normotensive as well as in those with labile hypertension. if the traffic noise (81 $\pm$ 3dB(A) exposure coincided with or followed a mental task. Puretones of 12 KHz (at 90 dB for a duration of 30 minutes) however gave a rise of systolic and diastolic BP only in subjects with labile hypertension but not in normotensive ones.

Von Eiff et al (1981) studied subjects with hereditary tendencies toward hypertension and their reaction to a 30 minute exposure to traffic noise. They found increases in BP more marked in these subjects than those who denied any such hereditary tendencies. Hence emotional lability of an individual should be considered in studies of cardiovascular parameter measurement, during noise exposure. (cited by Borg 1982)

Doyon et al (1979) matched factory workers exposed to 85dB(A) SPL with other workers in quieter environments. They reported a significant correlation between length of service in the noisy factory and level of BP. They also found that level of noise exposure and level of diastolic pressure were related. Ising et al (1980) conducted a short term study of exposure to industrial noise. Half the days of the 2 week period hearing protective devices were used so that each subject served as bis own control. They showed modest but significant BP and stress harmone precursor increases during the days when hearing protection device were on available. This proves the point that in hearing conservation programmes along with auditory effects, non-auditory effects of noise should also be emphasized on.

In a review Carturight and Thompson (1975) reported a decline in systolic pressure to 75 dB or 101 dB wide noise and the influence on the diastolic pressure varied. Lees and Roberts (1979) compared hearing loss and BP in a small industrial population exposed to high noise levels and found no relationship between the two variables. Similar comparisons performed on some relatively large (Malchaire and Mullier 1979) and on somewhat smaller (Cohea et al 1980) industrial population yielded negative or inconsistent results. Kryter and Poza (1980) failed to find consistent or significant changes in various physiological indices of automatic functions like peripheral vasoconstriction over a variety of noise conditions.

Cohen et al (1979) proposed that children may be more affected physiologically than adults by noise. This is partly because they have less well developed coping responses and are often less able to control their environments. They found that children exposed to high noise level had significantly higher systolic and diastolic BP than the low noise level group children. These differences were greatest during the first two years and became smaller thereafter. Karsdorf and Klappach (1968) showed that there was consistent increase in BP as noise exposure increased with approximately 9-16 mm Hg separating the highest and lower noise-exposure school children. (cited by Dejoy 1983)

**Effects of sound on endocrine function:**

Loud sounds, intense light, immobilisation, anxiety,forced exercise, surgery, cold and many other stressful agents increase the secretion of corticotrophic (ACTH) from the pituitary gland. In each case the mechanism by which the secretion of ACTH is accelerated is neurohumoral and is mediated through the CNS. The resulting elevation in plasma concentration of ACTH causes an increase in the secretion of adrenal corticoids. The additional corticoid secreted is characteristic of the particular species under stress. Thus loud sounds raise plasms concentration of 17 hydroxycorticosterone in man. No successful demonstration has, however been made of stress induced change in the thyroid function of man (Lockett, 1970).

According to Cannol (1929), selye (1971) the pituitary-adrenocortical system and the adrenal medulla play a central roll in the adaptation to and defence against changes in external and internal milieu.

Arguilles (1967) and Arguielles et al (1962, 70)found as increase of hydrocorticoids in plasma and urine in young male subjects with an increase in urinary secrretion of noradrenatine during an one-hour exposure to 125 Hz, 1KHz, 5KHz and 10 KHz sound at 63 or 93 dB. Response was greater at 10 KHz. Subjects with anxiety neurosis symptoms exhibited a more pronounced increase of hormone secretion than did normal subjects. Arvidsson and Lindwall (1978) studied the effect of traffic noise (85 dBA) on perceived annoyance and physiological reaction . No increase of urinary noradrenaline or adrenaline excretion was observed irrespective of whether subjects were at rest or engaged in a mental task. Those subjects who reported annoyance had tendency to physiological reaction Which agrees with findinga of Arguilles et al (1970) indicating the presence of risk group.

Artherley et al (1970) demonstratad that meaingless sounds at 95 dB(A) for 7 hours of exposure did not induce significant alteration of 17-ketesteriod. But sounds perceived as meaningful did cause changes in adrenal activity. (Cited by Pelmear 1985)

Noise is a known stressor to man and animals and affects almost every bodily system including the reproductive system. Past research on rodents shows that high levels of noise alter ovarian activity, inihibit fertility, interfere with fetal development and produce low-birth weight offspring. Possibility of experiments on the reproductive system in human beings is, for obvious reason limited.

In a research study involving pregnant woman living around an airport, noise was associated with reduced human placental lactogen levels Which was linked with low-birth weight infants. In another humen study woman who were exposed during pregnancy to high levles of noise from landing jet aircrafts had a higher birth-defect rate than pregnant women living in other areas of the same country (Hartoon, Treuting. 1981).

Salk (1961) reported of increase in weight development in babies stimulated by souud of human heart beats. But this is not verified by Palmquist (1975) (sull, 1979). They did not find difference in birth weight of children in a community near an international airport and a less exposed control community. Epidemiological studies reported a increased rate of premature births and a delayed weight development has been observed in babies born close to airports (Takahashi and Kyo, 1968; cited by Algers et al 1978).

Human plasmalactogen was lower in pregnant women near airports than in controls, particularly after the 36th gestational week. Such hormonal alteration may explain differences in birth weight.

**Other physiological effects of noise:**

Sound exposure causes a reduced gastric motility and secretion is humans (smith ahd Lavid, 1930) even at levels as low as 55 dB (Rougereau et al 1976). But the studies of Jungmann and Venning (1955) (cited by Stachler et al, 1979) indicated that the gastric motility decreased whereas secretion seemed to vary individually. Study by Davis et al (1955) indicated that a change of low to moderate level of sound stimulation caused an increase in gastrointestinal motility, whereas a decrease from a high level caused a decrease in gastrointestinal motility.

Noise, particularly of sudden onset, can causa reductions in salivary and gastric secretions and a general slowing of digestive functions. These changes together with other effects on respiratory dynamics seem to be a part of generalized stress reaction to noise (Pelmear, 1985).

Epldemiological studies form a necessary and valuable part of the analysis of any environmental effects. Studies regarding comparison of cardiovascular disease incidence and other physical illness between the noisy aad quiet area will give us a fair idea of general health in these areas. At present the emphasis of health effects expectation remains on the relationship between noise and cardiovascular function.

Several studies report various symptoms like cardiac arythmias (Jansen,(1959),Hypertension (McClean and Tarnopolosky, (1977) Hannukari et al(1978) increased neuro-vascular impairments (Suvarov at al 1979), cardiovascular diseases (Meecham and Smith, 1977, Hannukani et al 1978) and liver cirrhosis were greater in noisy areas than in quiet controlled areas.

Difficulty in epidemiological studies is the estimation of hearing loss. Some studies considers hearing loss to quantify noise exposure. Mainhart and Rinker (1970) found that employees with a severe noise inducad hearing loss had a significantly higher incidence of hypertension than subjects with a small amount of hearing loss.

Cohan (1973) reported higher incidence of diagnosed medical problems and absentuism in a factory with high sound level (exceeding 95 dB(A) than in a factory with low level noise (less than 80 dB(A). The frequency of accidents recorded was higher in the high level environment.

Though these epidemiological studies indicate that general health is poorer in the noisy areas the results are not conclusive since they do not take into account the other extraneous variables that may be affecting general health along with noise.

**Conclusion:**

1. Vasoconstriction is the earliest and well documented effect of noise on the cardiovascular system. This may relate to hypertension and coronary heart disease.

2. Heart rate is affected by noise exposure, but the Change is very small.

3. Noise exposure resulted in changes of systolic and diastolic blood pressure.

4. Changes in blood flow, heart rate, blood pressure was dependent on the personality types sensitivity to stress and emotional lability of the individual.

5. Duration of noise exposure, level of noise exposure, type of noise influence the cardiovascular parameters.

6. Quantitative data one lacking regarding the role played by the various physical parameters of noise in the production of non-auditory physiological responses.

7. The effects of noise on the endocrine system functioning, the respiratory system, gastrointestinal system has not yet been well established.

**Research needs:**

1. Attention should be given to identifying segments of the population that might be susceptible to the above mentioned effects.

2. Physiological effects of noise and their relation to general health in children should be investigated.

3. Research is also needed to know the extent to which chronic noise-exposure might exacubate pre-existing health problems based on the physiological effects of noise.

4. The biochemical mechanisms and cardliovascular mechanisms underlying long-term noise related changes and the extent to which noise operates in a similar manner of other stressors should be studied.

5. Relationship between a subjects self-reported annoyance reaction, effects on efficiency, psychological status and his/her physiological stress should be further investigated.

6. Studies concerning the physiological measurements of cardio-vascular functions.

Example: Blood pressure etc, should be done with respect to the different age and sex groups to find out if they vary with age and sex.

**b) Psychological effects of noise:**

Noise is a sound with a negative influence on a man's physical and psychic well-being, including change of behaviour and way of life in a direction experienced as negative by the individual (Relster, 1975). The psychological effects of noise differ from person to person and,in one and the same person. It is dependent on the hour, the character of the noise and the individual variable. The psychological changes canbe in teams of mental stress, maladjustment. chronic, fatigue, neurotic complaints and introversion.

Herridge (1972) studied the relationship between aircraft noise and admission rates to a psychiatric hospital. This was especially relevant for older women working alone and suffer from organic or neurotic mental illness. In organic illness the falling of intellectual ability through demantic processes, the struggle to cope with ordinary living increases. Much concentration is required to complete even the simplest of tasks. Deafness may make communication increasingly difficult too in these elderly patients. Therefore, the author concludes that, frequent piercing aircraft noises interrupting a slow and painful train of thought or already impaired concentration will precipitate breakdown. Thus noise may be precipitating factor for psychological breakdown.

The results of the study conducted by Broedbent (1972) indicated that there is no support to the view that neuroticism and annoyance by real noise are associated. Noise does not seem to increase the generaltendency to annoyance, even in neuotic introverts. Even if it does, it is in people with high general motivation. The conclusion is that people who complain when noise levels are relatively low have neurotic tendencies,but it does not follow that the complaints met at high levels of noise exposure come predominantly from this kind of person.

Cantrell (1974) studied the psychological effects of prolonged exposure to intermittent noise. Upto 90 dB no detrimental measureable effects were noted. However, the group mean state anxiety reached a peak at 90 dB. The noise was reported as the most irritating aspect of the environment during the 90 dB period. At least one-half of the subjects reported being bothered by the noise under some conditions, and there was evidence of attempts to avoid the tonal pulse.

Standing and Stace (1980) exposed 45 male and female undergraduates to low 43 dB, medium 61 dB and high 75 dB levels of ambient white noise for 30 minutes. Subsequent testing with the state-trait anxiety inventory revealed that mean situatlonal anxiety was significantly elevated for the 75 dB group. The variability of these scores increased for both 61 dB and 75 dB groups. Habitual or trait anxiety measures were not affected by noise. Farther testing indicated that essentially the same anxiety or noise relationship occurred in selected subgroups of subjects with extreme scores on trait anxiety, neuroticism, extroversion, lie and intelligence scales. The conclusion is that even quite moderate environmental noise levels can have undesirable psychological consequences among a wide range of individuals.

Donnesstein and Wilson (1976) conducted two experiments to study the effects of high intenaity (95 dBA) noise on ongoing and postnoise aggressive behavior. In the first experiment subjects were angered or treated neutral and given an opportunity to agress against another subject while being exposed to high intensity 90 dB or low intensity 55 dB noise. Results indicated that high intensity noise facilitated aggression for previously angered individuals.

In the second experiment post noise aggression, in which subjects completed a math task under high intensity noise with or without perceived control over the noise was examined. It was found that in comparison to a no-noise control, the angered subjects with no control revealed an increase in aggression where as perceived control subjects were no different from no-noise subjects.

Tolerance for noise in day-to-day living may depend on the basic personality of the individual.

Bergamasco et al (1976) studied the effects of urban traffic noise in relation to basic personality. 3 types of personality groups were considered. Group—I consisted of individuals with shallow affective discordance and high level of anguish. No difference in CNV amplitude in relation to normal quiet background and road noise was found; while greater percentage of EEG desynchronization during road noise was highly significant.

Group II individuals with deep affective discordance and medium-to-low level of anguish: statistically signiflcaat increaae la CNV amplitude during noise was found. EEG desynchronization was not statistically different during normal quiet background and roadnoise.

Group-III individuals with deep affective discordance with low and medium-high anguish level: No substantial differences in CNV amplitude and the EEG desynchronization percentage in the 2 experimental situations. The conclusion was that results confirm importance of basic personality in the way noise is tolerated and its greater or smaller capacity to disturb.

The status of general mental health is revealed by the admission rate to psychiatric hospital (as in the study by Herridge (1972) and consultation for psychiatric problems.

Meecham and Smith (1977) reported that maximum noise area (maximum-flyover noise exceeds 90 dB(A) shows a 29% increase in admission over those of a corresponding control area.

Ewersten (1979) gave the following results of a study conducted to find the difference in psychological effects of noise between the noisy area and quiet,area.

| | Noisy area N-477 | Quiet area N-483 |
|---|---|---|
| a) Medical consultation because of/sychiatric problems. | 19% | 12% |
| b) Use of sleeping medicines | 12% | 6% |
| c) Mental hospital admissions | 4% | 2% |

The difference between the two groups was statistically significant.

Relationship between emotional lability and noise effects have been studied in adults by a number of researchers. Very few studios have been done regarding emotional lability of children and affects of noise on them.Shigchisa and Gunn(l978) studied the reaction of emotionally disturbed children to Goldman-Fristoe-Woodcock test of auditory discrimination in quiet and in noise. Results reveal that their performance level was closer to the norms for poor discriminators than to the general population. Even in this population a significant number of children performed better in the noise condition than in quiet. They concluded that in emotionally disturbed children the background noise may act to mask out the internal noise in some emotionally disturbed children and result in batter performance than in quiet. Another factor may be that, listening in noise required maximal attending and resulted in improved performance in those,able to exert much attention. The results indicate that noise may be used beneficially for some segments of the population.

**Conclusions:**

1. Noise though not a cause for a psychological breakdown may act as a precipitating factor.
2. Noise does not lead to neurosis but individuals with neurotic tendencies will be affected more, even at low noise levels: than the others.
3. Anxiety reaches a peak at 75 dB-90dB noise level expopsure
4. Noise evokes emotions like aggression in addition to anxiety.
5. Perception of control over the noise influences the performance of the individual who has been emotionally aroused.
6. Tolerance of noise in day-to-day living depends on the basic personality type.
7. Emotionally disturbed individuals, especially children are affected by noise. In certain segments of such a population noise can be used benefically

**Research needs:**

1. Quantitative relationships have to be derived to express the effects of noise on behavior and psychological status of the individual.
2. Interaction of acoustic and nonacoustic factors, which are most important in mediating behavioral response to noise, during noise exposure should be studied.
3. Methodologically sound field studies on psychological effects of noise should be emphasized on.
4. Studies that investigate relation between annoyance, task efficiency, psychological effects and physiological measurements could be more useful in understanding the importance and relevance of some environmental conditions.

**C.Sleep:**

Noise may adversely affected Sleep in several ways. It may prolong the time initially needed to fall asleep, it may cause awakening once asleep, or interfere with returning to sleep once awakened. Research has also shown that noise may affect sleep by inducing shifts from deeper to shallower sleep stages as measured by EEG recordings.

Knowledge about how noise interferes with the sleep process and the conditions under which this occurs are important. But this information does not provide answers concerning the health and welfare consequences of chronically noise-disturbed sleep. To date, only a few studies have been (Conducted examining possible behavioral and health consequences associated with sleep disturbance. The consequence may be serious if the body does not adapt to persistent noise for a prolonged period, because adequate periods of rest and sleep are physiologically necessary.

Regarding sleep the following general relations appear to be established (Kryter, 1970).

1. As revealed by EEG, there are four stages of sleep, one of Which looks in general pattern like the EEG of an awake person but is accompanied by rapid eye movements (REM) as well as other muscle responses.

2. Man typically spends various portions of a night of sleep in these different stages in a cyclic pattern. Because the REM stage and awake EEG patterns are similar, it may indicate a state of normal cortical activity. However, man is usually insensitive to auditory or other stimulation during REM stage (Williams, 1964).

Some adaptation to noise during sleep may occur common experiences of sleeping batter in a familiar environment than in am unfamiliar environment containing unfamiliar sounds supports this notion.

Research data showing that a person, in some stages of sleep, cam discriminate among auditory stimuli in terms of their meaning is consistent with anecdotes that one can listen for certain sounds when asleep and ignore the others. This apparently is a form or recognition that is readily learned through previous awake exposure to a noise or a change in the acoustic environment. Ex. Clock ticking and AC sounds are ignored whereas the alarm awakens the person.

The auditory thresholds of awakening during sleep are functions of several variables. These include stimulus intensity, stage of sleep, subject differences, accumulated sleep time, time of night, amount of prior sleep deprivation and the subject's past experience with the stimuli. Sleep varies in depth in the same person at different times, and during sleep periods awakening by noise is less likely. During light sleep, awakening is easy and much fainter sounds will arouse. Young men tend to be heavy sleepers, older people especially woman sleep badly (McGhie and Russell, 1962). (Cited by Tempest, 1985) .

Subjects who have been deprived of sleep require more intense noises for waking than do normally rested subjects (Williams, et al 1965).

Persons over about 60 years of age are much more easily awaked or shifted towards lighter sleep stages than are middle-aged adults or children (Lukas and Kryeter, 1970)

Luk as and Kryter (1969) studied behavioral awakening response of the subjects to simulated sonic becames and recorded subsonic aircraft noise. With respect to behavioral awakening older persons are much more sensitive than the younger persons. Youngest subjects 7-8 years were not aroused by sonic booms more intense the booms that awakened the 67-72 year old man nearly 70% of the time. They conclude that possibly older people need less deep sleep and are therefore more sensitive to arousal, than the younger people, though their stage without causing wakefulness, and the arousal effect was dependent on the sleep stage according to the study done by Zung and Wilson (1961) (Cited by Borg, 1982).

Changes in the physiological responses due to noise exposure during sleep has been studied. There is some evidence that several cardiovascular system responses, most notably heart rate and finger pulse volume, show relatively little adaptation during sleep (Cantrell, 1974; Muzet and Ehrhart, 1978; Muzet et al, 1981) (cited by Dejoy, 1984).

Vallet at al (1983) studied the heart fate response to aircraft noise in a group of residents at 2 points intime. There was little habituation of heart rate activity over the time period studied.

Heart rate, finger vasoconstriction and EEG evoked response activity during sleep were studied by Cantrell(1974). Results indicated that at 90 dB young men could sleep in intermittent noise for 10 dayss Its inferred that a level of 85 dB can be tolerated for 20 days and 80 dB for 30 days without seriously affecting sleep or performance on the following day.

2-20 weeks old babies were studied regarding their sensitivity to acoustic stimulation with resect to sleep stage. Children below 6 weeks of age were found to be much less sensitive than older babies.

Ando and Hettori (1977) studied the reaction to aircraft noise of babies by means of electroplethysmography and EEG five groups of subjects were chosen. Group-I babies whose mothers had moved to the area around the Osaka international airport before conception.

Group-II: Babies Whose mothers had moved to the area around the Osaka international airport during the first 5 months of pregnabcy.

Group-III: Babies whose mothers had come during the last four months of pregnancy.

Group-IV: Babies whose mothers bold come after the birth of the child.

Groqp-V: Babies whose mothers lived in a quiet area.

Results were as follows:- Groups I end II showed little or me reactions on PLG and on EEG to aircraft noise but Groups III, IV, V showed reactions. Groups I and II showed differential responses depending on whether the auditory stimuli were aircraft noise or music showing a selective natural ability.

Abnormal PLG and EEG were observed in the majority of babies living in an area where noise levels were over 95 dB(A) This suggests that the deep sleep of the babies living in such an area was disturbed even in group I and II suggesting that no habituation to such an intense noise can occur and a limitation exists in the habituation during sleep of babies.

Thiessen (1978) compared the young, middle-aged and old subjects all together 35 subjects to determine the probability of disturbance of sleep as judged by EEG. Recorded noise of a passing truck was prevented 7 times per night. Young and old people have nearly the same reaponse While middle-aged subjects are more sensitive to the noise by about 15 dB. The probability of shifts in sleep to a shallower level does not appear to adapt in 24 suscessive nights but the probability of waking drops to half value in about 2 weeks. Response increases with duration of the stimulus at least over the limited range from fractions of a second to minute.

Lukes (1977) derived dose response relationships reflecting probability changes in sleep stage associated with various noise exposure levels (At peak noise levels there is a probability of 15% at 50 dB(A) and 45% at 70 dB(A) for changes in sleep stages to occur (Cited by Dejoy 1984).

Williams et al (1964) studied 3 types of responses with respect to the sleepstage at the various levels of noise above the awaking threshold of the listeners. They exposed the subjects to 5 second bursts of recorded random noise. Results were as follows.

1. With respect to the brainwaves (EER) and behavioural awake responses (BR), the subjects are more responsive in certain stages of sleep than in others.
2. As intensity of the stimulus is increased, the number or magnitude of the EER and BR responses increases.
3. following 64 hours of sleep deprivation, the number or magnitude of the EER and BR responses are lees during all stages and all levels of stimulation than during the base nights.
4. The vasoconstriction (VCR) response was only slightly less during the recovery nights than during the base nights and did not differ during the different stages as much as did EER and BR. Jensen and Shulze (1964) report a similar finding for the vasoconstrictive response to noise during sleep.

Bergamasco, Benna and Gilli (1976) studied the human sleep modification in 5 mala and 5 female subjects, induced by urban traffic noise. EEG recordings were obtained.

It was found that (1) arousal phase was of greater duration percentagewise than normal values indicating reduction in total sleep donation in ita various stages.

(2) Sleep phase was much longer in all subjects. Stage IV of Sleep was characterised by marked alterations; the reduced duration of the phases is of importance because this sleep stage is indispensable for CNS recuperation.

(3) Length of REM sleep was not substantially changed and if there was it was found that they were of anxiety introversion type individual.

Thus noise is more harmful and much more manifest in emotionally unstable individuals and its likely that noise plays a part in the development of mental disease symptomatology (cited by Rossi, 1976).

Borg (1981) also opines that long term forced wakefulness can cause mental disturbance.

Griefahn et al (1976) compiled results of 60 studies and compared working affects of 7 kinds of sound exposure. White noise was reportedly the most efficient stimulus. The after effects like functional or organic disease, reduction in performance was not related to the arousing effect of sound, according to them, based on the above 60 studies results (cited by Borg, 1982).

To know the significance of effect of noise on sleep and therefore on health, consequences of sleep disturbance due to noise should be studied.Upon 1978 according to Griefahn and Muset the significance of noise induced sleep disturbance remained unsolved.

(Chiles and West (1972) used simulated sonic booms to study the effects of noise disturbed sleep on monitoring, mental arithmetic or pattern discrimination tasks. Results indicated that there was no impairment on the above task performance (cited by Dejoy, 1984).

Ohrstrom and Rylander (1982)reported that 3 choice reaction times measured after night time exposures to taped intermittent traffic noise, were slower, compared to values obtained the previous evening. A similar comparison for continuous noise failed to yield adverse effects.

Other lab experiments have shown that intense noise presented during task performance may improve the performance of individuals who have been deprived of sleep, area on tasks Which are considered to be noise-sensitive (Wilkinson, 1963; Coreoran, 1967) (Cited by Dejoy, 1984),

Levere et al (1972) conducted an investigation to study how much the sounds of jet aircraft would disturb sleep and impair alertness and efficiency neat morning. The task which required memory was performed poorly after nights of aircraft noise than after an ordinary nights sleep. Moreover, while tha task was being carried out, the electrical brain rhythms contained many more slow -wave components, suggesting that brain was still tired and sleepy.

**Conclusions:** The majority of existing research has come from lab studies using recordings of air and surface transportation noises and from this literature some general conclusion about the affects of noise on sleep have emergad (Lukas, 1977: Griafahn, 1980, Muzet, 1983), findings indicata that -

1. People vary greatly in their susceptibility to sleep disturbance during noise.
2. Individual suscaptibllity varies from time to time as a function of situational factors.
3. Sleep disturbance, especially awakening is influenced by the degree of familiarity and significance of the noise to the individual.
4. Intensity level of the noise, its duration, intrusiveness, abruptness of onset, and predictability are related to sleep disturbance. Increase in stimulus intensity generally results in increased frequencies of behavioural awakening and arousal and reductions in the frequency of EEG change.
5. Older the individual, the more likely be is to be awakened or to change sleep stage, from exposure to noise.
6. Sleep arousal thresholds are lower in women than in man.
7. Specific distribution of responses to noise during different sleep stages is apparently a function of the age group.

8. Auditory thresholds of awakening during sleep are functions of several variables like stimulus intensity, stage of sleep, subject differences, accumulated sleep time, time of night amount of prior sleep deprivation and the subject's past experience with the stimuli.
9. Psychological and social consequences of sleep disturbing stimuli are greater for middle-aged and older persons.
10. Poor performance, dependent on the type of task, has been demonstrated following sleep disturbance for long periods of time than brief disturbance of sleep.
11. From the avaiolable data on task performance following noise impacted sleep and on the persistence of physiological responsivity during sleep it can be concluded that noise has the ability to interfere with the restorative function of sleep.
12. Chronic noise - disturbed sleep may be capable of producing adverse consequences on health and well-being.

**Research needs:**

1. Epidemiological studies to determine whether health and behavioural effects are associated with chronic noise -disturbad sleep. Care must be taken in collecting the data and also that the observed effects are attributable not only to noise exposure but also to sleep disturbance from noise.
2. Sleep studies should be done in natural environments rather than in the lab situation.

3. Additional research on task performance is needed which takes advantage of batteries of representative cognitive and psychomotor tasks. Lab tasks chosen should be representative of basic behaviour mechanisms so that it will provide a better understanding of specific information-processing impairment Which arise from noise-disturbed sleep.
4. Studies to collect data on accidents, employee turnover, absenteeism, interperaonal behaviour, general job satisfaction, should be carried out.
5. Sensitive groups like the elderly the ill or disabled, those with emotional disorders and children Who represent possible high risk group should be studies in more detail.
6. Further development and refinement of subjective measures of sleep quality are needed. A small scale field study suggests that subjectively judged sleep quality as well as bed movement recording may be useful for evaluating the efficiency of various noise geduettoa maajsmras (Oh*s&*@* and aylandmr, 1983)

**d) Extra auditroy effects on the special senses:**

Apart from its effect* on the function of the inner ear, noise has been shown to have effects œt the function of two of the special senses, vision and balance (as sensed by the vestibular system).

The vestibular organs are in close proximity to the cochlea of the inner ear. The vestibular labyrinth has its embryological and evolutionary development from the same source as the innerr ear. The vestibular organs the sacculus, utricle and semicicular canals are connected to the cochlea of the inner ear, they share certain fluids with the cochles and their innervation are closely connected. Thses vestibular organs are involved in maintaining body balance and orientation in space. Because of their close proximity and fluid connect-tions, is not surprising to find that intense sounds affect the cochlea and vestibular systems.

Powerful or moderate auditory stimulation can elicit nystagmus, vertigo and disruption of equillbrium. Sounds of modest intensity elicit lateral eyemovements in normal subjects Which Hennebert tremed as 'Audiokinetic nystagmus' (Weber et al 1957, 1967).

The levels of noise needed to csuse complaints of nystag-mus and vertigo are quite high.

In the 18th century Erasmus Darwin reported that certain patients with vestibular disorders could be made dizzy by the sound of waterfalls.

Bekesy (1935) - reported vertigo in normal subjects exposed to intermittent sound of 100Hz at 120dB for brief periods. according to Ades et al (1957) a level of 130 dB or more is required.

VonGierke (1965) also reported of dISturbanceS IN equilibrium and difficulty in maintaining balance during exposure to noise at 120 dB.

Dickson and Chadwick (1951) - noise at 140 dB or more may cause equilibrium disturbances.

When noise is 1ess intense (less than 130 dB) it may upset ones balance ex. balance on rails off different widths if the noise stimulation is unequal at the two ears (Nixon et al 1966). All these effects are believed to be due to noise directly stimmlating the vestibular organ of the inner ear (McCabe and Lawrence (1958).

Roggeveen and Van Dishoeck (1956) note that in persons who experience nystagmus to relatively weak sounds there are usuallt lesions present in the bony walls of the vestibular system.

**Vision**: The effects of noise on vision are less direct than thoae on the vestibular labyrinth, but as with stimulation of that organ, they are temporary in nataure and there no definite evidence for any long-term damaging effect.

Noise has been thought to influence visual acuity and field. Color vision and the so-called critical fricker frequency (CFF) . CFF phenomenon refers to the fact that alternating dark and light visual fields will become blurred (cease to the flicker) at some frequency of alternation.

The first observation or record of the effect of noise on vision has bean credited to Thomas Bartholinus (1669) Who noted that those who were partially deaf could hear better in the light than in the dark. Since then effect of noise on vision has been noted by many Authors (Kraukov, 1936, Serrat and Karevoski 1936; Benko, 1959; Letourneau and Ziedel 1971), and moast experimentres now agree that the visual effects from noise are probably caused by centrally located mediating processes (Letowineau 1972) (cited by Welch, 1970).

Visual contrast threshold and minimum visual acuity for lines and disc are generally apparently not affected by noise levels upto 140 dB or so (Browssand et al 1963). Loeb (1954) also found that broad band noise has no effect on visual acuity at 115 dB. However Rubenstein (1954) reported adverse effects from noise at 75-100 dB.

Grognot and Perdriel (1959) briefly exposed healthy young subjects to noise of different spectra ia the 98-105 dB range This caused colour perception to be modified with a tendency to protanomalic and night vision to be diminished.

Vynckier (1967) studied 100 wire mill worker exposed to 100-105 dB noise levels for an average of 16 years. He observed color perception alteration confirmed a pathologic relationship between excessive noise exposure and certain visual function.

According to Grognot et al (1965) sound adversely affects depth perception, it influences intraocular pressure according to Kishida (1960).0

Benko (1959) reported narrowing of the visual field which appeared to be permanent in workers who had been employed for 1-4 years. They were exposed to noise levels of 110-124 dB for a duration of 8 hours approximately.

Ogiebska (1965) - noise of 100dB intensity narrowed the field of vision for red in the 10.5% of the boiler makers examined.

Effect of steady noise on CFF, when the colour of light was varied has also been studied, but the results are very inconsistent. Ex. Maier et al (1961) found that, when light was changed from orange to red, CFF reduced with increased loudness. But no change occured with green light (cited by Kryter, 1970).

Thus noise can sometimes effect a 10% or so change*, usually a reduction in CFF from the CFF found in quiet, but the exact effects as a function of various noise and light conditions are highly variable (Kryter, 1970).

**Conclusions:**

To arrive at a conclusion regarding the extra-auditory effects of noise on the senses, more detailed studies in this area is essential. Though studies d0 report that vestibular organ and visual organ are affected, the implications of these have not been very well established.

4.1

## NOISE AND EFFICIENCY

"Of all forms of pollution, noise is perhaps the most inescapable for the urban dweller. It pursues him into the privacy of his home; trailS him in the street and quite often is the accompaniment of his labours (ward and Dubos, 1972).

Until the early 1950s there was considerable doubt as to Whether noise did exert any significant influence on performance at all (as indicated by the reviews of Berrien (1946) and Kryter. (1950). It has been suggested that efficiency is unimpaired by noise because a compensation effort occurs (Broadbent, 1957). Park and Payne (1963) reported that noise had no affect on arithmetic computation. This was also supported by Cantrell's (1974) finding mental and motor tasks showed no decrement when subjects were exposed to intermittent noise upto 90 dB. But Hockey (1984) points out that it is now fairly simple to demonstrate that noise can affect task performance.

One of the tasks on Which a noise-produced decrement first was reported, was in the vigilance task. In this task the observer is asked to detect relatively obscure signals occurring infrequently over an extended period of time, effects apparently do not occur when the signals are more conspicuous or when there is not a requirement for continuous scanning, as with multiple display.

When the noise is of rather moderate level, performance on the vigilance task may be enhanced (Kirk, and Hecht, 1963).

McGrath (1963) also reported improvement in performance when signal rate was low and acoustic stimulation interesting. But the reverse effect may be observed When the signal rate is high.

Corcoran et al (1977) studied effects of noise on auditory vigilance When the S/N ratio was maintained at the same level, at different noise levels. the effects obtained were complex and varied as a function of sound level, time of day, subject personality and previous experience with noise.

According to Poulton (1977) changes in vigilance are arte-factual and are due to masking of acoustic feedback. Some of the noise - induced changes la vigilance may be attributable to changes in criteria for responding (Broadbent,1978, 79).

Performance in vigilance situations deteriorates with time at work, sometimes as a result of a decline in perceptual sensitivity and sometimes as a result of Change in response bias. The type of change occuring depends on the nature of the demands made by the task, on time, pressure and working memory (Davies and Parasuraman, 1983).

Reaction time defined as the time required to respond or react to a given stimulus, may be affected by attention, habi-tuation and fatigue.

Reaction time can be studied under discrete reaction time (RT) i.e. where following the response to a RT stimulus. There is a short pause before the presentation of the next trial. In the case of serial or continuous RT tasks, the individual's response to one stimulus triggers the presentation of another.

According to Broadbent (1953) errors increased with time-on-task in noise. Reduction in correct responses, increased errors and gaps during the task where reaction time is measured. it may be antagonized by sleeplessness, Which in itself has deleterious effects (Wilkinson, 1963).

Increased reaction time or a transient slowing of response time on a serial RT task Whan exposed to 80 dB SPL noise was was reported. This was attributed to distraction effect (Fisher, 1972).

Loud noise in which the higher frequencies predominate, is more likely to impair performance than is noise containing predominantly lower frequencies. Errors were significantly increased only in the 100 da high frequency noise (Broadbent, 1957).

Hartley (1974) found that intermittent noise with an on-time of roughly 60% and alternating between 95 and 70 dB(C), increased the member of errors by about the same amount as did continous noise, relative to the 70 dB(C) quiet condition.

Theologus et al (1974) tested independent groups of people for 3 sessions. The first session was spent in familiarization of a 20-minute simple visual RT task. In the second session they were exposed to 85 dB noise bursts Which were random and in the third session patterened noise bursts.

Performance showed considerable improvement across sessions with the noise group showing greater improvement. When exposed to random intermittent noise performance was reliably worse in the first half of the task but not in the second, suggesting that some adaptation to noise had occurred.

Rossi at al (1976) conducted a comparative study of changes in RT to light an sound signals in the presence of urban traffic noise, RT in the absence of noise was also obtained to know the normal range. Read noise did not alter the mean reaction time in the case of light stimuli.

In response to an acoustic signal, less time is required for the execution of either a simple or complicated motor reaction as opposed to a light signal.

Multiple task performance in noise, involves use of simultaneous primary and secondary task. This is an important technique for assessing effects of incentives, stressers and fatigue. Under much conditions the primary task is often seen to be enhanced or unaffected and secondary task is impaired.

Finkelman and Glass (1970) found no effect of noise on a primary tracking task and impairment on a secondary digit recall task.

In a study conducted by Hockey (1970) signals on a secondary watchkeeping task were better detected in 100 dB SPL, noise in the proximity of a primary, centrally located visual task display and less well detected when located peripherally well away from the display. But Loeb and Jones (1978) who employed a similar task as Hockey, found impairment of the tracking task performance and no effect on watchkeeping.

Forster and Grierson (1978) failed to find any effect with a very similar but apparently slightly more difficult task. with noise 9 dB less intense.

Performance in noise can also be influenced by motivational variables such as knowledge of results (Wilkinson (1969) or by various psychological traits (McClean and Tarnopolsky, 1977).

Mech's (1953) study results indicates the importance of subjects expectation regarding the influence of noise on their performance. when the subjects were not biased, there was no effect of 70 d8 SPL noise on ability to perform simple computation.When they were informed that noise impairs or facilitates or noise impairs and then facilitates performance, profound changes in the suggested direction occurred.

Shambaugh (1950) and Broadbent (1961) showed that in general, subjects having personally traits of "anxious".

"introverted" and "somatic" response were more adversely affected by noise on performance of mental tests (IQ and arithmetic) and motor tasks (RT and tracking).

There is some indication that certain language and memory tasks may also be noise sensitive (Broadbent, 1983).

In memory task Which required visual recognition of visually presented words (Rabbitt, 1966) and acoustically presented words embedded in noise (Murdock, 1967) noise produced so increase in0 false recognition.

Baddley (1968) reported that While noise impaired discrimination of acoustically presented words there was no additional effect on later retention.

Hockey and Hamilton (1970) reported that if subjects were instructed to take order into account, noise improved later retention. If order was ignored in scoring, noise was seen to produce an impairment, and incidental memory for locus of the words warn poorer when they were presented in noise.

According to Wilkinson (1976) 95 DB SPL noise produced poorer retention of acoustically presented material even When discriminability was held constant by holding the S/N ratio constant.

Hamilton et al (1977) demonstrated that noise enhanced recall of more recent and impaired recall of leas recent material.

Lord and Finlay (1978) studied the effects of relatively low intensity noise on recall of previously learned list of syllables . They found significant differences between recall under noise and recall under silent condition. The noise condition produced more errors.

Salame and Nittersheim (1978) compared effects of noise coincidental with and subsequent to presented items with those of continuous noise. They found greater effects with continuous and coincidental noise than with subsequent noise.

Several studies have shown that although noise may not effect performance during exposure, decrements may occur on tasks performed subsequent to noise termination (Review by Cohan, 9980).

Loeb (1981) reasoned that subjects will exert adequate effort during noise exposure but will let down to a degree, following termination of exposure . These so-called after effects have been primarily reported on frustration, tolerance and proofreading tasks, and most often in response to prior exposure to unpredictable (Glass and Singer 1972) or multisource noise. (Wohlwill et al 1976, sheviod, et al 1977).

Studies have shown that the perception of control over the noise can eliminate or prevent the occurrence of these after effects (Glass and singer, 1972). Noise related decrements in standardized test performance particularly reading achievements.

have been found in response to aircraft noise (Moram and Loeb, 1977; Pencival and Loeb 1984 and Green et al 1982), elevated train noise (Bronfaft and McCarthy, 1975) and Roadway noise (Cohen et al 1973; Lukas, at al 198l).

Physiological effects during the performance of a task, under noise exposure has been studied the results of which can be very useful in the industrial area.

Quaas at al (1971) studied tha effect of sound on heart rate under conditions of moderate physical work. Among their 6 subjects, 4 showed increase heart rate and 2 others decrease in heart rate.

Finkelman at al (1979) studied heart rate during noise exposure to random white noise bursts at 90 dB; While physical and mental work was being performed. They found noise deteriorated performance, but did not affect heart rate. There warn no significant interaction between sound and physical work on either heart rate or mental performance.

Studies of non-auditory effects of noise in the children has been concentrated on effects of noise on academic performance and cognitive development. The general approach taken in most of the studies has bean to compare groups of children residing or attending schools at various distances from major noise sources.

Although most studies were on elementary school children some findings have been obtained in other age groups.

In a series of studies on infants. Observer-rated niose confusion in the home emerged as an important environment influence with respect to cognitive development (Wachs et al 1971, 1979). Deficits were reported on a variety of piagetian measures of sensorimotor development, including indices of exploratory, gestural and vocal behaviour. One possible interpretation is that noise may Adhibit development of selective attention, noise may produce effects even during the first year or second year of life, and that children from noisy home may be at a disadvantage prior to entering school (Dejoy,1983).

**Studies on pre-school age children**:

Hambrick Dixon (1982) found that noise interfered with psychomotor tasks but not with perceptual or cognitive tasks. follow-up study of visual vigilance performance indicated that, for the preschoolers tested, subway noise had some beneficial effects on performance during first years of exposure. But as duration of exposure increased, performance declined (Hambrick-Dixon, 1982). Children attending quiet centres showed consis-tent improvement over time.

Karadorf and Klappach (1968) found that there was a decrement on a concentration task in children of grades 7 to 10 attending schools impacted by high level of background noise. Questionnaires indicated that the students were aware and bothered by noise in their schools.

Cohen et al (1973) obtained measures of reading achievement and auditory discrimination on children in grades 3 to 5 residing adjacent to busy expressway. Noise level in the quietest apartment was 55 dB(A) and in the noisiest 66 dB(A). When tested under quiet condition. children living in the noiser apartments displayad poorer auditory discrimination and reading achievement than children living in the quieter apartments. These effects became more pronounced with increasing exposure duration.

Subsequent research has tended to support these findings. the effects of elevated train noise on reading achievement in children in grades 2, 4 and 6 was studied A poorer performance was found among children in classroom on the side of the building which faced the tracks as compared with children on the quieter side of the building (Bronzaft and McCarthy, 1975). Noise levels in the impacted classrooms were approximately 59 dB(A) between trains and rose to 89 dB(A) during the train pessby; which occurred every 4-5 minute.

Heft (1979) compared 4-6 years children from homes rated by their parents as being either quiet or noisy. On matching and incidental learning tasks, poorer performance was displayed by children from the noisy homes.

Cohen et al (1981) found that children of grade 3 and 4 attending schools located under the flight path of the Los Angles international airport failed more often or gave up on a puzzle solving task, relative to their quiet school counterparts Also, the performance of the noise-exposed children on a distraction task was initially better than the quiet school children, but became worse as the duration of exposure increased.

Lukas et al (1981() conducted a study of freway noise in 100 classrooms in 15 schools in California also found that as noise levels incereased, reading scroes decreased. Also, when the community was quiet, relatively more noise could be tolerated in the classroom without negatively affecting reading achievement.

Usha (1983) investigated the effects of noise on reading comprehension in children of different age groups and the interaction effects of age and noise on the performance of reading comprehension tasks.Results showed that there was no significant effect of the noise used on the reading comprehension task except in age group 11 years where the performance was slightly better in noise. They also longer time to read. There was no significant interaction effect of age and noise on reading comprehension. 37.5% of the children reported noise to be disturbing during reading.

Shashidhar (1983) studied effects of speech babble noise of 85 dB SPL on the performance of a mental task (digital cancellation test) and motor task (tapping test) in children of age 9-12 years. It was found that performance increased under noise in all 3 groups which was attributed to the noise induced arousal.

**Conclusion:**

1. The maximum benefit from the study results of effect of noiae on efficiency is, for the industries. Industrial studies and surveys indicate that there is a slightly reduced rate of productivity, an appreciably increased rate of absentecism apparently associated with illness and a higher accident rate in noisy industries (Cohen, 1976, Broadbent, 1979).

2. Mechanisms underlying relationships between noise and physiology and noise and performance reviewed include distraction, arousal, stress, concentration, masking of task produced feedback etc.

3. Effects of noise varied in some instaoces it increased performance and in certain others it hampered performance of certain tasks. Multiple tasks, task which involves auditory clues are effected negatively.

4. Motivation, expectation of indivlduals regarding influence of noise on their performance influences the efficiency in a task during noise exposure.

5. Effect of noise on performance depends on level, frequency of the noise, rise time of the noise.

6. Effects of noise on performance also depends on perceptual sensitivity of the individual, his personality, previous exposure with noise and to the task, nature of task etc.

7. Adaptation to noise, increase in concentration are given as explanation for better performance in presence of noise.

8. Individuals who do not get affected during exposure to noise nay be exerting adequate efforts to overcome it while performing tasks. Performance measured after termination of noise did show a change.

9. Perception of control over the noise can eliminate or prevent the occurrence of the after affects.

10. Noise has a potential to interfere with cognitive development and academic performance of children.

**Research needs:**

1. Studies involving comparison measurement of efficiency before, during and after noise exposure within the individual are required.

2. Direct effects of noiae on performance and its quantitative relationships should be derived.

3. Additional work to explain the apparently large individual differences which exist in sensitivity to noise.

4. Identification of sensitive individuals in terms of behavioral, attitudinal, personality and even physiological characteristics should be done.

5. Methodologically sound, field studies sbould be conducted to study the effects of noise on performance, the results of Which would be applicable and practical.

6. Workplace studies should also examine the interaction of noise with other physical factors such as toxic chemicals, heat stress and with various task dimension.

5.1
# CONCLUSION

This review aimed at creating an awareness and understanding of non-auditory effects of noise, has summarized the current state of research on the various non—auditory effects of noise. Illustrations of previous and the receat research findings and research needs have been presented.

The conclusions arrived at after reviewing the literature on non-auditory effects of noise are as follows:

1. While the effects of overexposure to noise on the auditory system are firmly established, disagrement regarding the non-auditory effects still exists.
2. The non-auditory effects of noise can be in terms of cardiovascular changes, endocrinal changes, psychological changes and disturbance of sleep.
3. The above mentioned effects are assumed to influence the general health of the individual.
4. 'One mans noise is another man's music. The vice-versa of this is also true. This is proved by studies of noise annoyance where the results indicate that more than the acoustic variables the monoacoustic variables like emotional content of noise,individuals sensitivity etc.are important.
5. Noise interferes with communication and may thereby result in annoyance and also affect efficiency.
6. Noise influences task performance differentially. Certain noise increase the performance where as certain others do not certain performance task efficiency are enhanced by noise while certain others are hampered.

7. Finally, the non-auditory effects of noise are not independent of each other.

There are multiple applications of the knowledge of non-auditory effects of noise.

1. It can be utilised during counselling of the individual constantly exposed to noise: Ex. factory workers.
2. Public awareness programs regarding the hazards of noise pollution will be more effective if non-auditory effects of noise are also included.
3. Hearing conservation programmmes can be better planned and executed if non-auditory effects of noise are considered along with the auditory affects.
4. Employer's awareness regarding the effect of noise on efficiency and general health of the individual etc. may help in improving the working conditions of an individual.

Finally, conclude that non-auditory effects of noise is a multidimensional problem. Tackling and solving of this problem requires that barriers between the professionals like physiologist, audiologlat, engineer, clinician, psychologist, jurist etc. must be broken down and a team approach be adopted.

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