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ENVIRONMENTAL ANALYSIS AND REPORT
FOR
ROUTE 18 FREEWAY EXTENSION
CITY OF NEW BRUNSWICK AND PISCATAWAY TOWNSHIP
MIDDLESEX COUNTY, NEW JERSEY

VOLUME II - APPENDIX
SECTION 5 - REPORT ON HUMAN RESPONSES
TO HIGHWAY NOISE

PREPARED BY

P. SUEDFELD, PH.D. AND L. M. WARD, PH.D.

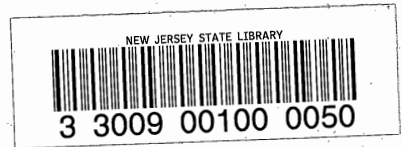
FOR

KING & GAVARIS
CONSULTING ENGINEERS

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HUMAN RESPONSES TO HIGHWAY NOISE

**Final Report prepared for King & Gavaris, Consulting Engineers -
Rt. 18 Extension Environmental Impact Study**

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June, 1972

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PREFACE

This report describes the results of an attempt to predict psychological and behavioral consequences of highway expansion. The extension of Route 18 in New Brunswick and Piscataway, New Jersey, had been planned for 8 years; however, while clearly desirable from the point of view of improved traffic flow, the plan has recently attracted considerable controversy because of its ecological and social implications. The extended portion would be located near Rutgers, The State University of New Jersey, and Rutgers students have been deeply involved in movements to stop the extension from being built. The intensity of feelings may be judged from the fact that the only major disruption of the recent inauguration of the new President of Rutgers, in New Brunswick, was caused by a group of anti-Route 18 activists.

In view of all of these facts, it would have seemed obvious that a study should be made of how the proposed construction might affect the people who would be located near it, both for empirical and for political reasons. With regard to the first, it is important to know whether the new road would be likely to interfere seriously with people's normal lives and if so, to attempt to minimize this interference -- e.g., by building a deck over portions of the highway. As far as the second is concerned, relevant data might indicate which bases of fear or opposition were groundless and which were realistic, besides indicating that the plans were not being bulldozed through without regard to their human impact.

Nevertheless, no such study was projected until extremely late in the chronology of the extension plan. In fact, arrangement for the work reported here were not made until April, 1972, when the Environmental Impact Study

was less than two months from its deadline. Because of this belated start the data collected here suffer some gaps: only one problem connected with the highway -- increased noise level -- was studied; only students were used as subjects, although other groups would also be affected by the road; instruments had to be quickly chosen, prepared, and administered, so that schedules were sometimes violated and the data array was incomplete: a replication of the experimental portion of the study, which would have remedied some of its procedural faults, could not be made; and the duration of the simulated noise conditions was insufficient.

With these shortcomings, it should be emphasized that the conclusions which can be drawn from the study are tentative, and the data more in the nature of pilot results than final answers. The findings, however, are relevant, interesting, and useful, and justify the inclusion of a fairly elaborate psychological component in the Environmental Impact Study. The initiative of King and Gavaris, Consulting Engineers, in arranging for such a component, should be noted appreciatively. We hope that this work may serve as a precedent for the inclusion of social and behavioral science research as integral parts of future plans for modifications of the environment.

INTRODUCTION

While it is obvious that the improvement or extension of highway facilities can result in a variety of desirable outcomes, the negative aspects of such projects have only recently become foci of attention. This lag may be due partly to the fact that the environmental impact of greater traffic volume has indeed become more severe as the absolute levels of traffic and of population density rise, and partly to the increased publicity and consequent awareness about the quality of the environment. It is clear that such economic and safety problems as faster and heavier travel loads, and such medical and ecological problems as air and thermal pollution, must be anticipated in any proposed road improvement project; however, relatively little attention has been paid to possible psychological effects.

Since the evaluation of environmental factors by the public is greatly affected by immediate experiences -- i.e., by psychological effects -- this neglect seems shortsighted. After all, when a human being responds to his environment, the most salient perceptions are how it affects his own behavior, his emotions, his work capacity, his sense of well-being, his relations with others. If these factors are adversely affected, even surroundings which to an outside observer appear favorable are rejected by those most closely affected. A great deal of evidence has shown, for example, that urban renewal projects, which are supposed to improve the living environment (and certainly do improve its physical qualities) are disliked by residents whose accustomed psychological-behavioral patterns are disturbed (see, e.g., Fried & Gleicher, 1961; Lewis, 1965; Schorr, 1966).

What aspect of a highway has the greatest psychological impact? The answer to this question obviously depends on the answer to another question: impact on whom? Obviously, different answers will be given by drivers, by civic officials, by ecologists, and so on. It does seem, however, that to the people most continuously affected -- those who live near the road -- the most striking characteristic is that of sound. Visual stimuli are perceived only when one is looking in their direction, and can be easily screened off; highway odors and vibration are also relatively restricted, and are limited in intensity and temporal duration; but sound travels, intrudes, and pervades the milieu. Sound is also of great subjective importance in that high sound levels seem salient and stressful, interfere with communication, and can arouse strong feelings of unpleasantness. Last, sound impinges on a great variety of behaviors, including work, social interaction, and sleep, and may also have deleterious physiological effects. For these reasons, when it became clear that our work would have to focus on only one of the environmental changes stemming from the extension of the highway, sound level was the variable which we chose to investigate.

Noise and human behavior.

The auditory sensory and perceptual systems represent an important source of information input from the environment to man. The information is usually important to survival or efficiency, and often has affective value either in itself or in terms of its meaning. In addition, sound also has both temporary and permanent effects on the physical auditory system.

Obviously, the informational, affective, and physical consequences of auditory stimulation can be of either positive or negative value to the organism receiving the stimulation. For the present paper, sound stimulation which results in negative consequences for the organism stimulated will be termed "noise." These effects are presumed to be "unwanted" in that they imply lowered efficiency, comfort, or potential for survival of the organism. Presumably, the sound which produces these effects is also unwanted. Thus, noise is unwanted sound. Obviously, there is no way to specify a sound as noise in the absence of a human or other living frame of reference, since there must be some organism doing the wanting. This obviously includes the effects of sound on non-living objects as well, since those objects cannot be presumed to "care" what effects the sound has on them. In addition, this definition subsumes various technical definitions of noise in fields such as communication, electronics, etc. since sound which does not carry information in those fields is "unwanted."

Thus, in the above definition, sound is specified as noise only when it produces unwanted effects. The search for and the detailed investigation of unwanted effects has produced a voluminous literature on the effects of noise on man (over 4,000 reports surveyed by Kryter, 1970). Several classes of unwanted effects have become apparent, the most convenient classification being that by Kryter (1970) into effects of sound on the auditory system itself, and its effects on nonauditory systems. This general scheme will be followed in the present brief review.

It should be mentioned that very little of the data available on the

unwanted effects of sound on man and other animals has to do specifically with highway generated sound. Most of these data were collected in the interests of providing information on the effects of wartime, industrial, and aircraft noise on hearing, emotions, and performance. In addition, quite a bit of laboratory research has been done on various effects using broadband sound of various loudnesses and durations depending on the nature of the investigation. Most of these data are at least potentially generalizable to the effects of highway noise, at least to the extent that the physical parameters of the sound being generalized to are similar to those for which the data were originally collected. Generalizability is easiest with respect to the physiological effects of sound. Difficulties arise when psychological effects are generalized too freely, since the information contained in the sound, either directly or implicitly, is very important to the kinds of effects it will produce (Kryter, 1970; Poulton, 1970).

Auditory system effects. The ear responds to several characteristics of sound waves, which are vibrations of the molecules of the conducting substance. The most important characteristics are frequency and amplitude of pure sounds, and spectral composition (which is a specification of amplitude at various frequencies) of complex sounds. The total spectrum of sound energy is generally divided into three parts, the infrasonic [below the lower frequency threshold of human hearing - about 16-20 Hz. (cycles/sec.) in young adults], ultrasonic (above the upper frequency threshold - about 16-20 kHz. in young adults), and sonic (between the thresholds - most young adults can hear these sounds if the amplitude is adequate). This division is based on statistical analyses of group data. The

ear is markedly nonlinear in response to sonic-range sounds of sufficient amplitude to be detected; it is most sensitive in the region of 1500 Hz. \pm one octave. The ear responds efficiently to sounds over a wide range of amplitudes, from an average threshold of about .0002 dynes/cm² to a level at least 100 dB. [Sound level in dB. = $20 \log_{10} (S_2/S_1)$, where S_1 is the reference level and S_2 the sound being compared with it] . Sound more intense than 120 dB above the standard reference level of .0002 dyne/cm² becomes appreciably distorted by the ear, and sound around 140 dB and above becomes intolerably painful.

The various physical characteristics of the sound wave have psychological correlates which can be fairly precisely related to the physical measurement of the wave. For example, the best correlate of amplitude is loudness; that of frequency is pitch. Loudness grows as a power function of amplitude (Stevens, 1956), with an exponent of about .6 for amplitude measured in pressure units. The relation of pitch to frequency is not so simple, but in general it is a monotonic function of its physical correlate (Stevens and Galanter, 1957). Pitch and loudness are not independent; changes in amplitude of sound do have some effect on judged pitch, and changes in frequency also have effects on judged loudness. Other psychological characteristics of sound stimuli have been investigated, such as timbre, density, volume, etc., but in general these are less important and less well understood.

In the effort to relate the effects of sound on the auditory system to physical specifications of the sound involved, a number of measurement schemes for complex sound have been developed. These are important here, for highway generated sound is complex sound. In general, there are

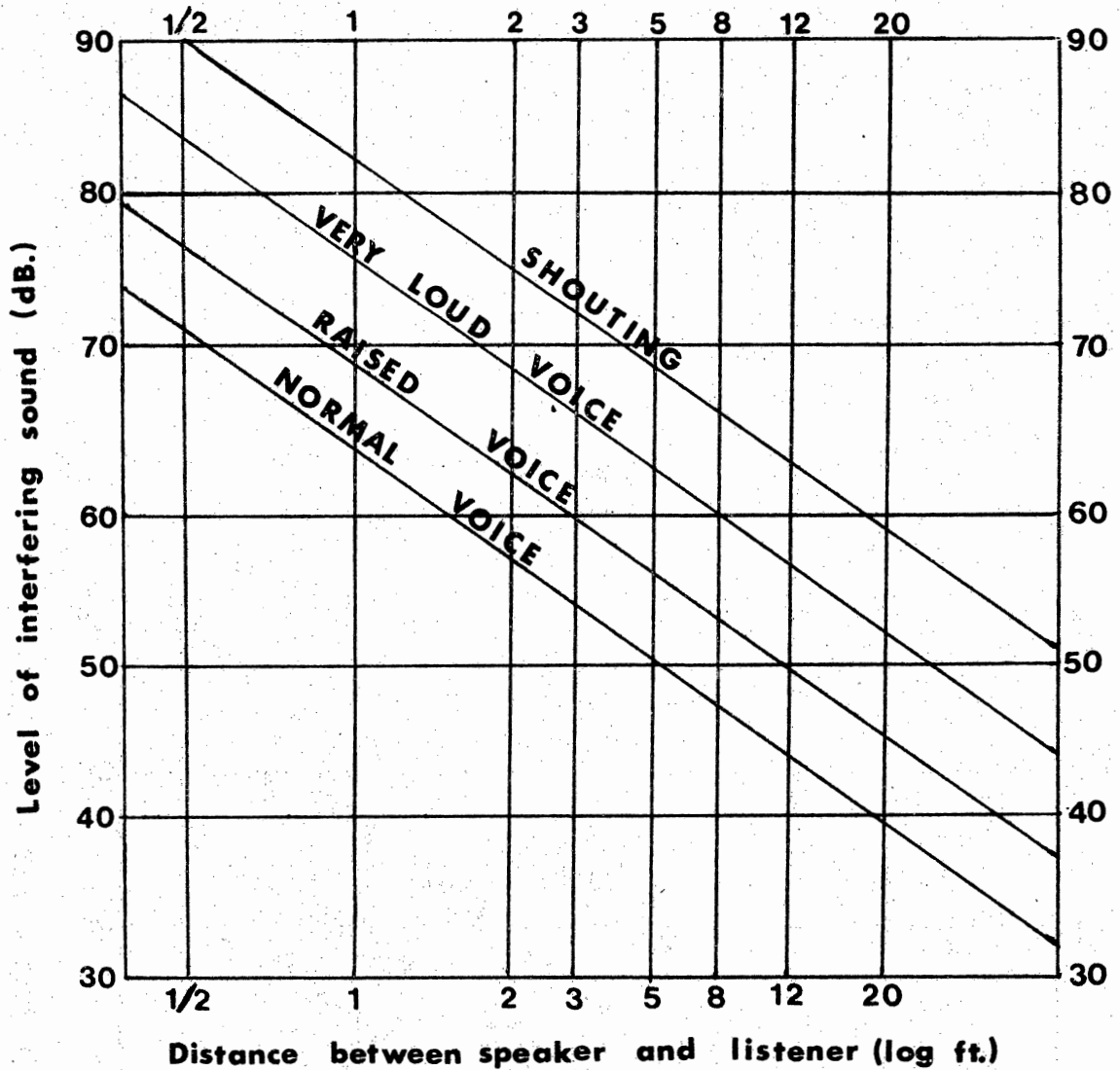
several competing schemes for each of the effects investigated. Almost all of the methods involve measuring the amplitude of the sound at various frequencies and then combining these measurements according to a specific weighting scheme for the amplitude at each frequency. When duration is important, it too is a parameter to be included in the weighting scheme. For the most part it is difficult to decide which of the various measures relevant to a particular effect correlates best with (i.e. predicts to) the measure of the effect. Because of this, and because the sound levels of the experimental part of the present study were measured in this way, one standard measure for average sound level or amplitude will be used throughout the paper. This is dB(A) of sound pressure, relative to $.0002 \text{ dynes/cm}^2$. This is a measure which weights the lower frequencies more heavily, gradually decreasing the weighting in an exponential curve up to about 1000 Hz. where the weightings are fairly equal until about 6000 Hz. at which point they become greater with frequency up to the limit of the instrument. The weighting is accomplished electronically in the sound pressure meter, and an average sound level over all frequencies is produced. This measure is convenient to use and correlates well with all effects of sound amplitude that have so far been investigated. It is the measure most commonly in use, although others have recently been suggested which may ultimately replace it (Kryter, 1970). Kryter (1970) gives rough equivalents in dB(A) to other measurements for all of the scales in use today, including his own PNdB measure of perceived noisiness; thus generalization from one measurement to another is relatively straightforward.

One of the most obvious characteristics of sound is that sounds from several different sources will mix. This means that sound such as speech, which carries information can be masked by other extraneous sounds. These extraneous sounds may themselves carry information, but the term "speech masking" used in these situations implies that the focus is on particular speech sounds as the wanted sounds; the extraneous or masking sounds are unwanted. Some simple examples of this effect include trying to converse at a loud party, or attempting to hear the loudspeaker announce a departing flight while standing near a taxiing aircraft. A great deal of research has been done on these unwanted masking effects, and it has been summarized in several places (e.g. Kryter, 1970; Poulton, 1970; Tolhurst, 1971). Figure 1 shows one aspect of these data, as presented by Poulton (1970). It is apparent from the figure that as the amplitude of the interfering sound grows, masking grows quite dramatically, necessitating an increase in the level of the speech or a decrease in the distance between the speakers in order to maintain communication. Both of these adjustments to speech masking by communicators may in fact be a source of stress. Brewer and Briess (1960) state that people working in high sound levels often develop hoarseness, coughs, lesions, and pains in their throats from the strain of talking over the masking sound. It has also been noticed that workers in high noise environments simply do less talking than those working in environments with lower sound levels (Kryter, 1970). Also, several studies have been done concerning peoples' responses to invasions of their "personal spaces," invasions which are likely to occur regularly in a high sound level

environment where it is necessary to communicate by speech (Sommer, 1959; Horowitz, Duff, & Stratton, 1964; Little, 1965; Rawls et al, 1972).

Presumably these invasions of personal space could become a source of stress, especially if occurring between strangers or people who dislike each other, and in cultures which emphasize large and inviolable personal spaces. This topic will be taken up again in the context of the present study in the Discussion.

FIGURE 1



The speech interference levels which permit speakers at various distances to speak to each other with only slight difficulty. Points below a line corresponding to the loudness of the voice are acceptable. Points above the line are not. (After Poulton, 1970).

An interesting and potentially important effect of high level sound on the auditory system is the aural reflex. When the ear is exposed to sound about 80 dB above threshold level, two little muscles in the middle ear, the stapedius and the tympani, contract. This contraction has the effect of stiffening the eardrum and the bones of the middle ear so that they transmit sounds less effectively than normal, especially in the frequency regions below 2000 Hz. Since the ear is most sensitive to sound in these regions, and since high level sounds are usually impulsive (large change in sound level in a relatively short time), with most of the energy below 2000 Hz. , this has the effect of protecting the ear against overstimulation to some degree. This protection is of relatively brief duration, however, since the reflex adapts rather quickly. Thus, it affords little protection for the ear in situations of steady, high level sound stimulation. For more information on this effect, see Gulik (1971) for the physiology and theory of the reflex, and Kryter (1970) for an extended discussion of the interaction of the reflex with masking, loudness, and auditory fatigue.

Perhaps the most dramatic and important effect of high sound levels on the auditory system is the induction of changes in hearing efficiency from optimum levels. It would appear that simply using the system in the sound environment in which it developed causes loss of efficiency since there are quite large hearing losses with aging (presbycusis). Peak hearing ability occurs in young adults and gradually declines after the age of 25 or so, with most losses being in the upper frequencies. It is not uncommon for an adult of 50 years of age to be unable to hear any sounds,

of whatever intensity, above 10 kHz. This natural decline in the efficiency and range of the auditory system can be greatly (and unwantedly) augmented, however, by prolonged exposure of the physical apparatus of the system to high sound levels.

The predominant way of expressing losses in hearing due to either aging or prolonged exposure to high level sound are the Temporary Threshold Shift (TTS) from pre-exposure threshold for pure tones measured two minutes after the sound is terminated, and the Permanent Threshold Shift (PTS), measured usually one month or so after termination of the sound. PTSs are usually found only after near-daily exposure to high level sound for a period of several years. Most exposures to high level sound result in only TTSs and the threshold returns to normal after a period of 16 hours or so (Kryter, 1970). Since it is very difficult to measure PTSs due to the long periods of time involved and humane considerations, Kryter (1970) suggests that TTSs should be used to form damage risk criteria for exposure to high level sound. Others disagree with this use of TTSs to estimate PTSs, (Ward, 1971), but it seems to be the best idea available. A rough rule of thumb, (based on numerous studies) given by Kryter to evaluate PTS from TTS is that the temporary hearing loss caused by a given sound on a single day is equal to the permanent hearing loss that will follow 20 years of near-daily exposure to that same sound. Again, this is somewhat controversial, (Ward, 1971) but it seems to be the best criterion available.

In general, hearing losses in frequencies above 2000 Hz. are not considered important, since they do not interfere appreciably with speech

communication. This is reflected in federal standards which allow exposure to levels of sound in industry and aircraft, etc. that could cause appreciable loss above 2000 Hz. if prolonged over a period of years. This seems unreasonable, since the frequencies over 2000 Hz. are quite important for other activities such as listening to music, and may have greater importance than was thought for the performance of many industrial tasks [see discussion of the experiment by Broadbent and Little (1960) later in this paper]. It is thus suggested that any hearing loss whatsoever should be considered in the tradeoff of positive and negative effects of building highways and other noise producing installations.

Effects on other systems.-- There are many systems of the human body besides the auditory system that potentially could be affected by sound. Of course, it is a characteristic of living organisms that specialized sensory systems are the most responsive of any part of the body to the particular type of energy to which they have developed sensitivity, and the remainder of the body is much less sensitive to that particular form of energy. Thus with sound, the auditory system is most sensitive, and considerably larger amounts of sound energy must be present in the environment for other systems of the body, such as other sensory systems, the autonomic nervous system, the reticular nervous system, the brain centers concerned with cognition and thinking, and their associated subsystems, to give any measurable responses. However, these and other systems do routinely respond to the presence and type of sound energy in the environment, and it is the purpose of this section to summarize these responses. Again, some of the responses are positive and some are negative with respect to hedonic and survival value for the organism.

It must also be kept in mind that these values of the effects for the organism may change radically from situation to situation.

One very comprehensive study of the effects of sound stimuli on a variety of physiological systems was by Davis, Buchwald, and Frankman (1955). They identified a complex of responses to sound which they termed the N-response. In the N-response, there is peripheral vasoconstriction everywhere except in brain blood vessels, very minor changes in heart rate, slow, deep breathing, a measurable galvanic skin response, and a brief change in skeletal muscle tension. Others have found changes in gastric motility, and chemical changes in the blood and urine from glandular secretions (Kryter, 1970). These responses generally adapt fairly rapidly to the sound after onset, although intermittent bursts of sound at unpredictable intervals are fairly successful in repeatedly reevoking the response. This complex of responses has some, if not all, of the components associated with arousal and/or stress. Since arousal and stress are two effects which could potentially be negative in value, especially over long periods of time, the question of adaptation to these effects of noise is an important one. According to Kryter (1970), there are no laboratory tests that definitively show that complete physiological adaptation to steady or predictable intermittent unwanted sound does not occur. As stated above, adaptation can be prevented to some extent by varying the amplitude, time of onset, etc. of the sound in an unpredictable way.

Sound of high amplitude and sudden onset, when unexpected and/or frightening, can also produce a startle response. Physiologically, this is similar to the N-response, except that usually changes in heart beat and

blood pressure occur that are not associated with the arousal produced by more normal or expected sounds. (Kryter, 1970). Even startle may eventually adapt out, but it is obvious that a very frequent startle response could be very "unwanted".

There is some evidence from studies in industry that prolonged exposure to very high sound levels can lead to significant impairment of normal function of the cardio-vascular, digestive, metabolic, etc. systems (e.g. Jansen, 1961). However, most writers are of the opinion that these studies have not been carefully enough controlled to be definitive (Kryter, 1970; Poulton, 1970). If the sound is indeed responsible for the adverse physiological effects reported in these studies, then this is presumably another unwanted effect of sound. In addition, even short-term disruptions of function may be important, in a positive or negative way, for the performance of mental or motor tasks. This will be discussed more extensively later in the paper.

Sound also has effects on sleep. Much remains to be learned about sleep in man, but it has been established that there is a minimum amount of sleep necessary for optimum performance and "happiness" or well-being, both physical and psychological. High levels of sound in general interfere with going to sleep and maintaining sleep [Kryter, (1970) reviews the data]. Sleepers are most vulnerable to disturbance by sound in the lightest phases of sleep and just before entering sleep. The effects of sound on sleep can be traced in a quite dramatic way by the changes in EEG waveforms as a result of application of sound stimuli as well as by other behavioral responses such as awakening and pushing a button (see Williams, Hammack, Daly, Dement, and Lubin 1964). Because the sleeper is in a more or less

"unconscious" state, and because learning and most other adaptation requires some kind of conscious activity, adaptation to sound effects on sleep has not been found to be very dramatic (Kryter, 1970). This is shown in a practical manner by the fact that one of the most common complaints from people continuously exposed to airport or industrial sounds is that the high sound levels interfere with sleep. This is especially true if the sound is intermittent and unpredictable as it is with airport sounds of aircraft taking off and landing. Interestingly, in the case of highway-generated sound, although the lowest average levels of sound occur at night, it is at this time that they are the most intermittent and unpredictable. Thus the occasional roaring truck on the highway at night may be expected to have a more disturbing effect on the sleep of those who live nearby than would the higher level but more steady sound of rush hour.

There are numerous other effects of sound on physiological systems other than the auditory, of both positive (audio analgesia) and negative (nausea in response to loud subsonics) value. Kryter (1970) gives an excellent survey of these effects, and they will not be pursued here since they are of somewhat lesser importance for the present study. In general it can be said that the effects of sound on various physiological systems are quite dramatic and important. The adaptation that has been found to occur in most systems to steady sound tends to reduce the importance of these effects for long-term consideration. However, there is some evidence that some long-term effects do occur in spite of adaptation, and that there are some important systems and activities in which adaptation does not

occur as readily as most (e.g. sleep). In addition, even short-term reactions, especially if caused by repeated unpredictable sounds of large amplitude so that adaptation is less likely to occur, can be of considerable importance for survival and efficiency of performance of motor or mental tasks.

There have been a number of studies of the effects of high level sound on mental or motor performance other than degradation of speech. Until 1950 (Kryter, 1950), it was thought that these studies were too poorly controlled to provide definitive evidence of any effects, either positive or negative. However, since 1950, the studies have become methodologically more sophisticated, and several kinds of effects have been found to be reliable. Again the effects of intermittent, unpredictable high level sound and those of continuous high level sound are somewhat different, especially in the light of two different possible general effects, distraction and arousal. That noise can be distracting, to the detriment of efficiency, has been shown by several investigators. In one study (Woodhead, 1959), subjects were performing an air traffic control task which involved looking at a number of sources of information in turn and remembering what they had just looked at and where to look next. A 1-sec. burst of high level sound upset performance significantly for the next 15-30 sec. This effect can be produced again and again by intermittent noise, since adaptation tends not to occur; the attention-getting effect of the extraneous sound is quite distracting. Even this kind of finding is not all negative, however, since Kryter (1970) reviews several

studies which tend to show that, after the momentary degradation of performance produced by the onset of the high level sound, there is a period of 30 or more sec. during which performance is improved, perhaps by the arousal which accompanies the distracting sound. Thus, if the distraction can be made up for by the period of increased efficiency, the two effects would tend to cancel out.

There is some disagreement about the effects of steady high level sound on performance of mental or motor tasks. Poulton (1970) argues from a number of studies that continuous sound of 100 dB or higher has degrading effects on tasks that require continuous performance or vigilance. An example of this kind of task would be monitoring a radar screen for targets, or keeping a lookout for brief signals which are difficult to discriminate (as in a machine-paced inspection task). These tasks typically must be performed for at least 1/2 - 1 hour for these deleterious effects to appear. One of the most well-known studies in this area is that of Broadbent and Little (1960), who examined the effect of decreasing background factory noise from about 100 dB to 90 dB on the performance of operators who threaded movie film onto rolls after it had been perforated. The operation was performed in dim light, and there were frequent accidents such as rolls being broken or machines jammed, with maintenance having to be called for. The study appeared to be carefully controlled, since the investigators used a period before the noise reduction as a base line, and had a control group for which the noise level in the threading bays was not reduced. They found significant pre-to post-experimental decreases in broken rolls and calls for maintenance in both the control and the

experimental groups, but the decrease was larger in the bays that had been treated so as to reduce the noise level to 90 dB. Broadbent and Little (1960) interpreted this in the light of Broadbent's (1954) theory of attentional "blinks", or momentary swings of attention to the background sound. Presumably there were fewer blinks in the reduced sound condition, and since these blinks would be detrimental to the performance of a delicate task, there were fewer accidents.

Kryter (1970) does not accept this interpretation, although he does agree that the results are reliable. First of all, there was no differential increase in output between the treated and untreated bays, even though the untreated bays had a higher incidence of broken rolls and other shutdowns. Thus, there was some compensation for the increased accident level, perhaps due to a higher level of arousal in the untreated bays. In addition, Kryter suggests that at least part of the decreased number of accidents in the treated bays could have been due to the increased ability of the operators to use information-carrying sound made by the machines in their work more than they could when the noise level was higher and these sounds were masked more effectively. The remainder of the decrease could have been due to the same unknown cause as the decrease found in the control bays where the sound level was not changed. Thus, there is no reason to assume that these results demonstrate anything other than the masking effects of high level sound, which are well known and do not have the same negative implications for human performance as does Broadbent's blink theory. In general, Kryter (1970) concludes that there are probably no effects of continuous high level sound on task performance except where

the noise is either response contingent (i.e. sound functions as a reward or punishment) or stimulus contingent (contains information relevant to the task). In reference to response contingent noise, there is some evidence that intermittent and unpredictable changes in noise levels affect rate of learning of irrelevant things, presumably because it is difficult to learn that the sound is not response contingent.

As is mentioned above, arousal induced by sound can have several kinds of effects, depending on the situation. One example of these effects and their ambivalence with respect to hedonic or survival value is a study by O'Malley and Poplawsky (1971) of the effects of noise-induced arousal on the breadth of attention. They showed that such arousal led to a general narrowing of attention to the task at hand. This was detrimental to performance of one kind of task, in which subjects were told to try to learn words placed in the center of cards and then were tested for memory of words placed peripherally on the same cards. On the other hand, performance on the Stroop Color Word test was enhanced by the presence of sound at levels of 85 and 100 dB. Sound at 75 dB led to no differences from control subjects on this task, which involves the names of colors printed in other colors (e.g., the word "RED" printed in blue) with the subject having to remember the color of the print. Thus it requires the subject to ignore the irrelevant information (the color word). This study demonstrates how the narrowing of attention caused by sound-induced arousal could have either beneficial or negative effects on human performance, depending on the task to be done. There is some evidence that whether a given sound is relevant or irrelevant to the activities of the task performer

can affect the value of the effects of the sound on performance. Harcum and Monti (1971) found that an irrelevant high level sound led to disturbance and annoyance in an experimental group; but that when a different experimental group was exposed to the same sound but thought it was relevant (but not contingent) to the task they were performing it disturbed them no more than the controls exposed to a much lower sound level. In addition, other workers in the same building to whom the noise was presumably irrelevant complained that the noise used in the experiment distracted them and made it harder for them to work. However, consistent with the summary of Kryter (1970), neither relevant nor irrelevant sound had any effect on actual task performance.

Sensory deprivation and sensory overload.-- In the previous pages we have been discussing the effects of what may be called sensory overload on a variety of human behaviors. In addition to these effects, there are some more mysterious effects of sensory overload on human perception and behavior. Haer (1971) has reported evidence that sensory overload can lead to what have been called "altered states of consciousness," characterized by hallucinations, illusions, and a loss of touch with reality. Any such effects would certainly be detrimental to performance of industrial and other kinds of work, although they may be sought after by some people. These presumably are the effects of arousal that does not adapt to the overload of the sensory channels. In the particular experiment mentioned, high level sound was one of the two overloading stimuli, the other being patterned light. Thus it is possible that prolonged sound-produced arousal could lead to effects such as these.

The above effects are very similar to those experienced by people who undergo relatively long periods of sensory deprivation. This is a situation where sensory and perceptual input is reduced to the minimum possible. In cases where it is impossible to eliminate information-carrying stimuli, they are masked. After relatively long periods (several hours) of this deprivation, subjects report hallucinations, illusions, etc. and also show changes (some positive, some negative) in performance on mental and motor tasks (Zubek, 1969). In addition, people seem to be more subject to suggestion and persuasion while experiencing sensory deprivation (Suedfeld, 1972).

It seems that both sensory overload and sensory deprivation can produce states of arousal that can be detrimental to certain kinds of performance. The organism works best (and complains least) when at an optimum level of arousal; the effects of arousal on performance, etc., can be displayed in the form of a family of inverted U-shaped curves, with peak performance at moderate levels of arousal. This suggests that there is an optimal sensory environment which has some, but not too much, stimulation present for the various sensory systems. It is difficult to specify what this optimum level is; we can assume, however, that it is a level which minimizes or eliminates the occurrence of unwanted effects.

Purpose and Design of the Present Study.

Why This Study?

The present research project was designed to measure the potential impact of the increased traffic sounds originating from Route 18 as enlarged, on the college students who would be living and working in the vicinity of

the highway. It was recognized that most of the existing literature reviewed above dealt with aircraft or industrial noise; that evaluations of social interaction effects, as opposed to task-performance and physiological effects, have seldom been attempted; and that the subject populations have usually been either experimental laboratory volunteers for brief studies or workers and householders in the field.

Are these differences significant? The evidence is clear that the spectral composition of the sound is indeed an important variable, so that the effects of vehicular traffic noise may be quite different from those of aircraft and machinery noises. Besides, the temporal pattern of highway traffic, and its associated sounds, impinges on those in its vicinity quite differently from noise "on the job" or the environment near an airport. Brief laboratory studies, of at most a few hours' duration, could not begin to answer the questions relevant to the psychological impact of living near a busy highway, especially for students whose work areas and living quarters overlap greatly.

For this reason, too, it is important here to include both task and social measures of impact, a consideration frequently overlooked. It may be noted that recent research on human crowding has shown strikingly that while task performance may not be affected over a short term, the nature of social behavior is changed considerably (Freedman et al, 1971; Epstein, 1972); other environmental variables, such as noise, may well have similar effects.

Finally, college students are different in important ways from the general population, and studies of, for example, the effects of machine noise

on assembly-line workers may not be highly predictive of students' reactions. It should be understood, by the way, that whereas workers may perceive the noise as an unavoidable byproduct of earning a living, informal discussions and observation of student actions indicated strongly that many Rutgers undergraduates perceived Route 18 noise as an arbitrary and unnecessary degradation of their environment.

Design of the Study.

Analysis of the campus milieu which would be affected by Route 18 noise indicated that the two major sites of potential impact were classrooms and dormitory rooms. In the former, the major activities included lecturing by professors, student listening and discussion, note-taking, answering and asking questions, and extraneous activities such as students talking among themselves, looking out the window, leaving the room, etc. In the dormitories, major activities were social interactions such as group discussion, various study-related tasks such as memorizing assignments and writing papers, and the casual activities of ordinary life -- sleeping, listening to music, reading, etc. It was decided that, for maximal reliability, we would collect whenever possible objective performance data, systematic ratings from trained observers, and introspective reports from the student subjects. Obviously, some of the types of data collection were less feasible in a given situation than others, so that not all three were obtained in every situation.

a. The Classroom Study.

Classroom behavior data were obtained during the course of three days in an experimental condition with traffic noise being broadcast via loud-

speakers outside the building, and in a control (normal) condition in the same classes a week later. Two kinds of data were collected: one was from questionnaires filled out by students attending classes in the building, the other consisted of rating forms completed by trained observers who were members of the research staff sitting in on classes.

Questionnaire topics concentrated on subjective reactions to the induced sound and on comparisons between cognitive and emotional responsivity to the experimental as compared to normal sound levels. Observer ratings used a modified Bales system to evaluate the level and nature of class interaction and student behavior (see Method).

b. The Field Experiment.

In the field experiment, 18 student volunteers spent five days living in dormitory rooms which were assigned to one of three sound conditions: control, moderate, or high. Six subjects underwent each of these conditions for four days, while the other day (the first of the session) constituted a normal-sound baseline condition.

Data collection occurred four times a day. Repeated measures of cognitive efficiency, affective reactions, physiological arousal, and social interaction parameters were collected. (see Method).

METHOD

This section describes in detail the procedures used to carry out the general research design described above.

Classroom Behavior. For this part of the investigation, highway generated sound was broadcast from equipment set up outside Frelinghuysen Hall, a large building with classrooms in the basement and ground floors and dormitory facilities on the floors above ground level. The sound was broadcast on April 14, 17, 18, & 19, 1972, although experimental data were collected only on the latter three days.

Sound level manipulation. -- The sound broadcast during the Frelinghuysen tests was recorded by precision equipment at several sites along the present Rt. 18 freeway during various time periods on several days near the end of March, 1972. This traffic-generated sound (see the G.E. report for a detailed physical analysis) was then broadcast through 24" and 31" speakers, using a Magnetic Data Recorder (G.R. #1525-A) and amplifier. The levels broadcast were measured with a G.R. 1565-A sound level meter and averaged 80 dB(A) ± 7 dB (A) at the speakers on April 14 and 18, and 77 ± 7 dB(A) at the speakers on April 17 and 19. Sound levels were also measured at various points in and around the Frelinghuysen building with windows open and closed. In general, levels around 80 and 77 dB(A) on April 14 & 18, and 17 & 19 respectively, were measured on the balconies outside the lounges, while the average levels inside the lounges were about 55-60 and 50-55 dB(A) respectively. In the classrooms, with windows open, the measured sound levels were about 70 and 67 dB(A) respectively, and with windows closed were about 66 and 63 dB(A) respectively. These sound levels were subsequently used in the field experiment.

It should be mentioned that the 24" speakers cut off frequencies below about 120 Hz. These frequencies are fairly prominent in highway-generated sound, corresponding to a great deal of the heavy "truck rumble." In an effort to improve the simulation, 31" speakers were substituted, but these speakers still cut off frequencies below about 80 Hz. This would appear to be a difficult problem in the reproduction of traffic sounds, and it may have had some effect on the data of the present study. However, most of the lower part of the spectrum was present in the broadcast sound, so these effects were probably minimal.

Observers' Ratings. -- One component of the Classroom Study was the rating of in-class behavior by trained observers. A meeting open to all instructors and students with classes in Frelinghuysen was held during the week prior to the study, and permission was obtained for the presence of the observer in each class.

Sample Selection.

One relevant aspect of the situation was that Frelinghuysen Hall contains classrooms of various sizes and classes with a wide range of subject matter, didactic methods, etc. Classes are held from early morning through the afternoon. We wanted to be certain that a fair representation of each type of class and each time period was included in our sample. A complete list of classes which met on the experimental days was provided, and the classes were divided into time and general subject matter categories. Within these categories, an attempt was made to include classes of various sizes to control both for number of students and, at least indirectly, for teaching method (e.g. seminar, discussion, or lecture). The final breakdown of the 33 classes in the sample is included as Table 1.

Table 1

Types of Classes Included in the Sample

Subject Category	AM		PM	
	Attendance: 15 or fewer	More than 15	Attendance: 15 or fewer	More than 15
Humanities (Foreign Language, Literature)	2	0	3	2
Social Sciences (History, Psychology, Economics)	5	0	1	3
Mathematics	2	3	1	4
Applied Sciences (Computer Science, Military Science, Business Administration)	4	1	1	1

Rating Categories and Procedure. -- Three observers, who were told nothing of the purposes or hypotheses of the study, were trained in the use of the rating categories, which are included as Appendix B. Identification of the class, including scheduled and actual starting time, and attendance, were recorded; modified Bales interaction categories were used to record the nature of verbal interaction in the class. The total number of verbal communications, and the location in the room of the source of each, were also recorded.

At fifteen minute intervals, the observer filled out the "15 Minute Summaries" (see Appendix B). These ratings asked for a general evaluation of the class proceedings, with categories measuring the nature of task-oriented (items 1, 2, and 3), affective (items 9, 10), and general classroom factors. Item 8, concerning the general level of noise, was a check on the experimental manipulation; item 7 ("Adequacy of classroom lighting") was a control question to indicate any possible rater bias (cf. Rosenthal, 1966).

Behavior rating forms, interspersed every 15 minutes by summaries, were filled out until the class was dismissed. One week after the first observation, the same observer again visited the same class and completed a second set of ratings and summaries. This served as a control comparison with the earlier, simulated traffic sound, condition.

Student Questionnaires. -- Large boxes of blank questionnaires were placed in the hallways and near classroom doors in Frelinghuysen Hall during the experimental sound-induction days. There were signs urging students to fill out a questionnaire, and other marked boxes were made

available in which completed forms could be deposited. Obviously, there was no control over which students chose to fill out questionnaires nor over the number of forms filled out by each respondent. A total of 819 completed questionnaires were turned in; the form itself is included as Appendix C.

Field Experiment.

Subjects. -- College students were recruited for the one-week experiment by offering them 70 dollars remuneration. Students who volunteered were screened in a telephone interview explaining the requirements of the experiment in terms of time necessary and limitation on movement. Twelve women and six men who participated in the study were randomly assigned to double rooms with the restriction that roommates were of the same sex and did not know each other prior to the study.

Procedure. -- The subjects were further randomly divided into three groups of four women and two men each. One group was designated as a control and was assigned to rooms on the 2nd, 4th, and 8th floors of the dormitory. The remaining two groups were assigned rooms on the first floor so that one group was in high level traffic sound rooms (see Sound Manipulation) and the other was in lower level traffic sound rooms. All subjects attended preliminary sessions on the Saturday and Sunday preceding the study week in order to receive orientation and familiarization with the forms. By Monday all subjects had moved into their assigned rooms and begun the week long experiment. The daily schedule was as follows: 8:00 - 10:00 AM complete morning packet of comprehension, memory, creativity, and adjective checklist tests and take pulse; 10:00 - 3:00 PM complete packet again,

with alternate forms of test except Adjective Checklist; 6:00 PM attend group discussion session and then do Prisoner's Dilemma game with roommate (order counterbalanced across days); 8:00 PM - 12:00 AM complete third packet of forms. This schedule was maintained with few exceptions through the week until Friday evening when the study ended. In instances where tests were missed, they were made up at the earliest opportunity except in the case of the group discussions and Prisoner's Dilemma games.

Monday served as a control or baseline day since the highway generated sound was not turned on until Monday night with the nighttime traffic tape (see sound level manipulation). Saturday and Sunday test administrations were also counted as baseline.

Dependent measures. -- There were four measures in the packets which the subject completed three times daily. Pairs of subjects sharing the same room administered the tests to each other, or timed themselves on the various tests, depending on convenience. The 18 memory tests consisted of definitions from the Encyclopedia Britannica Dictionary. Definitions were randomly selected with the restriction that each be approximately 100 words long (see Appendix D for an example). Subjects had 5 minutes to read the passage and 5 minutes to write their recollection of the passage on the provided form. The 18 forms of the reading comprehension test were selected from sample items in a Graduate Records Examination primer (see Appendix E for an example). Subjects spent 5 minutes reading the passage and answering the questions. The 18 forms of the story integration test were composed five words from which the subjects were requested to write a story (see Appendix F for an example). Subjects had 5 minutes to compose a story on each occasion. The five words on any particular test were drawn one each

from five classes of things: animals, vegetables, minerals, plants, and tools. The fourth test was the Affect Adjective Check List (AACL) (See Appendix G), the same form of which was used in all administrations. All tests were counterbalanced across administrations. For the group discussions, topics were chosen to be timely ones (women's liberation movement, case of a juvenile delinquent, etc.). Group discussions were to last 30 minutes, and the group was to try to come to some consensus regarding the topic of discussion. In actuality, discussions often stopped before 30 minutes had passed, while one session ran considerably over 30 minutes (see Results). The discussions were rated on a selected set of Bales interaction categories (see Appendices B & H) in blocks of 5 minutes. Raters were paid graduate students who attended a training session during which a consensus on the Bales category definitions was reached. Raters were assigned to groups at random, one to a group, and stayed with the same group all week, as the ratings depended on knowing the names of each person in the group. On the first day, raters explained their role to the group, introduced the topic, and then withdrew to the periphery of the room. On subsequent days, raters simply announced the topic and withdrew.

Raters also administered the Prisoner's Dilemma (P.D.) game in a counterbalanced order with the discussion. The game consisted of 10 trials per day of a standard, symmetric, medium payoff game (for points, not money) (see Appendix I for the payoff matrix.) Each subject was paired with his or her roommate; there were 10 occasions on which each had to choose to either cooperate or compete, with consequences described by the payoff matrix. Choices were made by selecting the appropriate slip of paper and handing it

to the rater. The rater then announced the payoffs, returned the choice slips, and administered the next trial. At the end of each session, the subjects were told their overall scores.

Sound level manipulation. -- As was mentioned above, the level of highway-generated sound in the environment of the subjects was the independent variable of interest in the present study. Three levels of sound were chosen, and a group of six subjects lived with this sound continuously for four days after the one-day baseline period. The sound used was a re-recording of the highway-generated sound played at the Frelinghuysen dormitory in the classroom study described above. The sound recordings used in the field experiment were made on April 14, 1972 in room A-3, Frelinghuysen Hall, with the windows open. The equipment used for the recording was as follows: Ampex 601 tape recorder, Ampex 620 playback amplifier/speaker, Shure 565 Cardioid microphone, and a Sony TC-104-A tape recorder. The traffic simulations recorded on the Ampex 601 tape recorder were being broadcast from the canal tow path behind the dormitory through 24" speakers that cut off frequencies below 120 Hz. and above 6 KHz. The 601 handles these frequencies easily. The Sony TC-104-A tape recorder was used to make 5 minute loop tapes from the master tapes. The highway generated sound broadcast in the rooms of the subjects in the H and M conditions* was from tapes played on the Sony tape recorder. The output of the Sony was fed through a Bogen M-120 mixer power amplifier to column level speakers that cut off frequencies below 100 Hz. Thus the spectral composition of the sound may have differed somewhat from the typical one (see Kryter, 1970) which includes a large component of frequencies under 120 Hz. Phenomen-

*See page 42.

ologically, the rumble of the trucks was somewhat attenuated.

Table 2 shows the measured sound levels of the tape loop broadcast at various times of the day for the two experimental conditions. These are average sound levels; actual levels varied ± 7 dB(A) from the averages. The control condition had no extra sound introduced into their rooms; they lived at the ambient noise level of the dormitory. This was measured to be about 40 dB(A) inside the rooms and 50 dB(A) in the corridor, providing no radios, record players, etc. were operating. Thus, there was a fairly large separation in average ambient sound level for the three groups of subjects. In addition, the control subjects heard very little, if any, traffic-generated sound, the dormitory being well insulated and isolated from any large highways.

Combining the testing schedule and the schedule of noise broadcasts, it will be seen that in general two of the three daily cognitive-affective batteries were run in the equivalent of rush hour sound conditions (the highest level); the other was run in nighttime intermittent, the lowest level. Also, the discussion and P.D. games generally took place during the highest or next highest level sound broadcasts.

Table 2

SCHEDULE OF SOUND BROADCASTS FOR THE
H AND M CONDITIONS

AVERAGE SOUND LEVEL BROADCAST (dBA)

<u>TIME OF DAY</u>	<u>H</u>	<u>M</u>
1. 7:30 AM-10:30 AM 2:00 PM- 6:30 PM	70	66
2. 10:30 AM-2:00 PM 6:30 PM-8:30 PM	67	63
3. 8:30 PM- 7:30 AM	57*	53**

* An average, intermittent noises peaked at 62 dB(A)

** An average, intermittent noises peaked at 58 dB(A)

RESULTS

The results will be presented in the same order used in the Methods section.

Classroom Behavior.

Since there was no difference between the effects of the two experimental sound levels, these were collapsed into one category. Thus, the major comparisons were between the experimental condition and the control or "usual" condition.

Observers' Ratings. -- Although there were several large differences between the pairs of ratings (noise broadcast vs. control days) on a number of categories, t-tests showed nonsignificant trends due to high variance. Therefore, the data were reanalyzed by use of the Sign Test. The following significant differences were obtained.

Under the experimental (induced sound) conditions, there was:

- a. Less classroom participation ($\underline{z} = 2.46, p < .02$)
 - b. Less attention to classroom proceedings ($\underline{z} = 2.30, p < .02$)
 - c. Lower audibility of instructor comments ($\underline{z} = 3.11, p < .002$)
 - d. Lower audibility of student comments ($\underline{z} = 3.01, p < .003$)
- (All of the above significance levels are two-tailed)

There were also trends to the effect that under induced sound:

- a. More lecturing rather than discussion ($\underline{z} = 1.46, p = .07, \text{one-tailed}$)
- b. Less asking for opinions ($\underline{z} = 1.37, p = .09, \text{one-tailed}$)

The manipulation check indicated that observers in all 33 classes rated the experimental session as higher in ambient noise than the control session ($\underline{z} = 5.57, p < 5 \times 10^{-4}$), whereas the "illumination" control question showed no differences (experimental and control ratings within one point in 12 of the 33 comparisons: in the other 21, experimental rated higher than control 11 times and vice versa 10 times). It thus appears that the manipulation was effective, and that the results were not due to generalized observer bias.

More detailed analysis indicated that there was no reliable effect of time within session on any item.

Student Questionnaires. -- Every one of the nine questionnaire items showed highly significant differences between "Today" and "Usual," with χ^2 s ranging from 50.90 to 883.31 (all but two of the nine were greater than 400). In every case, the induced sound condition was rated negatively: lower efficiency of note taking, lower attention to class proceedings, lower audibility of teacher and student contributions, lower general student enjoyment, lower own enjoyment, less seriousness, less discussion. The manipulation check was again confirmatory in that the "Today" condition was perceived as more noisy than usual ($\chi^2 = 883.31$). Again, no time effect within the day was found.

Comments (item 10, Appendix C) were slightly less unanimous (some students said that they could get used to the noise, or that they had expected it to be worse), but were still quite strongly unfavorable. Some were extremely indignant and hostile, including one from a student who asserted that his dormitory room on the fourth floor was being made uninhabitable by the sound. Also, several comments expressed indignation concerning the invasion of the classrooms and dormitory rooms by the noise, especially about the fact that decisions about the experiment were made by authorities without previous consultation with the students.

One piece of anecdotal data supports the evidence from both classroom observations and student reactions: the cable to the sound equipment was cut by students at least twice, and several questionnaire comments promised to destroy the equipment if it could be found unguarded.

Field Experiment.

Checks on Experimental Manipulations.-- On the final questionnaire which all subjects answered, there were several questions relevant to the subjects' perception of the sound level in their living quarters during the study and in their usual environment (see Appendix J for an example of the questionnaire). The responses to these questions can serve as a check on the manipulation of environmental sound level in the present experiment, as well as a preliminary indication of the subjects' rejection to the highway generated sound. Table 3 displays the mean responses of the subjects to all questions except number 7. Questions 3 through 6 are of interest here. The responses to these questions were subjected to an analysis of variance to see if the differences that can be observed in the means in Table 3 were statistically significant. The resulting F -ratios, with 2 and 15 degrees of freedom in all cases, are also displayed in Table 3, along with the p value for each F .

It can be seen that the differences observed on questions 3 and 5 were statistically significant, those on questions 4 and 6 were not. For question 3, this means that the experimental sound levels significantly affected how noisy the subjects perceived their rooms to be, from a mean rating of near the extremely noisy end of the scale in the high sound condition, to a rating on the quiet side of the midpoint for the control condition. Scheffé's tests on contrasts shows that at the .05 level of significance, both the high (H) and medium (M) sound level conditions are different from the control condition (C) but are not different from each other. The lack of statistical significance for question 4 means that there

were no differences between the various conditions in terms of how noisy our subjects reported their usual environments to be. This implies that the differences observed between the groups on question 3 were indeed due to the experimental manipulations.

The significant differences in responses to question 5 mean that the noise levels present in the subjects' rooms bothered them differentially depending on the condition: subjects in the H condition were greatly bothered (mean of 2.5 on a 7-point scale), subjects in the M condition next most, and subjects in the C condition, least. Again Scheffe's tests on contrasts, using the .05 level of significance, showed that the H and M conditions were both significantly different from the C condition but not from each other. The fact that there were no significant differences in responses to question 6, how much subjects were bothered by the noise level they usually live in, implies that the differences in responses to question 5 were a result of the experimental manipulation of the sound level in the subjects' rooms. Thus the manipulation of the sound level seems to have been successful, at least in so far as the subjects reported their environments to be differentially noisy over conditions. In addition, subjects in the high sound level conditions were significantly bothered by the highway generated sound, as compared to the control subjects.

Cognitive Performance. -- Subjects' scores on the memorization and story integration tasks were divided into three groups: the average score for the baseline period (BL), which included the Saturday and Sunday session and the first two (morning and afternoon sessions) on Monday, and the average scores for the first and second halves of the remaining administrations which occurred after the highway generated sound was turned

Table 3

MEAN RESPONSES TO FINAL QUESTIONNAIRE

Sound Level

Question	HI	MED	CON	<u>F</u>	<u>P</u>
1	4.33	2.83	2.50	1.17	N.S.
2	4.17	3.83	4.00	.08	N.S.
3	6.33	5.50	2.50	10.66	.001
4	3.33	2.83	4.50	.87	N.S.
5	2.50	3.17	6.33	5.93	.01
6	5.67	6.33	6.17	.29	N.S.
8	4.67	1.67	1.17	16.54	.0002

on on Monday evening. In this way the data were reduced to manageable numbers, and indices of both change from the baseline and change over time during the 'noisy' part of the study were available.

Table 4 shows the mean scores on the memorization tests over the three conditions and time periods. There seem to be differences in the scores, in the direction that performance declines from baseline levels over the week for the two induced sound groups, but remains the same for the control group. However, an analysis of variance of the memorization scores indicates that these differences are not statistically significant.

Table 5 shows the mean scores on the story integration test, higher scores indicating greater ability in creative synthesis. This is an ability which is quite important to a college student. There seems to be some decline in performance from baseline in both the M and C conditions, and no large differences over time for the H condition. However, an analysis of variance shows these differences not to be statistically significant.

Because of time limitations, the reading comprehension tests were not scored and so results on this test are not at present available. The raw data will be supplied on request (but in view of the fact that there are no significant differences on the above cognitive measures, a prediction of no differences on the reading comprehension could be made).

Group Problem-Solving. -- Table 6 shows the number of statements (meaning units) made by the subjects in each group which were scored in each of the Bales interaction categories for each discussion-day of the study. These are the basic data to be analysed here. Before discussing these data, it is necessary to report on one aspect of the group discussions that did not go as planned. Although the discussions were to last 30 minutes each day,

Table 4

MEAN SCORES ON THE MEMORIZATION TEST

		<u>TIME</u>		
		BL	1	2
SOUND LEVEL	H	148.8	120.5	100.5
	M	193.0	190.0	180.6
	C	158.1	150.9	156.0

Table 5

MEAN SCORES ON STORY INTEGRATION TEST

		<u>TIME</u>		
		BL	1	2
SOUND LEVEL	H	3.40	3.02	2.97
	M	4.27	3.82	3.06
	C	3.50	3.79	3.55

BL - Baseline

1 - First half of trials after baseline period

2 - Second half of trials after baseline period

the actual number of minutes spent in the discussions was different across days and groups. Table 7 shows the time spent in discussions for each of the groups for each of the days of the study. It is apparent that the H sound group spent most time in discussion, the M group next most, and the C least. This ordering does not reflect the ordering on the first day of the study, when the noise had not yet started. Even so, since the H group did spend longest on the first day and on subsequent days, the time spent on the first day was compared with the average time spent on the four experimental days. These averages were 37.5, 27.5, and 20 for the H, M, and C conditions respectively. It can be seen that in both experimental conditions, there was an increase that averaged 12.5 minutes per day over the time spent on the first day. There was no such increase in the control condition.

Table 8 shows the data of Table 6 collapsed over the different categories of statements in order to give an idea of the progression over time of number of statements coded and a clear picture of the differences in total units coded in the three conditions. It will be remembered that the initial discussion was held on Monday, May 1, before the highway sound was turned on in the experimental conditions. It can therefore act as a baseline for all of the groups. It can be seen that there is a general tendency for all groups to increase over the baseline in the number of meaning units coded in the different categories. In general, the number of units coded rises until the middle of the week, and then declines on the last two days of the study. Both the H and L conditions follow this general pattern closely. The M condition has peaks on the second and fourth days,

Table 6

Interaction Ratings - Total Occurrences
Collapsed Over 5 Min. Periods and Ss

Categories	<u>HI DAY (MAY)</u>						<u>MED DAY (MAY)</u>						<u>LO DAY (MAY)</u>					
	1	2	3	4	5	Σ	1	2	3	4	5	Σ	1	2	3	4	5	Σ
Agrees	5	10	13	25	18	71	6	24	14	8	8	60	2	3	5	1	15	26
Disagrees	9	16	50	14	2	91	4	24	2	3	1	34	5	2	6	1	7	21
Gives Info.	8	44	108	58	43	261	6	89	48	68	28	239	3	13	31	36	10	93
Asks Info.	0	25	55	7	12	99	10	26	17	21	7	81	3	8	15	9	9	44
Shows tens	0	6	25	1	0	32	0	7	4	1	0	12	0	0	0	0	0	0
Gives Opin.	8	15	106	22	15	166	27	22	29	67	62	207	16	18	26	36	26	122
Asks Opin.	0	9	45	1	0	55	3	0	0	22	1	26	3	2	1	0	0	6
Dramatizes	6	17	35	25	13	96	12	20	7	8	12	59	1	3	25	0	4	33
Σ	36	142	437	153	103	<u>871</u>	Σ 68	212	121	198	119	<u>718</u>	Σ 33	49	109	83	71	<u>345</u>

with a slight dip in the middle. The differences between the conditions in the pattern of change in units over days coded is statistically significant ($\chi^2 = 221.2$ with 8 df., $p < 10^{-5}$). It would seem that the peak on the third day for the H condition is higher than predicted, and the depression on the third day for the M condition is also deviant. Beyond this, it is difficult to interpret these differences.

It is easier to interpret differences in the total number of units coded in the various groups. It can be seen from Table 8 that the H subjects uttered the most codable statements over the week, followed by the M and then the C group, although on the first session the most units were scored for the M group. However, these differences may simply be due to the fact that the H condition spent more time talking than did the M, and the M spent more time than the C. In order to test whether the rates of emission of meaning units were different between the conditions, a chi-square test was done in which the expected frequencies in the cells were calculated from the proportion of time spent in discussion by the various groups. Thus, the H group accounted for 43.75% of the total time spent by all groups in discussion during the week, the M group 31.25%, and the C group 25%. Using these expected proportions, the χ^2 for the totals in Table 8 was 61.8, with two df, $p < 10^{-4}$. Thus, it can be asserted that not only did the H and M groups spend more time in discussion than did the C group, but also they uttered separately codable meaning units at a faster rate during that time.

It is also possible that the increase in units coded during the middle part of the week is simply a reflection of the greater time spent

discussing during those days. This certainly seems to be true for the dip in the third day for the M group, since there was a similar dip in time spent on that day for that group. In order to test this hypothesis, a similar chi-square test to the one described above was done, using the proportions of time spent as the expected proportions of units coded. For this test $\chi^2 = 353.9$, $df = 8$, significant at better than the 10^{-5} level. Therefore, although it may be true in some cases that the increased number of units coded was a result of increased time spent in discussion, it is not true in general for the data of this study.

Table 9 presents the discussion data collapsed across days, so that the overall pattern of statements scored in each of the interaction categories can be seen. The most obvious patterns are that the categories of giving and asking for information and giving opinion predominate in the discussions in all groups. On the other hand, there are relatively few examples of showing tension and asking for opinions. In order to determine whether there was any overall difference between the different groups in the pattern of interaction category frequencies, a chi-square test was done on the data of Table 9. The overall χ^2 was 83.4, $df = 14$ $p < 10^{-5}$. However, since the table is so complex, it is difficult to interpret this result. It was thought necessary to break Table 9 down and test the results of each category or pair of complementary categories separately.

There are three complementary pairs of categories which can be meaningfully compared with each other. They are Agrees-Disagrees, Gives Information-Asks for Information, and Gives Opinion-Asks for Opinion. A chi-square test was done for each pair separately on the data shown in

Table 7

DURATION OF DISCUSSIONS IN THE FIELD EXPERIMENT (MINUTES)

		<u>DAY</u>					
		1	2	3	4	5	Σ
<u>NOISE</u>	HI	25	30	60	30	30	175
	MED	15	30	25	30	25	125
	LO	20	10	30	30	10	100
	Σ	60	70	115	90	65	400

Table 8

TOTAL MEANING UNITS SCORED (DURING DISCUSSIONS) ON EACH DAY OF THE FIELD EXPERIMENT

		<u>DAY</u>					
		1	2	3	4	5	Σ
<u>NOISE</u>	HI	36	142	437	153	103	871
	MED	68	212	121	198	119	718
	LO	33	49	109	83	71	345
	Σ	137	403	667	434	293	1934

Table 9

TOTAL MEANING UNITS SCORED (DURING DISCUSSIONS) IN EACH MEANING CATEGORY

		<u>CATEGORY</u>								
		A	DA	GI	AI	ST	GO	AO	D	Σ
<u>NOISE</u>	HI	71	91	261	99	32	166	55	96	871
	MED	60	34	239	81	12	207	26	59	718
	LO	26	21	93	44	0	122	6	33	345
	Σ	157	146	593	224	44	495	87	188	1934

the appropriate columns of Table 9. It is not necessary to take time spent in discussion into account for any of these tests on complementary pairs, because what is looked at is the relative frequency of scoring of the two categories across the three groups. The χ^2 for the A-DA test was 9.8, which with 2 df is significant at the .007 level. This means that there was more disagreement relative to agreement in the H condition than in the M or C conditions. For the G1-A1 comparison, the χ^2 was 2.23, which is not significant at the .05 level. This means that there were no differences across conditions in the relative amounts of giving and asking for information. The χ^2 for the G0-A0 comparison was 30.4, which is significant at better than the 10^{-5} level, indicating that there was more asking for opinion relative to giving opinion in the H condition than in the M or C conditions.

Two of the interaction categories, Shows Tension and Dramatizes, do not easily pair up; therefore, separate analyses were made on the data in these columns of Table 9. Since the interest here is in absolute frequencies of occurrence, it is necessary to take into account the time spent in discussion in the same way as for the analysis for total categories coded. Therefore, chi-square tests were done on the data in these two categories, using the proportion of time spent by each group as the expected proportion of units coded. Thus the interest in rate of emission of these units.

The χ^2 for the Shows Tension data was 19.66, which with 2 df is significant at the .005 level. This means that the rate of emission of tension units was higher in the H condition than in the other two, and

higher in the M condition than in the C condition. It is interesting to note that not one occurrence of this category was recorded for the C condition over the entire week! Both of the experimental conditions showed a fairly moderate incidence of this response. As Table 6 shows, this category was not used for any of the groups on either the first or the last day of the study. All of this behavior came in the H and M groups during the middle three days, with the bulk of it during the marathon session on the third day for the H condition.

The analysis of the Dramatizes category in the same way gave a χ^2 of 6.47 which with 2 df is significant at the .05 level. This means that there was a tendency for the subjects in the H and M conditions to utter more statements which told a story, or called up illusions or images, than for those in the C condition. All conditions seemed to have a fairly high incidence of this kind of statement, however.

Prisoner's Dilemma Game. -- Two basic analyses (cooperativeness and contingent propensities - see Rapoport & Chammah, 1965) of the data were done for the data of the P.D. games played each day either before or after the discussion. However, it is necessary to preface these analyses with the statement that in general the P.D. game was not successful in differentiating between the groups with respect to post-baseline performance. (it will be remembered that the first game was run before the highway generated sound was turned on in the experimental conditions). On the first day, most of the subjects of the M group achieved cooperative lock-in (both players make only cooperative choices), which was quite different from the other two groups. This group persisted in cooperative lock-in, and therefore

did not change over the experimental period. In addition, the data for the first day of the C group are incomplete, since two of the subjects were not present on that day and did not play the game. Thus the data cannot be considered complete enough for definite conclusions, and are not very informative even where they are complete. In addition, the games were only 10 trials long, which is far too short for most patterns reported in the literature to appear (see Rapoport & Chammah, 1965).

Table 10 shows the results of the analysis of the data on cooperativeness. The data are the proportion of cooperative choices for all pairs of subjects in each group who played the game on a given day. It can be seen that for the most part there are no changes of any magnitude over baseline (the first day) in any of the conditions. The M condition starts out being most cooperative, and maintains that advantage. The H condition is next on the first day, with the C condition showing the lowest cooperativeness, and the order of conditions is the same on each succeeding day. From these limited data, it can be asserted tentatively that the experimental manipulations did not affect cooperativeness as measured by the P.D. game.

Table 11 presents the frequencies of cooperative and competitive moves, contingent on the moves made by both members of the pair on the previous trial. It was not possible to analyze baseline and experimental data separately, because of the number of data points needed for this analysis. A defection is a competitive move made by one player when the other has made a cooperative move. Chi-square analyses were done on each of the subtables associated with the different possible combinations of

Table 10

PROPORTION OF COOPERATIVE CHOICES IN
THE PRISONER'S DILEMMA GAME

		<u>DAY</u>				
		1	2	3	4	5
<u>NOISE</u>	HI	.62	.65	.50	.62	.52
	MED	.88	.83	1.00	1.00	.98
	LO	.3	.47	.43	.30	.42

Table 11

CONTINGENT PROPENSITIES IN THE P.D. GAME

<u>PRESENT CHOICE</u>	<u>PREVIOUS CHOICES</u>							
	<u>BOTH COOP</u>		<u>OTHER DEFECT</u>		<u>SELF DEFECT</u>		<u>BOTH DEFECT</u>	
	Coop	Comp	Coop	Comp	Coop	Comp	Coop	Comp
HI	70	20	36	11	19	28	10	40
<u>NOISE</u> MED	219	5	7	2	5	4	3	7
LO	43	19	16	19	13	22	16	86

previous choices. The χ^2 for the data when both players cooperated on the previous move was 50.58, which with 2 df is significant at better than the 10^{-5} level. According to Rapoport and Chammah (1965), a tendency to respond cooperatively when both players had responded in that way on the previous trial is indicative of trustworthiness, or a willingness to continue the cooperative interaction. This result means that the M group displayed much more trustworthiness than did either of the other conditions. This was already apparent from the first day, and so a separate analysis was done dropping the M condition from consideration. The χ^2 for this analysis was only .96, which for 1 df has a p of .32 of occurring by chance. Therefore, there seems to be no difference between the H and C conditions in the amount of trustworthiness displayed in the P.D. game.

When the other player defected on the previous move, and a player makes a cooperative move, this implies that the cooperating player has forgiven the other his defection. Thus, the proportion of cooperative moves which follow defections by the other player is a measure of forgivingness. An analysis of the frequencies in the columns under this category in Table 11 gave a χ^2 of 9.12 with the M condition included and 6.97 without that condition. These χ^2 s are significant at the .025 and .008 levels, with 2 and 1 df respectively. This means that both the H and M conditions were more forgiving than the C condition over all the days of the experiment. There is no reliable way of telling whether this represents a change from the baseline in the experimental conditions, so the interpretation of this result remains uncertain. The remaining two sets of data in Table 11 represent measures of responsiveness and trustingness respectively. For neither of these was the χ^2 significant

at the .05 level (χ^2 's were 1.01 and 1.49 with 2 df). Therefore, it can be concluded that there were no differences among the various groups in responsiveness or trustiness as shown by the P.D. game.

Pulse Rate. -- Table 12 displays the mean pulse rates of the subjects in the three conditions for the baseline period, and the first and second halves of the experimental period. There are differences between the groups in pulse rate, but they are present from the first day. There seem to be no reliable changes over time, and indeed an analysis of variance resulted in no significant F-ratios. Thus it can be asserted that the experimental manipulations did not affect the pulse rate of the subjects.

Affect Adjective Check List. -- Three times a day during the week and once each on Saturday and Sunday (see Appendix G), subjects checked how applicable each of 33 different adjectives were to their feelings. Analyzing the responses to each of the adjectives would be cumbersome and quite complex. Therefore, 9 indices were created from subsets of the 33 adjectives. These were as follows: High Energy (full of pep, energetic, vigorous, alert), Low Energy (weary, tired, exhausted, listless), Happy (happy), Unhappy (blue, hopeless, unhappy, discouraged, miserable), Interpersonal Hostility (annoyed, ready to fight, peeved, furious, spiteful, rebellious), Free-floating Anxiety (anxious, uneasy, on edge, shaky), Cognitive Decrement (confused, uncertain about this, unable to concentrate, forgetful), Depression (unworthy, sorry for things done), and Positive Affect (relaxed, cooperative, good-natured). A subject's score on each index was the mean rating over all of the adjectives making up the index

Table 12

MEAN PULSE RATE

<u>SOUND</u> <u>LEVEL</u>	<u>TIME</u>		
	BL	1	2
H	74.4	75.4	78.0
M	78.5	78.3	75.8
C	82.8	83.0	83.0

and over all administrations of the checklist for the particular time period (baseline, first and second half) as defined above.

Table 13 displays the overall mean ratings of each index across time and conditions. It is apparent that for the most part subjects were unwilling to say that very many of the adjectives described their feelings to any great degree. For example in the High Energy index, most of the mean ratings are about 1 or below, which on the 0-3 scale used represent "A little like me" to "Not at all like me". Analyses of variance were performed on the data summarized in each of the nine parts of Table 13. Only two of these (High Energy and Positive Affect) F-ratios yielded significant at acceptable levels, so the data of the remaining seven indices will not be discussed in any detail. For those indices, there seems to have been no effect of the experimental manipulations of sound level on the feelings of the subjects as represented by their ratings on the checklist.

For the High Energy index, the analysis of variance revealed a significant interaction between the experimental conditions and the time factor ($F = 7.03$ with 4 and 30 df , $p < .01$), but no significant main effects either time or sound level. Thus the differences between the patterns of mean ratings over time for the three experimental conditions is statistically significant. Overall, the C condition reports an increase in energy over the experimental period as revealed by their increasing ratings on the High Energy index. The M condition also displays this increase in energy, but it is less dramatic. The H condition, on the other hand, shows a sharp drop in reported energy level over the week. It seems that it started out with the highest and finished with the lowest energy level. Thus,

Table 13

MEAN SCORES ON AFFECT ADJECTIVE CHECKLIST INDICES

		BL	TIME 1	2
HIGH ENERGY	H	.89	1.15	1.44
	M	.53	.87	.96
	C	1.03	.82	.49
LOW ENERGY	H	1.11	.84	.66
	M	1.29	1.03	1.15
	C	1.17	.90	.96
HAPPY	H	1.42	1.29	1.36
	M	.99	.98	.96
	C	1.21	.68	.67
UNHAPPY	H	.40	.67	.34
	M	.47	.45	.48
	C	.40	.40	.29
INTERPERSONAL HOSTILITY	H	.35	.47	.39
	M	.21	.54	.60
	C	.63	.35	.35
FREE-FLOATING ANXIETY	H	.45	.64	.48
	M	.89	.71	.87
	C	.44	.41	.48
COGNITIVE DECREMENT	H	.76	.70	.65
	M	.97	.83	.81
	C	.93	.47	.70
DEPRESSION	H	.15	.62	.32
	M	.22	.14	.09
	C	.23	.23	.23
POSITIVE AFFECT	H	1.70	1.42	1.37
	M	1.23	1.03	.99
	C	1.86	1.27	.92

high levels of traffic generated sound had the effect of decreasing subjects' energy levels, at least as measured by this kind of self-report. It must be noted again, however, that none of the subjects in any group felt extremely energetic, as seen by the low mean ratings on this index.

On the Positive Affect index, there was a significant main effect for time ($F = 8.76$, $df = 2,30$, $p < .01$). As one might expect, subjects reported decreasing levels of positive affect as they spent more time in the experiment. Neither the sound level nor the sound \times time interaction effects were statistically significant.

Final Questionnaire. -- Each subject filled out a questionnaire just before the termination of the study. Besides the manipulation checks whose results are analyzed on page 42, the questionnaire contained items designed to measure the subject's estimation of the study and of its effects upon him.

The three questions related to affective evaluation of the study were numbers 1, 2, and 8 (see Table 3). The results were very interesting: while there was no significant intergroup difference on item 1, liking the study ($F = 1.17$), or on item 2, time spent in room during the study ($F < 1$), the difference on "Would you be willing to participate for another week under the same conditions" was highly significant ($F = 16.54$, $p = .0002$). Tukey tests indicated that the H group was significantly less likely to respond affirmatively to this question than either the L ($q = 7.53$, $p < .005$) or the M ($q = 6.45$, $p < .005$) groups, while the L-M difference was not significant ($q = 1.08$). Thus, while subjects exposed to high sound levels did not admit to being less favorable toward the experience nor to trying to avoid it by leaving the room, they were much less willing to prolong it.

Another part of this instrument listed a number of psychologically relevant functions or activities, and asked the subject to rate whether during the course of the study he had experienced improvement, impairment, or no change in each function as compared to normal levels (see Table 14). Analyzing responses on this tripartite basis, we found that subjects in the H group reported more deterioration as compared to improvement or no change than did M subjects, who in turn reported much more than did the C group. The last reported primarily "no change" (see Table 14). The row totals were subjected to a χ^2 test and the overall effect was highly significant ($\chi^2 = 43.406, p < .0001$).

Table 14

FREQUENCIES OF RESPONSES ON QUESTION 7 OF THE FINAL QUESTIONNAIRE

	RESPONSE	Sleep	Study	Social Relations	General Mood	Conversation	Concentration	Judgment	Alertness	Nervousness	
HI SOUND	+	3	0	0	0	0	0	0	1	1	5
	0	0	1	2	1	1	1	2	1	0	9
	-	3	5	4	5	5	5	4	4	5	40
MED SOUND	+	0	0	1	0	0	0	0	0	0	1
	0	2	0	4	4	1	1	4	3	3	22
	-	4	6	1	2	5	5	2	3	3	31
CONTROL	+	0	0	1	0	0	0	0	0	1	1
	0	5	5	4	4	4	4	4	5	4	42
	-	1	1	1	2	2	2	2	1	1	11

DISCUSSION

Interpretation of Results

This section is divided into two parts: extrapolation from previous studies, and discussion of present results. The first is included because all of the possible effects of the sound levels used were not tested in the present study. The second, of course, is a discussion of those aspects which were tested in the present study.

Extrapolations from Previous Studies. -- A number of effects of high levels of sound on various human systems, which were discussed in the Introduction, were not directly tested in the present study. Among these are threshold shifts, most physiological effects, effects on vigilance and other perceptual-motor tasks, speech masking, and effects on sleep. While these effects were reviewed in general in the Introduction, it is necessary to determine just what might be the actual effects of the highway-generated noise projected to accompany the extension of Route 18 through New Brunswick and Piscataway.

The highway-generated sound used in the present study was actually recorded from the present Route 18 freeway. Since both trucks and cars use this road, there is a fairly broadband spectrum of sound present in fairly high levels (80-90 dB(A) at the roadbed). During the course of the study, various frequencies (especially the low frequencies) were attenuated due to limitations of the speaker systems used in the various tests. The comments in this section will apply to the actually anticipated spectral composition of the sound, rather than to the somewhat distorted sound used in the tests. However, level measurements of the simulated sound will be used, since indoor measurements were made with this sound. In general, an average sound pressure level of 65-70 dB(A) will be considered typical for

daytime highway activity. This level was measured in classrooms and lounges with the windows open. An average level of 55-60 dB(A) will be considered typical for nighttime activity. It must be noted that these are averages; deviations of ± 7 dB(A) from these levels are to be expected. In addition, the nighttime sound is considerably less constant than the daytime rush-hour sound. The sound levels used here span the range of sound levels which highway engineers extrapolated to occur from 1975-1995 if the extension of Route 18 is built as planned. Of course, much higher levels are to be expected near the road, and outdoors; the present comments will be limited to the effects of the levels to be expected in interior spaces with the windows open.

Kryter (1970) presents several excellent summaries of many studies concerned with the various effects of noise. In addition, he constructs from these summaries standards based on principles that can be considered to be established by scientific research. For these reasons, much of the present extrapolation will be from the standards recommended by Kryter (1970) consistent with the review of findings presented in the introduction to the present paper.

Two summaries by Kryter (1970) are of primary importance to the present study. They are the setting of "maximum tolerable limits" for broadband sound level in various locations (homes, schools, businesses, etc.) which take into account the various effects of sound on human behavior and physiological systems, and the projection of actions taken by people in response to noise of various levels from documented legal and civil actions already completed or in progress. With respect to the first, the limits of interest here are those for schoolrooms and for homes. The first is

set by Kryter at 42 dB(A), the second at 47 dB(A). These are based on such principles as the threshold for interference with speech, which is at about 27 dB(A), and the effects of sound on physiological arousal. The levels extrapolated for an uncovered extension of Route 18 --65-70 dB(A) during the daytime and 55-60 dB(A) during nighttime -- are clearly far in excess of these maximum tolerable limits. Also, Kryter recommends that these levels be reduced by 10 dB(A) at night, so that the projected Route 18 nighttime sound levels do not come any closer to these limits by virtue of averaging 10 dB(A) less. The most significant effects of these levels of sound are on speech masking, an intolerable effect in the classroom where speech communication is essential to the learning process, and on the activities of the home which include sleep as a major component. As discussed above, neither of these effects shows much, if any, adaptation in the studies conducted to date.

As demonstrated in our present study and in numerous other studies reviewed by Kryter (1970), these sound levels are perceived as extremely noisy and annoying. In fact, according to the extrapolations provided by Kryter's Figure 238 (1970, p. 444), these levels of noise could be expected to cause group appeals for cessation of the noise and possibly even legal action. Of course, most of the data for this projection come from the problems connected with the building of airports, but there is a considerable similarity of a major highway to an airport approach in the type of sound found there, if not in the intensity of sound (airports routinely generate sound in excess of 100 dB(A) even for people several miles from the airport proper, due to flyover of planes at low altitudes).

Since most physiological effects of the levels of sound generated by highways show some adaptation, there probably would not be too much negative physiological effect of the proposed Route 18 extension sounds. There may be an increase in arousal because of the intermittent nature of the sounds, but even this should eventually adapt out. At present, the long-term effects of continuous high-level arousal are not known.

Another area where no drastic changes would probably be seen would be on vigilance and perceptual-motor tasks, since these are little affected by continuous high-level sound. Any negative effects of distraction seem to be cancelled by the increased arousal caused by these sounds. Also, since the highway-generated sound would obviously be irrelevant to the learning taking place in the classroom, at least in the direct sense, there should be little effect of the sound on learning (other than that caused by increased speech masking or the other undesirable effects discussed above and in the next section).

A final area of concern is the possibility of permanent hearing loss caused by the sound generated by an open highway. The average levels generated by the highway for the people very near the road are clearly in excess of the threshold for permanent loss, which is set at 66 dB(A). If persons were exposed to the high level sounds (80-90) dB(A)) daily for a period of 20 years or so, extensive loss beyond presbycusis could be expected. This is undoubtedly happening to commuters. [REDACTED]

[REDACTED] The lower sound levels observed in the classroom and lounges in the Frelinghuysen tests could not be expected to cause this kind of permanent loss, but it is observed that these levels are near or above the threshold

for permanent loss. Kryter (1970) projects that some 10 dB(A) of loss at frequencies above 2000 Hz. could be expected in a large percentage of the population exposed to these levels for a considerable length of time. Being relatively transient, students probably would not meet the length of time criterion for exposure; but other residents of the area certainly would be in some danger. In addition, thresholds are statistical criteria, and there is always some slippage. The possibility that even a few people had extensive loss above 2000 Hz (which is presently permissible according to Federal guideline) should be taken into consideration when decisions about the construction of noise-producing structures are being made.

Discussion of Current Results. -- Before looking at what our data indicate, we need to point out that the manipulation worked well in every case. That is, in every component of the study subjects who were in the induced-sound condition perceived that their environment was high in ambient sound. These manipulation checks, too frequently omitted in psychological research, are a necessary basis for the interpretation of the other data.

Another interesting point is the necessity for baseline or control data. It is obvious in the field experiment, for example, that the M group was different from the other two even before any manipulation took place. They had better baseline scores on both cognitive tasks, achieved almost immediate cooperative lock-in in the Prisoner's Dilemma Game, etc. Such differences may very well have been ascribed to the manipulation had there been data collection only under experimental conditions. As it is, they are apparently due to pre-existing differences in personality, intelligence, motivation, and/or some other unmeasured but obviously important organismic variable.

The major innovative step in this study was the inclusion of measures of social interaction, and the data fully supported the importance of such measures. Induced sound significantly affected performance in group discussion, with the H group spending more time in discussion, making more statements per unit of time, expressing disagreement rather than agreement, showing tension and asking other people for opinions more often, and resorting to irrelevant dramatization more. In the Prisoner's Dilemma game, H subjects were more forgiving of their opponents' breach of cooperative precedents. In the classroom, high sound levels led to less classroom participation and less attention to classroom proceedings, with trends away from discussion and toward lecturing, and toward less asking for opinions.

What do these differences imply? There seems to have been heightened negative affect in the sound conditions, leading to significant deterioration of the relatively unstructured and long-lasting performances which involve group behavior. The increased time spent in discussion and increased speech rate may be due to the difficulty of transmitting information clearly over the speech masking noise of the experimental sound; note that in class, where discussion is desirable (and was used when the room was normal in ambient sound), the option of turning to lecture was taken when -- as the raters and questionnaires indicated -- student and instructor comments became less audible. This was difficult to do in the group discussion task, whose explicit goal was participation and development of a group consensus.

With this increase in difficulty, subjects began to express displeasure and to withdraw concentration from the task at hand. Disagreements, tension, uncertainty (as shown by asking for opinions) and withdrawal into

dramatization characterized behavior in the discussion situation, while in the classroom there was less attention to the class, less seriousness, and less efficient note-taking. There was also significantly less student enjoyment of class, with a corresponding unwillingness for M students to prolong their participation in the study. While we cannot identify the reason for the increased forgivingness of H subjects in the Prisoner's Dilemma, we can speculate that at least a possible factor was the perception of unpleasant experiences suffered together. While prolonged participation of the study in itself led to reduced AACL positive affect, negative emotional consequences were obviously caused by the experimental sound.

Other significant negative effects were indicated on the final field experiment questionnaire. When subjects rated how their experimental milieu had affected their sleep, studying, social relations, general mood, conversation, concentration, judgment, alertness, and nervousness, the H group reported significantly more adverse changes than did the M group, which itself reported more than the controls. The H group, unlike the other two, also experienced a progressive decrease in energy level over the course of the study.

Emotional reactions to the sound itself were uniformly, strongly, and sometimes violently negative. Subjects reported that they and their fellow students were bothered by it both in class and in the dormitory, and that it led to less enjoyment of class and to less desire to participate in the study. Spontaneous comments and both threatened and actual vandalism supported these data. Group action against such sound levels, either of the sort discussed by Kryter (1970) and in the previous section, or more direct ones cannot be ruled out if the actual environment imposes this magnitude

of noise on the student population.

On the more traditional measures the effects were much less dramatic. Brief tests of cognitive performance and other indices related to arousal, showed no reliable effects of induced sound. Contrary to some theoretical predictions, sound did not raise general arousal level, either as measured by heart rate or as inferable from improvements on simple cognitive tasks and decrements on complex ones (Hull, 1955; Spence, 1956). The only exception was the higher rate of output in group discussion among H and M subjects.

These findings relate in interesting ways to other reports of environmental effects on arousal. For example, both Freedman et al. (1971) and Epstein (1972) failed to find predicted arousal effects of crowding; Zajonc (1965) and others have found that under some, but not all, conditions the presence of conspecifics has arousal consequences, and there is a considerable body of evidence that a low-stimulation environment has the same effects (Suedfeld, 1969).

What this seems to mean is that the activating impact of environmental parameters is not a very reliable phenomenon. Presumably, the intensity of the variable levels employed interacts with both the task and with personality variables to determine the outcome: as long as the chosen level of the parameter is not overwhelming, a significant number of subjects may be able to concentrate on some tasks sufficiently to screen out its effects. It should be noted that group results mask individual differences; a subject-by-subject examination of the data might identify students who in fact were highly aroused by the experimental manipulation, and for whom even the medium sound level may be psychologically harmful.

Also, if the cognitive tasks used had been longer in duration, so that intense concentration could not be maintained and fatigue or boredom began to set in (as is the case in many real school-connected assignments), a more obvious effect on intellectual performance might have been found. It is relevant here that the classroom observer and student questionnaire responses indicated such results as lessened attention in class, reduced note-taking, etc., supporting this hypothesis, and that in group discussion H and M subjects gave more irrelevant statements (dramatizations).

It is clear that more research needs to be done in this area, utilizing considerably more time both in planning and in execution. The inclusion of personality measures and of a greater variety of physiological dependent variables, the use of more types of cognitive tests, the extension of experimental sessions to several weeks, and especially the collection of data from more representative samples of impacted populations, would all help to test more definitively the results of this research. What does seem sufficiently clear from our data is that increased sound levels from highway traffic do have some significant and reliable adverse affects on the daily lives of people living and working nearby, and that planners and decision-makers involved in projects which would increase such sound levels would do well to predict and minimize these effects along their particular routes.

Recommendations. -- In view of the various undesirable effects of highway-generated sound discussed in this report, the following recommendations are tendered:

1. That alternative routes for the extension of State Highway 18 be given serious consideration to determine which will afflict the fewest people with sound levels outside their maximum tolerance levels, or will route traffic past the best sound-resistant environments.
2. That every effort be made to minimize the undesirable sound levels (as well as other factors) associated with the extension. Decks built over the highway supposedly reduce sound levels by as much as 20 dB(A). For people indoors this would result in levels only slightly over the maximum tolerable limits suggested by Kryter (1970), as opposed to levels grossly over these limits.
3. That both University and non-University groups in the vicinity of the proposed highway route be fully informed of the predictable effects of the extension, of the necessity for taking the steps which might have adverse effects, and of the attempts being made to minimize such effects, and that members of such groups be invited and urged to make inputs into the decisions to be made beginning as early during planning as possible. Such a procedure may identify problems not covered by the present study, suggest new and improved solutions, and reduce the level of hostility toward what may appear to be arbitrary decisions imposed by external authorities on uninformed and unconsulted victims.
4. That future environmental impact studies include, as an integral component, studies of the effects of the proposed environmental

changes on human behavior, and that this component be planned, financed, and designed as thoroughly as those dealing with traffic, ecological, economic, and other effects.

SUMMARY

Studies were made of some psychological and behavioral effects of the proposed extension of a major highway near the Rutgers University Campus, using the expected increased levels of ambient traffic sound as the major independent variable. On self-reports, observation of classroom behavior, and in data collected during a five-day dormitory field experiment, increased ambient sound produced a set of reliable, generally adverse, effects. These were particularly evident in situations involving social interaction for group problem-solving, in the classroom teaching-learning process, and in the expression of strong negative affect by students subjected to the induced sound. No reliable changes were found in pulse rate nor on individual cognitive performance in brief tests. In addition, a brief review was made of other published studies in this area, and effects of high sound levels such as speech masking, permanent hearing loss, and distraction and arousal were discussed in the light of the sound levels expected from the proposed extension of Rt. 18.

Extension of the highway as proposed can be predicted both to have undesirable effects on the campus milieu and to evoke strong protests from students upon whom the increased noise impinges. Plans should be formulated with the goal of minimizing the impact of the highway on the surrounding population, and attempts should be made to inform impacted groups of the expected results, attempts at amelioration, etc.

The study demonstrates the need for careful, long-duration, multi-variable psychological research as a part of environmental impact predictions of major construction projects.

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Woodhead, M.M. Effects of brief loud noise on decision making. Journal of the Acoustical Society of America, 1959, 31, 1329-1331.

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APPENDICES

APPENDIX A

CURRICULUM VITAE

NAME: Peter Suedfeld

DATE OF BIRTH: August 30, 1935

ADDRESS: Department of Psychology
University College
Rutgers - The State University
New Brunswick, New Jersey 08903

TELEPHONE: (201) 247-1766, Ext. 6292

EDUCATION: B.A., Queens College (New York), 1960
M.A., Princeton University, 1962
Ph.D., Princeton University, 1963

HONORS: Fellow, Amer. Psychological Assoc.; Member, Society of Experimental
Social Psychology; Phi Beta Kappa; Sigma Xi; Psi Chi.

PROFESSIONAL SOCIETIES: Amer. Psychological Assoc. (Div. 3, 8, & 9); Psychonomic
Soc.; Eastern Psychol. Assoc.; Amer. Assoc. for the
Advancement of Science; Amer. Assoc. of University
Professors.

EMPLOYMENT: Research Associate, Princeton University, 1963-64.
Lecturer, Trenton State College, 1963-64.
Visiting Assistant Professor, University of Illinois (Urbana), 1964-65.
Assistant Professor, 1965-67; Associate Professor and Chairman, 1967-71;
Professor and Chairman, 1971-72; Department of Psychology, University
College, Rutgers University, The State University of New Jersey.
Professor and Head, Department of Psychology, University of British
Columbia, 1972-

EDITORIAL AND REVIEWING ACTIVITIES:

Member, Editorial Board, J. Applied Social Psychol.
Editorial Consultant

Books: Wm. C. Brown Co.

Articles: J. Personality & Social Psychol.; J. Exper. Social
Psychol.; Science; J. Exper. Research in Personality;
Canad. J. Psychol.

Book Reviews in: Amer. Scientist; Amer. J. Ment. Def.; Science Books;
Behavior Therapy.

Grant Proposals Reviewed: Nat'l Science Foundation; Nat'l Defence
Research Board (Canada).

PUBLICATIONS:

A. Books

Schroder, H. M. & Suedfeld, P. (Eds.) Personality Theory and Information Processing. N.Y.: Ronald Press, 1971.

Suedfeld, P. (Ed.) Attitude Change: The Competing Views. Chicago: Aldine-Atherton, 1971.

B. Sections and Chapters

Suedfeld, P. Social processes. Dubuque, Io.: Wm. C. Brown Co., 1966. (Revised ed. in preparation). (Reprinted in F. Cox, Psychology. Dubuque: Wm. C. Brown Co., 1970.)

Suedfeld, P. Models of attitude change: Theories that pass in the night. In Suedfeld, 1971, above, pp. 1-62.

Koslin, B. L., Pargament, R., & Suedfeld, P. An uncertainty model of opinion change. In Suedfeld, 1971, above, pp. 234-253.

Suedfeld, P. Information processing as a personality variable. In Schroder & Suedfeld, 1971, above, pp. 3-14.

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Suedfeld, P. Theories of sensory deprivation: II. In Zubek, op. cit. Pp. 433-448.

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C. Journal Articles

- Grissom, R. J., Suedfeld, P., & Vernon, J. Memory for verbal material: Effects of sensory deprivation. Science, 1962, 138, 429-430.
- Suedfeld, P. Birth order of volunteers for sensory deprivation. J. Abnormal & Social Psychol., 1964, 68, 195-196.
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C. Journal Articles continued

- Suedfeld, P. Paternal absence and overseas success of Peace Corps Volunteers. J. Consulting Psychol., 1967, 31, 424-425.
- Suedfeld, P. & Goeller, N. The effect of motivational arousal on information processing in the convergent word identification task. Psychonomic Science, 1967, 9, 231-232.
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- Suedfeld, P. Sensory deprivation stress: Birth order and instructional set as interacting variables. J. Personality & Social Psychol., 1969, 11, 70-74.
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- Landon, P. B. & Suedfeld, P. Information and meaningfulness needs in sensory deprivation. Psychonomic Science, 1969, 17, 248.
- Suedfeld, P. & Landon, P. B. Motivational arousal and task complexity: Support for a model of cognitive changes in sensory deprivation. J. Experimental Psychol., 1970, 83, 329-330.
- Suedfeld, P. & Epstein, Y. M. The egghead and "i": A look at the professorial personality. Worm Runner's Digest, 1970, 12, 138-140. (Reprinted in J. V. McConnell & M. Schutjer, Eds., Science, Sex, and Sacred Cows. N.Y.: Harcourt Brace, Jovanovich, 1971.)
- Suedfeld, P., Landon, P. B., Epstein, Y. M., & Pargament, R. The role of experimenter and subject expectations in sensory deprivation. Representative Research in Social Psychology, 1971, 2, 21-27.

C. Journal Articles continued

- Lore, R. K., Blanc, A., & Suedfeld, P. Empathic learning of a passive-avoidance response in domesticated Rattus norvegicus. Animal Behaviour, 1971, 19, 112-114.
- Suedfeld, P., & Epstein, Y. M. Where is the "D" in dissonance? J. Personality, 1971, 39, 178-188.
- Epstein, Y. M., Suedfeld, P., & Bresnahan, D. Reactions to a campus confrontation. J. Applied Social Psychology, 1971, 1, 57-66.
- Suedfeld, P., Epstein, Y. M., & Buchanan, E. The effects of set on the "effects of mere exposure." J. Personality & Social Psychology, 1971, 17, 121-123.
- Suedfeld, P. Evanescence of sensory deprivation effects: A comment on Oleson and Zubek's "Effect of one day of sensory deprivation...." Perceptual & Motor Skills, 1971, 33, 753-754.
- Suedfeld, P., Landon, P. B., Pargament, R., & Epstein, Y. M. An experimental attack on smoking. (Attitude manipulation in restricted environments, III.) Int'l. J. of the Addictions, in press.
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- Suedfeld, P., Bochner, S., & Matas, C. Petitioner's attire and petition signing by peace demonstrators: A field experiment on reference group similarity. J. Applied Social Psychol., 1971, 1, 278-283.
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- Suedfeld, P. The psychiatric relevance of sensory deprivation: A selective review. Comments on Contemporary Psychiatry, in press.

D. Participation at Meetings**I. Papers Read at International Meetings:**

Suedfeld, P. Isolation, confinement, and sensory deprivation. Invited symposium paper, International Summer Institute on Biology in Space, Cambridge University, 1967.

Suedfeld, P. Sensory deprivation as a cognitive disorganizer: Implications for clinical psychology. Invited symposium paper, XIIIth. Interamerican Congress of Psychology, Panama, 1971.

Suedfeld, P. Attitude manipulation in restricted environments: V. Theory and research. Invited symposium paper, XXth. International Congress of Psychology, Tokyo, 1972.

II. Other Papers:

Suedfeld, P. The effects of sensory deprivation and social isolation on the performance of an unstructured cognitive task. EPA, 1963.

Suedfeld, P., Vernon, J., & Goldstein, K. M. The relationship between sensory deprivation stress and lowered activation level. EPA, 1964.

Suedfeld, P. Toward greater specificity in evaluating cognitive and attitudinal change. Symposium paper, APA, 1964.

Suedfeld, P. Activation level as a mediating construct in sensory deprivation research. Symposium paper, NYSPA, 1966.

Suedfeld, P. The delectable "D" and the ubiquitous "U." Symposium paper, NASA Conference on Arousal, University of Vermont, 1969.

Suedfeld, P. & Epstein, Y. M. "Mere exposure"--plus set. Symposium paper, APA, 1970.

III. Other Participation:

Chairman, Symposium on: "The contribution of psychologists in the Peace Corps: Assessment and selection." NJPA, Spring 1966.

Participant, Symposium on: "The effects of confinement on long duration manned space flight." NASA, 1966.

Chairman, Symposium on: "Personality theory in vivo: Field research in conceptual structure." EPA, 1967.

Chairman, Paper session on: "Social perception." EPA, 1968.

D. Participation at Meetings continued

III. Other Participation continued

Member, Subcommittee on paper selection, EPA, 1969.

Chairman, Workshop on: "Current developments in psychological research." NJPA, 1969.

Discussant, Symposium on: "Teacher selection, teacher training, and teaching methods in overseas service." APA, 1969.

Moderator-discussant, paper session on "Cognitive complexity" APA, 1970.

E. Other Professional Activities

Consultant, Peace Corps, 1965-67

Consultant, Drake-Beam & Assoc., 1966-

Consultant, Riverside Research Institute, 1969-1971.

Chairman, Committee on Academic & Scientific Affairs, N. J. Psychol. Assoc., 1968-70.

Co-Director, Study on Human Responses to Highway Noise (Route 18 Extension Environmental Impact Study), King & Gavaris, Consulting Engineers, 1972.

CURRICULUM VITAE

- Name:** Lawrence McCue Ward
- Personal:** Born December 11, 1944; Canton Ohio
Married, no children
- Education:** A.B. Cum Laude in Social Relations, Harvard University, 1966
Ph. D. Experimental Psychology, Duke University, 1971
- Awards
& Honors:** Harvard College Scholarship
National Science Foundation Award for undergraduate research
Nominated for Woodrow Wilson Fellowship
USPHS Trainee in Social Psychology, Duke University, 1966-68
USPHS Predoctoral Research Fellow, 1968-70
Phi Beta Kappa
- Professional
Societies:** American Association for the Advancement of Science
American Psychological Association
Psychonomic Society
Classification Society
Psychometric Society
Sigma Xi
American Association of University Professors
- Present
Position:** Assistant Professor of Psychology, Livingston College,
Rutgers University
- Courses
Taught:** At Duke University:
Tutorial Seminar in Intergroup Relations
Tutorial Seminar in Sensation and Perception
At Livingston College, Rutgers University:
Human Experimental Psychology (Lab course in sensation,
perception, and cognition)
Statistics
Perception (Interdisciplinary seminar with an artist,
a philosopher, and a geographer)
Graduate proseminar in Perception and Psychophysics
- Additional
Experience:** Extensive work in multidimensional scaling at Duke University;
Theory, practice, and realization of the various
algorithms in computer programs
National Science Foundation Summer Institute in Computer Science
in Social and Behavioral Science Research, University of
Colorado, Summer, 1971
- Research
Grants:** Rutgers Research Council Grant (1971-72) for research in
environmental perception and signal detection theory
Co-investigator on a grant from the New Jersey Agricultural
Station (1971-73) to study processes of adjustment to
the natural environment among in-migrant populations

Research
Grants
cont'd:

Rutgers Summer Research Fellowship (1972) for research in the psychophysical properties of cross-modality matching data
Co-director on a grant to study human responses to highway noise, part of the environmental impact study prepared by King and Gavaris, Consulting Engineers, for the proposed Route 18 Extension in New Brunswick, N.J.

Publications
and papers:

Jones, E.E., Rock, L., Shaver, K.G., Goethals, G.R., and Ward, L.M. Pattern of performance and ability attribution: An unexpected primacy effect. Journal of Personality and Social Psychology, 1968, 10, 317-340.

Ward, L.M. and Lockhead, G.R. Memorial processes and category judgments. Presented at the meeting of the Psychonomic Society, November, 1969.

Ward, L.M. and Lockhead, G.R. Sequential effects and memory in category judgments. Journal of Experimental Psychology, 1970, 84, 27-34.

Ward, L.M. and Lockhead, G.R. Response system processes in absolute judgment. Perception and Psychophysics, 1971, 9, 73-78.

Ward, L.M. Category judgments of loudnesses in the absence of an experimenter-induced identification function: Sequential effects and power function fit. Journal of Experimental Psychology, 1972, in press.

Papers in
Preparation:

Ward, D.V. and Ward, L.M. Biological magnification: A quantitative formulation.

Ward, L.M. Sequential effects and other properties of magnitude estimations of loudnesses.

Atkinson, W.H. and Ward, L.M. On the internal consistency of magnitude estimations.

Ward, L.M. and Lockhead, G.R. Reciprocal inhibition and the influence of remote contours in binocular rivalry.

Ward, L.M. The influence of information in finite Markov sequences on numerical signal detection.

Suedfeld, P. and Ward, L.M. Human responses to highway noise.

Wexler, D. and Ward, L.M. An information processing model for defense.

Research in
Progress:

1. Psychophysical properties of cross-modality matching data, and data collected by other psychophysical methods.
2. A number of experiments on the perception of the molar physical environment, indices of environmental satisfaction, and theories of migration, using multidimensional scaling and factor analysis techniques.
3. A series of studies of the pre-attentive processes in visual scanning, investigating the stages of information processing therein. (With D. Wexler)
4. Experiments and theoretical work on the sleep-wakefulness cycle; the effect of changes in relative surface temperature of different body areas on sleep induction. (With S. Tomkins)

References:

Dr. Gregory R. Lockhead
Dr. Edward E. Jones
Dr. Norman Guttman
Dr. Harold Schiffman

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Vita

Name: Landon, Philip Bruce

Address: 1124 Myrtle Av.
Plainfield, N. J.

Place of Birth: Boise, Idaho

Date of Birth: April 25, 1946

Phone: Home - 201-755-0478
Rutgers - 247-1766
X 6292
Office 201-463-6485

Marital Status: Married

<u>Degrees:</u>	<u>Degree</u>	<u>Field</u>	<u>Date</u>	<u>Institution</u>
	Honors B.S.	Psychology	June, 1967	University of Utah
	M.S.	Psychology	June, 1969	Rutgers - The State U.
	Ph.D.	Psychology	January, 1972	Rutgers - The State U.

Academic Experience:

1971-72	Co-adjutant Instructor, (Introductory Psychology) University College, Rutgers - The State University.
1972	Co-adjutant Instructor, (Tests and Measurement) University College, Rutgers - The State University.
1971	Co-adjutant Instructor, (Elementary Statistics) University College, Rutgers - The State University.
1971	Co-adjutant Instructor, (Tests and Measurement) University College, Rutgers - The State University.
1970	Co-adjutant Instructor, (Elementary Statistics) University College, Rutgers - The State University.
1969-70	N.I.M.H. Predoctoral Fellow, under the direction of Peter Suedfeld, Rutgers - The State University.
1969	Co-adjutant Instructor, (Introductory Psychology) University College, Rutgers - The State University.
1968-69	Teaching Assistant for University College Psychology Department, Rutgers - The State University.
1968	Research Assistant, under the direction of Peter Suedfeld, Rutgers - The State University.

- 1967 Research Assistant, (Urban Renewal Project interviewing) for the City of New Brunswick, New Jersey.
- 1967 N.S.F. Undergraduate Research Fellow, under the direction of B. Jack White, University of Utah.
- 1967 Research Assistant in selection test development for Peace Corps for Iran Training Project, Clearfield, Utah.
- 1967 Research Assistant in measurement of human relations skills for Clearfield Job Corps Institute, Clearfield Utah.
- 1967 Research Assistant for Esso Creativity in Engineering Project under the direction of Al Wight, University of Utah.
- 1966 Research Assistant under the direction of B. Jack White, University of Utah.
- 1966 Research Assistant under the direction of Larry Reid, University of Utah.

Publications:

- Landon, P. B. & Suedfeld, P. Complex cognitive performance and sensory deprivation: Completing the U-curve. Perceptual and Motor Skills, in press.
- Suedfeld, P., Landon, P. B., Pargament, R., & Epstein, Y. M. An experimental attack on smoking. (Attitude manipulation in restricted environments, III.) Intl. J. of the Addictions, in press.
- Suedfeld, P., Landon, P. B., Epstein, Y. M., & Pargament, R. The role of experimenter and subject expectations in sensory deprivation. Representative Research in Social Psychology, 1971, 2 21-27.
- Suedfeld, P., Epstein, Y. M., Buchanan, E., & Landon, P. B. The effects of set on mere exposure. Journal of Personality and Social Psychology, 1971, 17 121-123.
- Suedfeld, P., & Landon, P. B. Motivational arousal and task complexity: support for a model of cognitive changes in sensory deprivation. Journal of Experimental Psychology, 1970 83 329-330.
- Landon, P. B., & Suedfeld, P. Information and meaningfulness needs in sensory deprivation. Psychonomic Science, 1969, 5 (4) 248.

Papers in Preparation:

Landon, P. B. Experimenter bias in sensory deprivation research?

Landon, P. B., & Suedfeld, P. Response bias and the complexity-arousal relationship, a hypothesis.

Nonacademic Employment:

Research Psychologist, Bell Telephone Laboratories, 1970-72

Research Specialist, Riverside Research Institute, 1972-

APPENDIX B

CLASSROOM BEHAVIOR RATING FORM

Rater _____

Class Title _____

Room _____

Building _____

Date _____

Nominal Starting Time _____

Attendance _____

Time Class Called to Order _____

CLASSROOM BEHAVIOR RATING FORM

SEGMENT _____

1. Participation occurrences

2. Interaction category checklist:

Agrees -----

Disagrees -----

Gives information -----

Asks for information --

Shows Tension -----

Gives opinion -----

Asks for opinion -----

Dramatizes -----

15 Minute Summaries

1) Level of private conversations

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

2) Level of note taking

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

3) Attention to class proceedings

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

4) Nature of class

/ / / / / / / /
Lecture 1 2 3 4 5 6 7 Discussion

5) Audibility of teacher's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

6) Audibility of student's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

7) Adequacy of classroom lighting

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

8) General level of noise in classroom (all sources)

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

9) Level of student enjoyment of class

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

10) General affective tone of class

/ / / / / / / /
Serious 1 2 3 4 5 6 7 Frivolous

CLASSROOM BEHAVIOR RATING FORM

SEGMENT _____

1. Participation occurrences

2. Interaction category checklist:

- Agrees -----
- Disagrees -----
- Gives information -----
- Asks for information --
- Shows Tension -----
- Gives opinion -----
- Asks for opinion -----
- Dramatizes -----

15 Minute Summaries

1) Level of private conversations

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

2) Level of note taking

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

3) Attention to class proceedings

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

4) Nature of class

/ / / / / / / /
Lecture 1 2 3 4 5 6 7 Discussion

5) Audibility of teacher's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

6) Audibility of student's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

7) Adequacy of classroom lighting

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

8) General level of noise in classroom (all sources)

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

9) Level of student enjoyment of class

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

10) General affective tone of class

/ / / / / / / /
Serious 1 2 3 4 5 6 7 Frivolous

CLASSROOM BEHAVIOR RATING FORM

SEGMENT _____

1. Participation occurrences

2. Interaction category checklist:

Agrees -----

Disagrees -----

Gives information -----

Asks for information --

Shows Tension -----

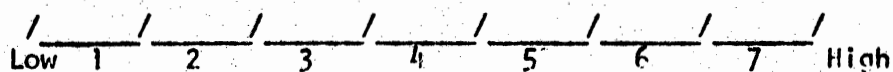
Gives opinion -----

Asks for opinion -----

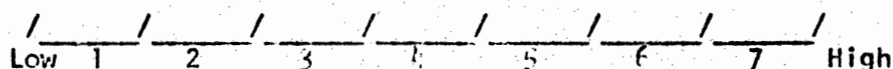
Dramatizes -----

15 Minute Summaries

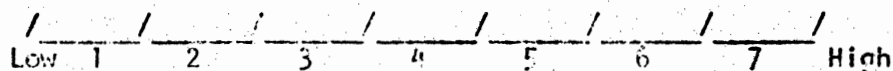
1) Level of private conversations



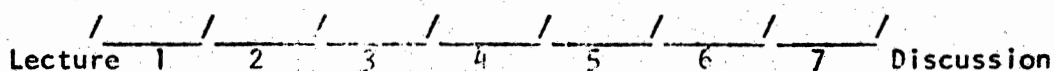
2) Level of note taking



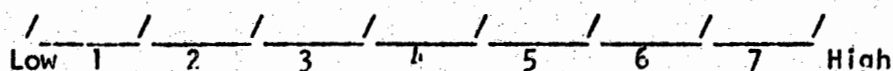
3) Attention to class proceedings



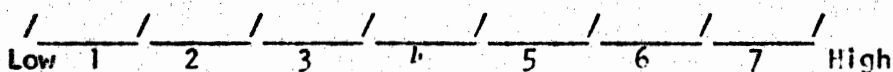
4) Nature of class



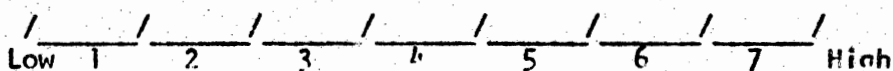
5) Audibility of teacher's contributions



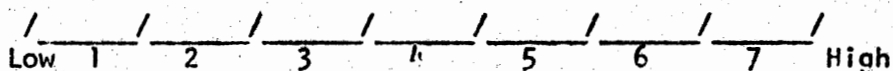
6) Audibility of student's contributions



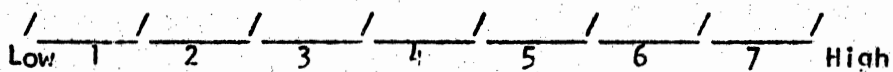
7) Adequacy of classroom lighting



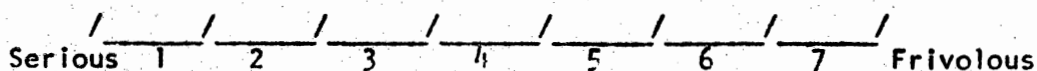
8) General level of noise in classroom (all sources)



9) Level of student enjoyment of class



10) General affective tone of class



CLASSROOM BEHAVIOR RATING FORM

SEGMENT _____

1. Participation occurrences

2. Interaction category checklist:

Agrees -----

Disagrees -----

Gives information -----

Asks for information --

Shows Tension -----

Gives opinion -----

Asks for opinion -----

Dramatizes -----

15 Minute Summaries

1) Level of private conversations

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

2) Level of note taking

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

3) Attention to class proceedings

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

4) Nature of class

/ / / / / / / /
Lecture 1 2 3 4 5 6 7 Discussion

5) Audibility of teacher's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

6) Audibility of student's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

7) Adequacy of classroom lighting

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

8) General level of noise in classroom (all sources)

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

9) Level of student enjoyment of class

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

10) General affective tone of class

/ / / / / / / /
Serious 1 2 3 4 5 6 7 Frivolous

CLASSROOM BEHAVIOR RATING FORM

SEGMENT _____

1. Participation occurrences

5

2. Interaction category checklist:

- Agrees -----
- Disagrees -----
- Gives information -----
- Asks for information --
- Shows Tension -----
- Gives opinion -----
- Asks for opinion -----
- Dramatizes -----

15 Minute Summaries

1) Level of private conversations

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

2) Level of note taking

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

3) Attention to class proceedings

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

4) Nature of class

/ / / / / / / /
Lecture 1 2 3 4 5 6 7 Discussion

5) Audibility of teacher's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

6) Audibility of student's contributions

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

7) Adequacy of classroom lighting

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

8) General level of noise in classroom (all sources)

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

9) Level of student enjoyment of class

/ / / / / / / /
Low 1 2 3 4 5 6 7 High

10) General affective tone of class

/ / / / / / / /
Serious 1 2 3 4 5 6 7 Frivolous

NOISE POLLUTION

We would like you to compare today's class session with the usual session of this course. On each scale, indicate your reactions today with a "T" and your usual reaction with a "U".

- 1) Efficiency of note-taking.

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 2) Attention to class proceedings.

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 3) Nature of class.

Lecture / 1 / 2 / 3 / 4 / 5 / 6 / 7 Discussion

- 4) Audibility of teacher's contributions.

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 5) Audibility of student's contributions.

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 6) General level of noise in classroom (all sources)

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 7) Level of general student enjoyment of class.

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 8) Level of your own enjoyment of class

Low / 1 / 2 / 3 / 4 / 5 / 6 / 7 High

- 9) General affective tone of class.

Serious / 1 / 2 / 3 / 4 / 5 / 6 / 7 Frivolous

- 10) Do you have any other comments?

APPENDIX D

MYS-TE-RI-OUS *adj.* Involved in or implying mystery; unexplained; obscure. — **-LY** *adv.* — **-NESS** *noun.*
Synonyms: abstruse, cabalistic, dark, enigmatic, hidden, incomprehensible, inexplicable, inscrutable, mystic, mystical, obscure, occult, recondite, secret, transcendental, unfathomable, untathomed, unknown. That is *mysterious* in the true sense which is beyond human comprehension; that is *mystic* or *mystical* which has associated with it some *hidden* or *recondite* meaning, especially of a religious kind. That is *dark* which we cannot personally see through, especially if sadly perplexing; as, a *dark* prospect. That is *secret* which is intentionally *hidden*. See **DARK**, **SECRET**. *Antonyms:* see *SYNONYMS* for **CLEAR**.

3

APPENDIX E

The standardized educational or psychological tests, that are widely used to aid in selecting, classifying, assigning, or promoting students, employees, and military personnel have been the target of recent attacks in books, magazines, the daily press, and even in Congress. The target is wrong, for in attacking the tests, critics divert attention from the fault that lies with ill-informed or incompetent users. The tests themselves are merely tools, with characteristics that can be measured with reasonable precision under specified conditions. Whether the results will be valuable, meaningless, or even misleading depends partly upon the tool itself but largely upon the user.

All informed predictions of future performance are based upon some knowledge of relevant past performance: school grades, research productivity, sales records, batting averages, or whatever is appropriate. How well the predictions will be validated by later performance depends upon the amount, reliability, and appropriateness of the information used and on the skill and wisdom with which it is interpreted. Anyone who keeps careful score knows that the information available is

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always incomplete and that the predictions are always subject to error.

Standardized tests should be considered in this context. They provide a quick, objective method of getting some kinds of information about what a person has learned, the skills he has developed, or the kind of person he is. The information so obtained has, qualitatively, the same advantages and shortcomings as other kinds of information. Whether to use tests, other kinds of information, or both in a particular situation depends, therefore, upon the empirical evidence concerning comparative validity, and upon such factors as cost and availability.

In general, the tests work most effectively when the traits or qualities to be measured can be most precisely defined (for example, ability to do well in a particular course or training program) and least effectively when what is to be measured or predicted cannot be well defined (for example, personality or creativity). Properly used, they provide a rapid means of getting comparable information about many people. Sometimes they identify students whose high potential has not

been previously recognized. But there are many things they do not do. For example, they do not compensate for gross social inequality; and thus do not tell how able an underprivileged youngster might have been had he grown up under more favorable circumstances.

Professionals in the business and the conscientious publishers know the limitations as well as the values. They write these things into test manuals and in critiques of available tests. But they have no jurisdiction over users; an educational test can be administered by almost anyone, whether he knows how to interpret it or not. Nor can the difficulty be controlled by limiting sales to qualified users; some attempts to do so have been countered by restraint-of-trade suits.

In the long run it may be possible to establish better controls or to require higher qualifications. But in the meantime, unhappily, the demonstrated value of these tests under many circumstances has given them a popularity that has led to considerable misuse. Also unhappily, justifiable criticism of the misuse now threatens to hamper proper use. Business and government can probably look after themselves. But school guidance and selection programs are being attacked for using a valuable tool, because some of the users are unskilled.

—by *Watson Davis, Sc.D.*, Director of Science Service
(reprinted with permission)

1. The essence of this article on educational tests is:
 - (A) These tests do not test adequately what they set out to test.
 - (B) Don't blame the test—blame the user.
 - (C) When a student is nervous or ill, the test results are inaccurate.
 - (D) Publishers of tests are without conscience.
 - (E) Educators are gradually losing confidence in the value of the tests.
2. Tests like the College Entrance Scholastic Aptitude Test are, it would seem to the author,
 - (A) generally unreliable
 - (B) generally reliable
 - (C) meaningless
 - (D) misleading
 - (E) neither good nor bad.
3. The selection implies that, more often, the value of an educational test rests with
 - (A) the interpretation of results
 - (B) the test itself
 - (C) the testee
 - (D) emotional considerations
 - (E) the directions.

4. Which statement is not true, according to the passage, about educational tests?
 - (A) Some students "shine" unexpectedly
 - (B) Predictions do not always hold true
 - (C) Personality tests often fail to measure the true personality
 - (D) The supervisor of the test must be very well trained
 - (E) Publishers cannot confine sales to highly skilled administrators.
5. The worthwhileness of a test requires, most of all,
 - (A) cooperation on the part of the person tested
 - (B) sufficient preparation on the part of the applicant
 - (C) clearcut directions
 - (D) one answer—and only one—for each question
 - (E) specificity regarding what is to be tested.

APPENDIX F

Write a brief story which includes all of the following:

DUCK ORANGE GOLD FLOWER SCREWDRIVER

APPENDIX G

MAC I

Darken in the appropriate space on the IBM answer sheet.

Key:

- 0 = not at all like me
- 1 = a little like me
- 2 = a lot like me
- 3 = extremely like me

61. Anxious

63. Relaxed

65. Uneasy

67. Annoyed

69. Ready to fight

71. Peeved

73. Full of Pep

75. Energetic

77. Blue

79. Hopeless

81. Unhappy

83. Cooperative

85. Happy

87. Weary

89. Tired

91. Confused

93. Uncertain about this

62. On Edge

64. Shaky

66. Rebellious

68. Furious

70. Spiteful

72. Alert

74. Vigorous

76. Unworthy

78. Discouraged

80. Miserable

82. Sorry for things done

84. Good-natured

86. Exhausted

88. Listless

90. Unable to Concentrate

92. Forgetful

Rater _____
Treat _____

Name

1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

IBEES

DISAGREES

GIVES INFO

ASKS INFO

SHOWS TENSION

GIVES OPINION

ASKS OPINION

DRAMATIZES

APPENDIX H

0-5 5-10 10-15 15-20 20-25 25-30

APPENDIX I

Payoff Matrix in Prisoner's Dilemma

		<u>Player B</u>	
		Cooperate	Compete
<u>Player A</u>	Cooperate	3/3	-5/5
	Compete	5/-5	-3/-3

APPENDIX J

NAME _____ PUT AN X IN THE APPROPRIATE BOX AFTER EACH QUESTION.

1. How did you like being in this study? / / / / / / / /
 Liked it 1 2 3 4 5 6 7 Disliked it
 a lot a lot

2. Did you spend about as much time in your room as you usually do?
 Spent much more time than usual / / / / / / / / Spent much less
 in my room 1 2 3 4 5 6 7 time than usual
 Same in my room

3. How noisy was your room during the study? / / / / / / / /
 Extremely quiet 1 2 3 4 5 6 7 Extremely noisy

4. How noisy is the room in which you usually live? / / / / / / / /
 Extremely quiet 1 2 3 4 5 6 7 Extremely noisy

5. Did the noise level in your room during the study bother you?
 Bothered me / / / / / / / / Didn't bother me
 very much 1 2 3 4 5 6 7 at all

6. Does the noise level in which you normally live bother you?
 Bothers me / / / / / / / / Doesn't bother
 very much 1 2 3 4 5 6 7 me at all

7. Which, if any, of the activities listed below were affected by the noise level during the study? Put a + next to those activities which were improved, a - next to those which got worse, and a 0 next to those which were not affected by the noise level.

- a. Sleep _____
- b. Studying _____
- c. Social relationships _____
- d. General mood _____
- e. Conversation _____
- f. Ability to concentrate _____
- g. Good judgment _____
- h. Alertness _____
- i. ~~Nervousness~~ Nervousness _____

8. Would you be willing to participate in this study for another week under the same conditions?
 / / / / / / / /
 Certainly 1 2 3 4 5 6 7 Certainly NOT
 Not sure

9. COMMENTS about the study, form, discussions, joint game, etc.

