OFFICE WORKER PERFORMANCE AND SATISFACTION:

THE EFFECTS OF OFFICE NOISE AND

INDIVIDUAL CHARACTERISTICS

by

CHEUK FAN NG
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to the required standard

[redacted]

Dr. Robert Gifford

[redacted]

Dr. Ronald Hoppe

[redacted]

Dr. Lorne Rosenblood

[redacted]

Dr. Douglas Porteous

[redacted]

Dr. Bart Cunningham

[redacted]

Dr. Bruce Dunn, Department of Psychology, U. of Calgary.

UNIVERSITY OF VICTORIA

Supervisor: Professor Robert D. Gifford

ABSTRACT

The effects of office noise on employees' satisfaction and performance are investigated in three studies, with attention given to individuals' characteristics that may modify these effects.

128 office workers completed questionnaires about themselves, their jobs, the physical features of and the perceptions of their offices. The information was used to test a causal model of employees' response to the work environment.

To most respondents, particularly those in open-plan offices, their offices were too noisy and not private enough. They were distracted from work, had difficulty hearing others, and were irritated by noise. Noises made by office machines and telephones, and co-workers' conversations were distracting.

The results of a path analysis were that job level affected office openness directly, office openness affected both aural distraction and conversational privacy directly, which in turn affected overall privacy. Finally, overall privacy affected satisfaction with the environment directly. Females and younger employees had less conversational privacy. Females also had more aural distractions.

Unfortunately, the hypothesized model was rejected. There may be direct effects of (1) aural distraction on satisfaction, (2) job level on aural distraction, and (3) aural distraction on conversational privacy.

Coworkers' conversations are a prime noise source, but their effects on office task performance have rarely been examined. In Experiment 1, the hypotheses that background conversations impaired performance, and that screeners performed better than non-screeners in the presence of irrelevant information and especially in high information rate settings are tested.

A between-subjects factorial design (information rate, information relevance, stimulus screening) with a single control group was used. Sixty-one clerks performed simulated office tasks for 30-45 minutes. Subjects in the experimental groups heard a tape recording of a conversation. The conversations differed in information rate and information relevance. Subjects' stimulus screening abilities were measured with Mehrabian's Scale. The speed and the accuracy of each task were measured.

Background conversation did not lower the performance of the tasks. Spelling speed was lower when the information was irrelevant. Spelling accuracy was affected by information rate, information relevance, and stimulus screening in combination. As predicted, non-screeners

worked significantly more slowly overall and on spelling when irrelevant information was present. However, screeners were no faster than non-screeners in high information rate settings. Perhaps speech rate does not validly measure information rate. Consistent with previous findings, the background conversation made working less enjoyable and was fairly distracting.

Individual differences in noise response must be considered, and yet have received little attention. In Experiment 2, the hypotheses that individuals perform best at the most preferred sound level and that personality may modify such relationship were tested.

A within-subject repeated measures design was used. Twenty-eight data-entry operators' productivity (speed and accuracy) was measured in five one-hour sessions in which background office noise was presented at five levels. In the first session, each subject completed a sound sensitivity and an introversion-extraversion scale, and selected her most preferred sound level.

All subjects preferred the lower noise levels (48-56 dBA). Extraverts chose higher sound levels than did introverts. Only the operators with more extreme scores on the introversion-extraversion rating scale produced most at the most preferred sound level, as predicted. Noise-sensitive operators were clearly more accurate than were

less-sensitive operators.

Difficulty in recruiting office workers resulted in small samples. The use of single items as measures of some variables in the survey, questionable operationalization of information rate in Experiment 1, and the inability to reduce ambient noise to much lower levels in Experiment 2 pose some limitations to these findings.

Compared with many laboratory experiments in which meaningless noise, unfamiliar tasks, and unrealistically high noise levels are used, the experiments have greater external validity.

Exami[redacted]

Dr. Robert Gifford

[redacted]

Dr. Ronald Hoppe

[redacted]

Dr. Lorne Rosenblood

[redacted]

Dr. Douglas Porteous

[redacted]

Dr. Bart Cunningham

[redacted]

Dr. Bruce Dunn, Department of Psychology, U. of Calgary

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The purpose of this dissertation is to investigate issues in three areas of noise research in relation to the office environment: satisfaction-dissatisfaction, job performance, and individual differences in response to noise, and to integrate them by examining job performance as a function of sound level preference.

The office is the most common workplace in the 80s in North America. In Canada, 2.4 million employees (25% of the labor force) spend about 40 hours a week in their offices. Seventy-two percent of these employees (1.7 million) are clerical workers, and the rest hold managerial positions (see Table 1 in Braden, 1980).

Nevertheless, the internal physical environment of offices has been given little attention by researchers and is one of the most vaguely understood aspects of management (Davis, 1984). To date, we still know relatively little about what role physical settings play in organizations (Becker, 1981; Steele, 1973; Sundstrom & Sundstrom, 1986). The possible impacts that the physical characteristics of the office environment may have on employees' well-being and organizational effectiveness measures such as employee satisfaction, motivation, and productivity have not been adequately explored (Oldham & Brass, 1979). The studies to be reported focus on two of these outcomes: satisfaction with the workplace and job performance.

The physical environment of one particular type of office, the open-plan or landscaped office, has received a lot of attention though. In the last twenty years, researchers have investigated in a number of studies attitude changes after office workers have moved from conventional to open-plan offices. Evidence (e.g., Brookes & Kaplan, 1972; Hundert & Greenfield, 1969; Marans & Spreckelmeyer, 1981) suggests that most office workers prefer conventional private offices to open-plan designs.

One reason for such a preference has to do with noise in the office. Dissatisfaction seems to be more severe in open-plan offices, although other attitude surveys (for example, Louis Harris & Associates, 1978) show that office workers in general are fairly dissatisfied with noise in their work environments. Apparently, two major problems are distractions by noise and lack of conversational (or speech) privacy.

As for job performance, a considerable amount of research on the relation between noise and task performance has already been conducted in the laboratory since the 1950s. With a few exceptions, these studies have used unrealistically high noise levels (over 80 decibels), unfamiliar and meaningless sounds (e.g., pure tone and white noise), college students as subjects, and simple tasks (e.g., vigilance). Although research findings from these laboratory studies may have some relevance to understanding the impact of noise on office workers' productivity, it is more useful to examine how typical office noise at realistic levels affects performance of normal office activities. It is also crucial that some research is done in the real office where normal office productivity can be measured.

Most of the questionnaire surveys and laboratory experiments have ignored any effects of individual differences, yet some evidence suggests that people show great variability in their responses to noise (Bryan & Tolcher, 1976; Griffiths & Delauzun, 1977; Keighley, 1966). Some individuals seem to be more easily and severely disturbed by noise than others. Therefore, individual differences are considered in the studies to be reported.

Although the effects of noise on satisfaction-dissatisfaction and on task performance have been studied, they have been studied separately; an integration of these effects is lacking. One approach that has received very little attention is integrating satisfaction, task performance, and individual differences in response to noise by examining task performance as a function of an individual's sound preference. Zimring (1981) has suggested that a misfit between an individual's needs and attributes of the physical environment can result in stress. Thus, the importance of matching individuals' characteristics with features of their work environments is assessed.

A fundamental assumption in the work to be reported is that empirical links between environmental factors and work behaviors exist, but that these links are modified by individual differences. The design of the built environment affects, in subtle ways, the way people carry out their activities. The physical environment sets the conditions for certain responses to occur (Ittelson, Proshansky, Rivlin & Winkel, 1974; Parsons, 1976) although it does not unilaterally determine responses to a given environment.

The overall organizing framework of the set of studies is shown in the diagram below.

```
+------------------------------+        +-------------+
! Satisfaction-dissatisfaction !        !    Task     !
!    with the Acoustical       !        ! Performance !
!       Environment            !        +-------------+
+------------------------------+

                     +------------------------+
                     !    Task performance    !
                     !    as a function of    !
                     ! Sound Level Preference !
                     +------------------------+


                        +--------------------+
                        !     Individual     !
                        !   Differences in   !
                        ! Response to Noise  !
                        +--------------------+
```

This dissertation consists of a questionnaire survey and two experiments, which address issues in three areas respectively. In the questionnaire survey, satisfaction-dissatisfaction with the acoustical environment in offices is examined. Information regarding the physical characteristics of offices, individual characteristics, job characteristics, and office workers' perceptions of the internal acoustical environment of their offices is used to test a revision of Ferguson's (1983) causal model. The interrelations between organizational variables, physical environmental variables, individual characteristics variables, and organizational effectiveness outcomes are examined in the model.

Experiment 1 focuses on the effects of a particular noise source on task performance. The effects of background conversations with varying information rates and relevance to the task at hand on office workers' satisfaction and performance are examined. In addition, individual differences in stimulus screening ability are considered.

Experiment 2 focuses on task performance as a function of individuals' sound level preferences. The issue of whether individuals perform best at their most preferred sound level is addressed, and any individual differences that may affect task performance and satisfaction are examined.

LITERATURE REVIEW OF NOISE RESEARCH

To begin with, what is noise? How is noise different from sound?

Noise as a Sound

Sound represents air pressure changes created by wavelike movements of air molecules in response to object vibration. The frequency of a sound wave is perceived by the listener as pitch; the range of frequencies audible to human ears is from 20 to 20,000 Hertz. The amplitude of a sound wave determines its amount of energy and is perceived as loudness.

In psychology, noise can be defined as unwanted sound (Cohen & Weinstein, 1982; Kryter, 1985). Whether a particular sound is heard as noise depends on the individual and the situation. A baby's cry of hunger may be a joyous sound to her mother, but an unbearable noise to others. Likewise, your favourite rock music may be noise to me. Moreover, not all noise is loud; a whisper behind you at the movies can be as unwelcome as a jackhammer at work outside your bedroom window.

Nevertheless, sounds that possess certain physical characteristics (e.g., impulsive, high intensity, high frequency) are likely to be labelled noise (Dunn, 1979).

The range of sound levels in most offices is below that which impairs hearing. But other factors such as the source, meaning, controllability, and predictability of the sound may be more important than sound level in determining whether an office sound has become a noise.

The sound intensity is commonly expressed in decibels (abbreviated as dB). Zero decibel at a frequency of 1000 Hertz represents the weakest sound that can be heard by a person with very good hearing in an extremely quiet environment; at the other end of the scale, 120 dB at 1000 Hertz represents the sound level at which a person feels pain. The decibel scale is logarithmic; although an increment of 3 dB reflects a doubling of sound intensity, an increment of 10 dB is required for a sound to be perceived twice as loud (Stevens & Warhofsky, 1965).

The A-weighting decibel scale (dBA) is designed to closely approximate perceived annoyance. This scale is used in most behavioral studies of sound and noise. Because people perceive high-frequency sounds as louder than low-frequency sounds of equal intensity except at very high intensity levels, this scale assigns lesser weight to low-frequency than to high-frequency sounds in calculating the total sound level (Cohen & Weinstein, 1982; Kryter, 1985).

Next, research on noise effects will be reviewed. The purpose of this review is to give the readers some background information about the research area; some information may be peripheral to the purposes of the studies to be presented. Research that leads directly to the studies will be described in their respective introductory sections.

This literature review is organized in the same manner as is illustrated in the diagram on Page 4. First, the literature relating to two outcomes of organizational effectiveness, satisfaction with the workplace and job performance, is reviewed in two separate sections; theories, methodology, and empirical findings are included. Second, research on individual differences in reaction to noise is summarized. Finally, research on preferred acoustical environments is reviewed.

Satisfaction with the Acoustical Environment

Ideally, the acoustical environment of an office should allow for office workers (1) reasonable freedom from distracting sounds, (2) private conversations to be carried out without being overheard, and (3) face-to-face and telephone communication to be clearly understood by the people involved (Bains, 1976; Cavanaugh, Farrel, Hirtle & Watters, 1962; Lewis & O'Sullivan, 1974).

Unfortunately, contemporary offices often fall short of these ideal requirements. In the last twenty years, a number of surveys of office workers' attitudes about their offices have been conducted (Boyce, 1974; Brookes & Kaplan, 1972; Goodrich, 1982; Hedge, 1981; Hundert & Greenfield, 1969; Louis Harris & Associates, 1978; Man-environment

Systems, 1978; McCarrey, Peterson, Edwards & von Kulmiz, 1974; Nemecek & Grandjean, 1973; Sundstrom, Herbert & Brown, 1982a; Sundstrom, Town, Osborn, Rice, Konar, Mandel & Brill, 1985). A few have focused on the acoustic aspect of the office environment (Hay & Kemp, 1972; Keighley, 1966 & 1970). When asked about the acoustic aspect of their work environments, office workers have consistently indicated dissatisfaction; they have complained about (1) disturbance by noise and (2) lack of conversational privacy.

Disturbance by noise

Perceived Effects

Office workers are dissatisfied with the noise in their offices; they believe noise disturbances affect their satisfaction on the job and their satisfaction with the work environment. In a United States national survey of office workers (Louis Harris & Associates, 1978), "the ability to concentrate without noise and other distractions" was rated the third worst among 17 office characteristics in their own offices.

Similar results were reported in their second survey (Louis Harris & Associates, 1980, cited in Sundstrom & Sundstrom, 1986); although 84% of the office workers felt that having quiet surroundings affected their personal comfort on the job "a great deal" or "somewhat", 49% said that they did not have quiet in their offices.

In the Sundstrom et al. (1982a) study, employees completed questionnaires both before and after moving to a new office. Those who had more disturbances from people talking, telephone rings, or typewriter noise after the move were less satisfied with their environments; those who had less noise after the move were more satisfied.

Noise and Office Openness

Noise is a problem in open-plan offices in particular. Several surveys of employees working in open-plan offices showed consistently negative results (e.g., Boyce, 1974; Brookes & Kaplan, 1972; Hundert & Greenfield, 1969; Keighley, 1970). As examples, 35% of the respondents in the Nemecek and Grandjean (1973) Swiss survey of 15 open-plan offices reported severe disturbance by noise, and 45% reported slight disturbance. Seventy-four percent of the employees in Hedge's (1981) Australian survey agreed that there were many noise disturbances and distractions in their open-plan offices.

Office workers often attribute frequent aural distractions to the openness of their offices (Man-environment Systems, 1978; Marans & Spreckelmeyer, 1981), and therefore show low preferences for working in open-plan offices if they are disturbed by noise (Nemecek & Grandjean, 1973).

Primary Noise Sources

Apparently, the primary sources of noise disturbance are other people's talking, office machine noise, and telephone rings (Boyce, 1974; Hedge, 1981; Keighley, 1970; Nemecek & Grandjean, 1973; Sundstrom et al., 1985). Other sources of interruptions are movement-based, including others passing by or working nearby (Man-environment Systems, 1976; Purcell & Thorne, 1977).

Factors that Affect Noise Disturbance

Several factors, including the physical characteristics of the sound (e.g., intensity level), cognitive demand (e.g., meaning), and individual characteristics (e.g., sound sensitivity), have been found in some studies to relate to noise disturbance.

Information Content or Meaning. The most disturbing noise sources are apparently those that carry information or have meaning. For example, co-workers' conversations demand attention because their contents may be important to one's work. Telephone rings may be disturbing because they signal demands for attention.

Average sound level. Acceptability of noise declines with increases in the average sound level (Keighley, 1966). The average levels of the 12 offices in Keighley's study were, however, higher than those in many offices [over 60 dBA as opposed to 45-55 dBA (Boyce, 1974; Keighley, 1970; Nemecek &

Grandjean, 1973)]. Even lower sound levels (only 47 dBA) were annoying to the office workers in two field experiments (Keighley & Parkin, 1979; Warnock, 1973).

On the contrary, some researchers have reported noise annoyance in offices to be unrelated to ambient sound level (Boyce, 1974; Nemecek and Grandjean, 1973).

Degree of Momentary Fluctuations above the Average Level. One reason that employees' annoyance ratings were unrelated to the ambient sound level in some studies is that the average noise level alone may not accurately predict annoyance. As Keighley (1966) showed, acceptability of office noise declined with increases in the degree of momentary fluctuations about the background level. When a peak index was computed from measurements of the peak sound levels in 40 offices, Keighley found a strong and highly significant correlation between the peak index and acceptability of noise. Similarly, Purcell and Thorne (1977) reported that most interruptions to office activities were due to sudden changes away from the ambient level.

Thus, telephone rings may be disturbing because of their loudness in relation to the background level (Boyce, 1974). Other noise sources that have fluctuating sound levels are footsteps, and impact sounds of equipment and furniture (Keighley, 1970).

Predictability and Controllability. Unpredictable and uncontrollable noise have been shown in laboratory studies to be more annoying than predictable or controllable noise (Glass & Singer, 1972). In the office, employees who had greater degree of control over their immediate environment were more satisfied than those who had little control (Marans and Spreckelmeyer, 1982).

In summary, many office workers, particularly those in open-plan offices, are dissatisfied with noise in their offices. Others' conversations, telephone rings, and office machine noise are the primary sources of noise disturbance. Their information content, average sound levels, sound level fluctuations above the background level, and unpredictability or uncontrollability of the sounds may all contribute to the disturbances.

Therefore, the effects of background conversations on satisfaction are investigated in Experiment 1, and the sound level distribution of office sounds that are annoying is examined in Experiment 2. In both experiments, office noise and conversations at typical office sound levels are used as stimuli.

Conversational Privacy

Besides disturbance by noise, another common complaint is the lack of conversational privacy (Hedge, 1981; Louis Harris & Associates, 1978; Man-environment Systems, 1978;

Marans & Spreckelmeyer, 1982; Nemecek & Grandjean, 1973). For example, in the Louis Harris & Associates survey (1978) and the Marans and Spreckelmeyer (1982) case studies of office workers, conversational privacy was the worst-rated attribute of their offices. Conversational privacy (or speech privacy) refers to the ability to hold a conversation without being overheard and understood by people outside it (Cavanaugh et al., 1962; Sundstrom & Sundstrom, 1986). About 90% of the workers in Goodrich's (1978) study, including clerical workers and mid-level managers, felt that they could be overheard to some extent.

As in noise disturbance, conversational privacy is particularly inadequate in open-plan offices. For example, eleven percent of the employees in the Necemek and Grandjean (1973) study of open-plan offices reported that confidential conversations were impossible. Among those who had to carry on confidential office conversations, 75% believed their conversations were overheard. Eighty-four percent of the respondents in the Hedge (1981) study agreed that it was easy for others to overhear private conversations in their open-plan offices. So were many employees in the Oldham and Brass (1979) interview study.

Privacy

On a broader level, privacy can be viewed as a form of information management (Margulis, 1979, cited in

Sundstrom & Sundstrom, 1986; Westin, 1967), or as a form of regulation of social interactions in order to achieve and maintain an optimal level of social interaction (Altman, 1974 & 1975).

Altman (1975) has defined privacy as "the selective control of access to and from the self or one's group by other people". Privacy is viewed as a bi-directional process involving the perceived ability (1) to control input from others or the environment, and (2) to regulate transmission of information to others selectively. Optimal control of privacy is attained when the desired level of privacy equals the achieved level of privacy.

The findings of a study of business executives (Justa & Golan, 1977) supported these views of privacy. Privacy meant being able to work without distractions (60% of the executives agreed), controlling access to information (35%), having freedom to do what they wanted to do (35%), controlling access to space (35%), and being alone (25%).

Based on Altman's conceptualization, disturbance by noise and lack of conversational privacy represent two aspects of privacy; disturbance by noise involves the inability to control input from others or from the environment, whereas lack of conversational privacy involves the inability to regulate transmissions of information about oneself to others. Both noise disturbance and lack of conversational privacy contribute to inadequacy of overall privacy.

Researchers have investigated the relationships between adequacy of privacy in work settings and the following variables: physical setting, job level, task requirement, and social norm.

Physical Setting

The physical environment can either enhance or hinder the flow of behaviorally relevant information. Clearly, privacy in the office is influened by physical structures, and particularly those that control inputs and outputs such as doors and windows (Justa & Golan, 1977). Other general characteristics about offices such as openness, density, and architectural accessibility may influence the adequacy of privacy. Some of these characteristics have been measured objectively (e.g., Oldham & Rotchford, 1983; Sundstrom et al., 1982b).

Since different types of office vary in these physical characteristics, the privacy provided by the physical setting (architectural privacy, Sundstrom et al., 1980) varies; consequently, the adequacy of privacy perceived by individuals (psychological privacy, which correlated positively with architectural privacy in Sundstrom et al., 1980) tends to vary with the type of office: conventional private office, shared private office, open-plan office, or pool arrangement (Becker, Gield, Gaylin, & Sayer, 1983; Dean, 1977; Hundert & Greenfield, 1969; Man-environment Systems, 1978; Marans & Spreckelmeyer, 1982; Sundstrom et al., 1980; Zeitlin, 1969).

Job level

The adequacy of privacy may be influenced by job level. Some surveys showed that managers and clerical workers required different levels of concentration and confidentiality in their jobs, and thus might have different privacy requirements. For example, Hedge (1981) found that clerks suffered less from noise disturbance, distractions, and loss of privacy than did managers. Sundstrom et al. (1982a) also reported that speech confidentiality varied by job level. Secretaries, bookkeeper-accountants, and office managers rated privacy at their workspaces differently even in workplaces with equivalent enclosures such as private offices.

As is proposed by Sundstrom & Sundstrom (1986), perhaps privacy needs are organized in a hierarchy. At lower job levels, certain aspects of privacy are more salient, but at higher job levels, other aspects become more important. For example, employees at lower levels may be more concerned about social control, and in particular, keeping others out. At the middle level, employees often require greater concentration than do lower level employees. Freedom from distractions such as noise down the hallway may become more important.

Task requirements

Ralated to their job levels are the types of tasks performed by office workers (Knopf, 1982; Thachenkary & Conrath, 1982; cited in Helander, 1985). The degree of privacy required by a worker is likely to depend on the type of activity the worker's job calls for (Cavanaugh et al., 1962; Justa & Golan, 1977). Some work (e.g., writing) requires concentration and solitude, and other work (e.g., employee liaison) may require accessibility to other employees.

Nevertheless, both Sundstrom et al. (1982b), and Hay and Kemp (1972) reported that office workers generally preferred privacy over accessibility irrespective of the type of work they did. Although the work done by the clerks in Sundstrom et al.'s (1980) study was monotonous, they were happier with their job when working in areas they saw as relatively quiet. Marans and Spreckelmeyer (1981) also reported that employees in open-plan or pool arrangement offices were equally disturbed by their inability to carry on conversations in private irrespective of the type of work they did.

Social Norms and Office Policies

Privacy can be facilitated by social norms and organizational policies. How effective the use of the physical environment is in achieving privacy depends to some extent on the norms of the organization. For instance, some organizations may have the unwritten rule that office doors are always open (Justa & Golan, 1977); privacy is decreased in these offices. In other organizations, it is an accepted procedure to announce one's presence and to wait for recognition before entering a workspace in an open-plan office; in which case, privacy can be enhanced by organizational norms.

To summarize, many office workers are dissatisfied with the lack of privacy in their offices. As with noise disturbance, dissatisfaction is more severe in open-plan offices. Based on Altman's conceptualization, disturbance by noise and lack of conversational privacy represent two aspects of privacy. Both conversational privacy and overall privacy may be related to job level and task requirement.

In the questionnaire survey to be reported, a model of office workers' satisfaction with their acoustical environment is proposed and tested; the inter-relationships between job level, degree of office openness, aural distraction (or noise disturbance), conversational privacy, overall privacy and satisfaction with the acoustical environment are examined.

Methodology

Researchers concerned with the effects of the office environment on the well-being of office workers have used several data-collection techniques.

Most of the research has consisted of attitude surveys (e.g., Louis Harris & Associates, 1978; Hay & Kemp, 1972; Hedge, 1981) and post-occupancy evaluations in which office workers' responses before and after renovations, or relocation from conventional offices to open-plan offices are compared. Pretesting may sensitize the respondents to the issue and therefore may introduce bias in their responses to the surveys.

Some of the post-occupancy evaluations are retrospective surveys, in which employees recall their previous office environments and compare them with their current offices (e.g., Hundert & Greenfield, 1969). The validity of such evaluations relies heavily on the accuracy of recall of office workers' former environments. Evaluations that are made about both their environments before the move and their current environments (e.g., Boyce, 1974; Brookes & Kaplan, 1972; Sundstrom et al., 1982a) represent a stronger research approach.

In both cases, many of the attitude changes are possibly due to the novelty of relocation or renovation. Rarely has the stability of responses been assessed in follow-up evaluations, as in Boyce (1974). When relocation or renovation occurs, many features of the office environment such as lighting, amount of space, and availability of common facilities change at the same time. It is impossible to determine whether noise alone lowers satisfaction or causes dissatisfaction.

In the questionnaire survey to be reported, path analysis is used to analyze the data so that causal relationships between variables can be inferred.

The second most common research method in this area is the laboratory experiment. Typically, subjects are presented with a set of similar sounds played through loudspeakers or headphones and are asked to rate the annoyance of these sounds. The subject's attention is directed specifically to assessing whether a noise is more annoying than other noises, or other levels of the same noise (e.g., Rylander, Syostedt & Bjorkman, 1977).

Very few field studies or field experiments have been done. Oldham and Brass (1979) designed a quasi-experiment to compare office workers' reactions to office relocation. The results were that employee satisfaction, motivation, and concentration of the experimental group declined significantly after the move, whereas those of the comparison group remained the same. In two field experiments (Keighley & Parkin, 1979; Warnock, 1973), artificial sounds were introduced deliberately into the offices at a gradual pace. Their employees showed annoyance when the average sound level reached about 47 dBA.

Occasionally, other methods of research have been used. Becker et al. (1983) used both the questionnaire survey and the behavior observation techniques to assess the effects of having open-plan, shared, or private offices on college professors. Professors in open-plan offices said that distractions reduced their abilities to concentrate, increased the time to complete tasks, and reduced their abilities to conduct meetings with students on sensitive issues. They reported spending less time in their offices than did those in closed-private or closed-shared offices, but systematic observations showed no differences in the actual amount of time they spent in their offices. Therefore, self-reporting of behavior may not be an accurate measure of behavior.

Finally, diary-keeping was proposed by Purcell and Thorne (1977) as a means of studying interruptions in the office. Their subjects were asked to record in diaries (1) the times at which interruptions occurred, (2) when they ceased, (3) the causes of the interruptions, (4) the activities carried out at those times, and (5) the subjective effects of the interruptions. Using this method, one can identify the relationships between noise source, noise intensity, the type of task being performed, and subjective effects during interruptions. However, keeping a diary obviously constitutes an interruption on its own.

In the studies to be reported, three common techniques are used: questionnaire survey, laboratory experiment, and field experiment. Office workers report their satisfaction levels and any perceived noise effects.

Theories of Noise Annoyance

To date, there is no accepted theory of noise annoyance. In some cases, annoyance may represent fear, aversiveness, or a mild form of anger (Cohen & Weinstein, 1982). It may be an expression of (1) an attitude toward the noise source, (2) frustration over task disruption or over verbal communication interference, or (3) uneasiness caused by physiological aftereffects of continued exposure to an intense sound (MacKenzie, 1975). But the theory remains very undeveloped.

Task Performance

Let us now turn to the second organizational effectiveness outcome that is of concern to organizations: productivity or job performance of office workers.

Self-reported Effects of Noise on Task Performance

Office workers believe that noise has detrimental effects on their job performance. In a United States national survey of office workers (Louis Harris & Associates, 1978), 41% rated "the ability to concentrate without noise and other distractions" to be the most important criterion for getting work done. In Marans and Spreckelmeyer's (1981) survey of U. S. federal government employees, noise was believed to cause reductions in co-workers' productivity.

Several perceived undesirable consequences are (1) disturbance in concentration (Hedge, 1981; Nemecek & Grandjean, 1973; Purcell & Thorne, 1977), (2) increased difficulty in decision-making (Hedge, 1981; Keighley, 1966), (3) difficulty with telephone conversations (Hedge, 1981), and (4) hindrance of confidential conversations (Hedge, 1981; Nemecek & Grandjean, 1973).

Behavioral Effects

Despite these perceived consequences, it is not clear whether office noise affects actual productivity (Becker et al., 1983). The effects of noise on office activities have rarely been measured in the office, although since the 1950s, a considerable amount of laboratory research on the effects of noise on task performance has been conducted.

Auditory Tasks

Clearly, any task that requires the perception of auditory signals for correct performance will be impaired by noise (Kryter, 1970; Loeb, 1980; Miller, 1974). One common laboratory task is the reporting of words or syllables presented against background noise. The percentage of words or syllables heard typically decreases and the percentage of words misunderstood increases in the presence of noise (Gawron, 1982). For example, Jones and Broadbent (1979) reported slower and less accurate verbal proofreading when attempted in a loud noise environment.

Non-auditory Tasks

Research results on performance of non-auditory tasks have been confusing, contradictory and inconsistent (see the reviews by Broadbent, 1957 & 1979; Glass & Singer, 1972; Kryter, 1970; Poulton, 1979). All possible effects have been reported: (1) that noise produces a decrement in performance (e.g., Boggs & Simon, 1968; Woodhead, 1964), (2) that noise has no effect on performance (e.g., Hockey, 1970; Rotton, Olszewski, Charleton & Soler, 1978; Theologus, Wheaton & Fleishman, 1974; Wohlwill, Nasar, DeJoy & Foruzani, 1976), and (3) that noise improves performance (Wilkinson, 1963).

Recent reviewers (Broadbent, 1979; Dunn, 1981; Gawron, 1982; Loeb, 1980; Sundstrom & Sundstrom, 1986) have attempted to clarify some of these apparently conflicting results; they suggest that the relations between noise and performance are, to a great extent, dependent on noise type and task type.

Type of Noise

Noise can be loud or soft, of high or low pitch, continuous or intermittent, familiar or novel, meaningful or meaningless, musical or mechanical, natural or human, predictable or unpredictable, controllable or uncontrollable, and so forth. For example, white noise is continuous and meaningless; a conversation is continuous and meaningful; music is continuous and variable.

Information Content or Meaning. Noises made by people can be particularly distracting because they are meaningful (Brebner, 1982). Even the awareness of other people passing by or working nearby was distracting (Purcell & Thorne, 1977). Overhearing conversation in particular has been described as a nuisance by office workers (Cavanaugh et al., 1962). As some researchers (e.g., Boyce, 1974; Nemecek & Grandjean, 1973) suggested, it may be the information content of a conversation rather than the sound level per se that is distracting.

Listeners who are trying to work must attend to sound selectively and filter out irrelevant stimuli (Brebner, 1982). The filtering process itself requires effort, which presumably detracts from the total amount of effort available for one's job.

Predictability and Controllability. Unpredictable noise may affect task performance more adversely than predictable noise. Glass and Singer (1972) exposed subjects to either predictable or unpredictable noise in the laboratory. After exposure to unpredictable noise, subjects showed "behavioral aftereffects", i.e., impaired performance on both proofreading and a Stroop color word task, and showed reduced tolerance to frustration.

Perceived control of noise is important too. When subjects were allowed to terminate the noise, the aftereffects of noise was reduced even when the control was not exercised (Glass & Singer, 1972).

Noise level. Widely different noise levels have been used by researchers in different studies. The sound intensity level of the "noise" condition has varied from unspecified, or 70 to 120 dB, and that of the "quiet" condition has varied from the ambient sound level of the laboratory to as high as 80 dB. Thus, any discrepancies between findings of different studies may simply be a result of the variation in sound levels used (Broadbent, 1979; Gawron, 1982).

Nevertheless, Goldstein and DeJoy (1980) concluded in a review that: "(1) few performance decrements occur under continuous noise below 80 dB that lacks special meaning, and (2) exposure to unpredictable or aperiodic intermittent noise may result in more pronounced performance effects at considerably lower than 80 to 90 dB."

However, what about the effects of moderate level noise that has meaning? In Experiment 1, the effects on task performance of others' conversations at normal speech levels are examined.

Type of Task

Unaffected by noise. In a review, Broadbent (1979) concluded that, "Almost any task in which a person has to react only at certain definite times, receives a clear warning of the need for reaction, and receives an easily visible stimulus will show no effect in continuous loud noise" (p. 174).

Tasks affected by noise. When individuals are required to perform two or more tasks simultaneously (e.g., Boggs & Simon, 1969; Finkleman & Glass, 1970), or to process multiple sources of information in noise, the performance of of tasks is impaired. Apparently, noise increases the amount of effort applied to the primary task or cue at the expense of the less important task or cue (Broadbent, 1979;

Cohen & Weinstein, 1982).

Tasks improved by noise. Occasionally, noise can even improve performance. For example, Wilkinson (1963) showed that the combined effects of noise (an arousing stimulus) and sleep deprivation (an underaroused state) facilitated performance.

Using a different task classification (clerical, mental, motor, vigilance, and dual), Sundstrom and Sundstrom (1986) have concluded in a recent review that predictable, or regular noise has little adverse effect on the performance of routine clerical tasks or mental tasks, except when the noise starts or changes.

Clerical Tasks. Of the 11 experiments they reviewed, adverse effects of predictable noise appeared in only two of them. The decrement occurred after an unannounced change in the sound level (Teichner, Arees, & Reilly, 1963), or in a 36-minute exposure to very loud noise (Harris, 1972). In these studies, the predictable noise was either white noise or continuous fan noise, and the task was number comparison or letter recognition. Continuous or regular noise may even improve speed or accuracy of simple clerical tasks when the noise is keyed to the task.

Unpredictable noise has no effect on clerical tasks. The noise used in the experiments they reviewed were intermittent bursts, bells, or discontinuous recorded music.

<u>Mental Tasks</u>. As for simple mental tasks such as simple arithmetic, predictable noise had no effect in seven of the ten experiments Sundstrom and Sundstrom reviewed. Continuous or regular noise may even improve speed or accuracy of simple mental tasks in brief work-sessions.

On the other hand, unpredictable or irregular noise may disrupt performance of mental tasks that requires learning or short-term retention of new information (e.g., Rabbitt, 1966; Weinstein, 1974).

Task complexity seems to be important in determining the relation between noise and performance (Boggs & Simon, 1969; Dunn, 1981). In Weinstein's (1974 & 1977) studies, subjects proofread in noise and in quiet conditions. Neither accuracy in detection of non-contextual errors (e.g., typographical errors) nor proofreading speed was impaired by noise. However, noise reduced accuracy in detection of contextual errors (e.g., grammatical errors), which presumably demanded higher mental effort.

In summary, although office workers believe noise affects their job performance, the effects of typical office noise and background conversations on the performance of non-auditory office tasks is not clear.

Thus, the effects of background conversations on the performance of simulated office tasks of different complexity are examined in Experiment 1. In Experiment 2, the effects of office noise on data-entry performance are examined in a natural work setting. The noise level and the speech level are kept within the typical office noise range. In these experiments, both perceived noise effects and behavioral effects of performance are examined.

Methodology

Studies in the Office Setting

Not surprisingly, the effects of noise on ongoing office activities have rarely been measured in the office. First, gaining access to organizations has been the greatest challenge to researchers. Second, once access has been obtained, many practical concerns prohibit or at least make it difficult for the conduct of research on the possible effects of noise upon work output and efficiency.

Furthermore, researchers who do conduct field studies have usually measured the performance of relatively simple and repetitive tasks that clerical workers do. Seldom has the job performance or productivity of administrators and executives been measured. Because of the cognitive nature of their work, there is often no tangible product with which to assess their performance.

Over the years, only a few studies in the actual office have been published. Kornhauser (1927, cited in Kryter, 1985) measured the work output of only four typists; two worked for the first two days in a quiet office, then two days in a noisy office, and the other two worked in the reverse order of noise and quietness. Contrary to prediction, wasted lineage was 23% greater in the quiet room than in the noisy room, and 1.5% more lines were written under noisy conditions.

In 1952, an American insurance company conducted a major field study in its own offices (cited in Kryter, 1985). Semi-monthly bonus records for typists, clerical checkers, punch-card, and comptometer operators were compared for a year before, and a year after sound absorbing material was installed in all clerical offices. Substantial improvement in productivity was reported. When the sound-absorbing material was covered up a year later, the efficiency dropped to some extent, but within two months was as high as the level of the quiet year. This finding showed that noise did not reduce productivity. But note that the sound levels in these offices (35-41 dB) were much lower than those in many offices today.

Laboratory Studies

Since the 50s, most of the research that examines the effects of noise on task performance has been done in the laboratory. Typically, subjects' performance is measured while they are exposed to one or more types of noise, or different intensity levels of the same noise.

There are four obstacles to generalizing the results of most laboratory experiments to the office environment.

(1) The use of noise levels much higher than those naturally occurring in the office. The average sound levels in offices range from 45-55 dB with peaks at 58-65 dB (Boyce, 1974; Hay & Kemp, 1972; Keighley, 1970; Nemecek & Grandjean, 1973). But subjects in many laboratory experiments are exposed to noise levels of over 80 dB (e.g., Boggs & Simon, 1968; Glass & Singer, 1972; Harris, 1980; Hockey, 1970; Theologus et al., 1974; Wohlwill et al., 1976; Woodhead, 1964).

(2) The stimuli used in most experiments have been white noise (e.g., Theologus et al., 1974), pure tones (e.g., Bachman, 1977), and artificial or unfamiliar sounds (e.g., rocket noise in Woodhead, 1964; air horn in Park & Payne, 1963; bandsaw noise in Bogg & Simon, 1968; sound recording of sounds of a vacuum cleaner, a food blender, a metronome, an aquarium pump, and a man and woman speaking German in Harris, 1980). A few exceptions are unamplified sounds of a teletype machine (Weinstein, 1974), radio news broadcast (Weinstein, 1977), and office noise (Jones & Broadbent, 1979).

(3) College students have been the subjects in most of these experiments (e.g., Glass & Singer, 1972; Weinstein, 1974 & 1977).

(4) Subjects in most of these laboratory experiments

performed simple tasks such as vigilance (e.g., Broadbent, 1957), serial response (e.g., Wilkinson, 1963), and simple arithmetic (e.g., Glass & Singer, 1972; Harris, 1980; Park & Payne, 1963; Rotton et al., 1978; Woodhead, 1964). Tasks requiring slightly greater cognitive demands such as proofreading, comprehension (Weinstein, 1974 & 1977), and verbal proofreading (Jones & Braodbent, 1979) have been used on rare occasions.

Office activities vary in complexity. Some office tasks are simple tasks: calculations, filing, copying, and typing (Engel, Groppuso, Lowenstein & Traub, 1979; Knoff, 1982; Thachenkary & Conrath, 1982; all cited in Helander, 1985). Others such as reading, writing, discussing, and decision-making demand greater mental effort (Fucigna, 1967; Klemmer & Snyder, 1972, cited in Helander, 1985; Purcell & Thorne, 1977; Zeitlin, 1969). But the performance of these mental tasks is very difficult to measure.

Despite numerous laboratory experiments on noise and task performance, what effects typical office noise of realistic levels have on typical office activities still remain unclear. As Weinstein (1974) stated more than ten years ago, "the use of realistic noise levels and meaningful tasks is still uncommon". Again in 1980, Goldstein and DeJoy concluded, "There is a definite need for methodologically sound, performance-oriented field studies in various types of work environments."

The experiments to be reported were conducted in a simulated office and in a natural work setting. Subjects were exposed to office noise and background conversations at realistic levels. Subjects in Experiment 1 carried out typical simulated office activities of varying complexity, whereas subjects in Experiment 2 did their normal work -- data-entry.

Theories of Noise on Task Performance

To date, three different but not necessarily independent general theories about the relationship of noise and performance have been proposed: those of Broadbent (1971 & 1978), Cohen (1978), and Poulton (1977, 1978, & 1979).

Broadbent: The Arousal Hypothesis

Broadbent (1971) has theorized that exposure to moderate or high intensity noise causes an increase in arousal. Heightened arousal leads to a narrowing of an individual's attention. As a result, inputs that are irrelevant to task performance will be ignored first. As arousal increases, attention is further restricted; task-relevant cues may be ignored as well. Thus, performance of tasks that requires only a restricted range of cues may be enhanced with narrowing of attention to the essential task cues only. Where proficiency demands the use of a wide range of cues, any narrowing of attention is likely to affect performance adversely.

According to the arousal theory, the relation between arousal level and task performance is represented as an inverted U-shaped function, known as the Yerkes-Dodson Law. Performance is maximal at moderate arousal level and gradually tapers off as the arousal level either increases or decreases.

Further, the effects of arousal on performance vary with task complexity. The optimal arousal level is lower for a complex task than for a simple one. In other words, a moderate level of arousal may affect performance on a complex task adversely, but may faciliate performance on a simple task.

Cohen: Information Overload Hypothesis

According to Cohen (1978), both noise and an ongoing task put demands on one's information processing capacity. When one is exposed to high intensity noise, one's attention narrows in order to decrease the amount of information processed. The information load imposed under noise exposure is affected by cognitive factors such as the meaning of the noise, predictability or controllability of the noise, and expectancies about its effects more than by sound intensity level. Thus, decrements in task performance that follow exposure to unpredictable, uncontrollable noise are attributed to cognitive fatigue and consequent loss of information-processing capacity.

Poulton: Composite Theory of Arousal and Internal Speech Masking

Poulton (1979) has attempted to integrate arousal and auditory masking in a model. He argues that the positive effects of noise on performance are due to arousal, the negative effects to auditory masking, and no effect to the result of arousal and masking effects cancelling each other.

In his model, arousal increases when continuous noise is first switched on, but gradually lessens over time. This initial increase in arousal often results in improved performance. When the noise is stopped, arousal drops below the resting level. This post-noise drop in arousal may account for the adverse aftereffects reported in some studies.

In addition, Poulton believes that auditory masking is responsible for decrements in task performance under continuous noise. Noise can mask either acoustic cues that give individuals feedback about their performance, or their internal speech. By internal speech, Poulton means the internal articulation or rehearsed verbalization of words or numbers involved in many tasks.

Individual Differences

The research reviewed so far has not addressed the issue of individual differences in response to noise. Yet some community surveys and some personality studies have shown great variation in people's reaction to noise. In view of these findings, individual differences should be considered in any noise research, and should not be considered just another extraneous variable and be ignored.

Several community surveys have shown great variation in the annoyance ratings that different individuals give the same noise (Langdon, 1976; Moreira & Bryan, 1972; Weinstein 1980). In several studies of traffic noise and aircraft noise, the noise level accounts for 70-80% of the variation in the median dissatisfaction scores of residents in areas of varying noise exposure, but only 10-20% of the variation in individuals' responses (Griffiths & Langdon, 1968; Langdon, 1976; McKennell, cited in Griffiths & DeLauzun, 1977).

The differences in annoyance ratings between individuals exposed to the same sound level may be due to real and persistent differences in individuals' reactions to noise (Weinstein, 1980). Other factors may include unreliability of the measures, different linguistic usages between people, real differences in annoyance within the same persons from time to time (Griffiths & DeLauzun, 1977), perceived control over the noise, and perceived danger of noise exposure (Jonah, Bradley, & Dawson, 1981).

Researchers have attempted to relate dissatisfaction with noise to personality traits as measured by a number of scales (e.g., the MMPI, Rorschach Inkblot Test, Eysenck Personality Inventory, and Cattell's 16 PF), but have obtained mixed results (Griffiths & Delauzun, 1977; Moreira & Bryan, 1972).

Introversion-extraversion

For example, Weinstein (1978) reported that introverted students were more annoyed by dormitory noise. Griffiths and Delauzun (1977), and Moreira and Bryan (1972) were, however, unable to show such an effect. On the contrary, Jonah et al. (1981) reported that extraverts showed greater annoyance with traffic noise than did introverts.

The evidence that extraverts prefer higher sound levels than do introverts is clearer (Bryan & Tolcher, 1976; Elliot, 1971; Geen, 1984; Hockey, 1972). Geen (1984) also showed that subjects performed their best when stimulated by white noise at a sound level chosen by another subject of their own personality type (introvert or extravert).

Noise Sensitivity

In several studies (Griffiths & DeLauzun, 1977; Langdon, 1976; Moreira & Bryan, 1972), subjects who were sensitive to noise were more annoyed with traffic noise. Because these studies used single-item self-ratings of noise sensitivity, the reliability of the ratings may not be satisfactory (Nunnally, 1967).

As an improvement to single-item scales, Weinstein (1978) developed a 21-item rating scale to assess self-reported noise sensitivity. Using this scale, Weinstein found that the more noise-sensitive college students became increasingly disturbed by dormitory noise during the year, whereas the less noise-sensitive students did not.

Moreira and Bryan (1972) attempted to use an individual's noise loudness function as a measure of annoyance. Noise-sensitive subjects tended to have higher initial annoyance at moderate noise levels (50-60 dBA), but their annoyance did not increase much with increasing sound level. Less noise-sensitive subjects did not find the sound noticeable until it reached quite a high level, but then their annoyance rose sharply.

Critical Tendencies

Differences in critical tendencies (i.e., tendencies to express critical or negative judgments) have been proposed to influence noise annoyance ratings (Weinstein, 1980). Dissatisfaction with noise tends to correlate with dissatisfaction with other features of the neighborhood (Jonah et. al., 1981; Langdon, 1976; Weinstein, 1980). Those who are less critical tend to give uniform evaluations.

Contrary to common belief, the more critical individuals do not seem to be indiscriminate in their complaints (Weinstein, 1980).

Stimulus Screening

That there are individual differences in stimulus screening ability, i.e., in the ability to block out irrelevant stimuli and to rapidly habituate to distracting, irrelevant stimuli was proposed by Mehrabian and Russell (1974). Screeners have the ability to rank information in term of priority, whereas non-screeners have difficulty blocking out irrelevant information.

In the studies to be reported, some of these individual characteristics (introversion-extraversion, noise sensitivity, and stimulus screening) are measured and their effects on dissatisfactioon with noise and task performance in noise are examined.

Preferred Acoustical Environment

It seems obvious that one of the individual differences in reaction of noise is sound preference. Allowing individuals to adjust the ambient sound to what they consider acceptable or satisfactory represents another approach to understanding the impact of office noise and to determining an acceptable acoustical environment. Yet surprisingly, very few studies that use this approach have been reported in the psychology literature.

Previous Studies of Sound Preferences

A number of studies in which subjects are asked to choose their preferred environments have appeared in the acoustics literature. Researchers have attempted to determine preferred levels of a variety of noises while subjects work on a variety of tasks (Bryan & Tolcher, 1976), or of the sound level of speech or other desirable auditory signals (e.g. television or radio program) that subjects prefer to listen to (e.g., Pols, van Heusden & Plomp, 1980; Rice, Sullivan, Charles, Gorden & John, 1974).

Advantages of this Approach

Giving subjects the freedom to choose their preferred levels of sound has the advantage of permitting a wider range and continuity in sound levels. For instance, subjects in the Bryan and Tolcher (1976) study have chosen levels between 0 dB to 100 dB.

On the other hand, annoyance rating scales have often used a five- to seven-point scale ranging from, for example, "quiet", "noticeable" to "annoying", "unbearable". The range of responses is thus limited by the measuring instrument.

The relationship between preferred sound level and annoyance rating has been examined. In a study by Bryan (cited in Bryan & Tolcher, 1976), subjects rated the degree of annoyance with sounds of 45 to 105 dBA while solving mental arithmetic problems. A sound level of 53 dBA, which was the mean preferred listening level of white noise in the Bryan and Tolcher (1976) study, fell nicely midway between the annoyance ratings of "quiet" and "noticeable" in the Bryan study. This finding suggests that subjects choose for comfortable working a level that they find to be "quiet-noticeable" (c.f., Bryan & Tolcher, 1976 and Bryan, undated; Bryan & Tolcher, 1976 and Moreira & Bryan, 1972).

In Experiment 2, both the sound preference approach and the annoyance ratings approach are used. Subjects select their most preferred sound level for comfortable working and also rate the comfort levels of several sound levels.

Integration of Task Performance and Satisfaction: Task Performance in the Preferred Environment

As reviewed above, most researchers have used either the questionnaire survey approach to investigate office workers' satisfaction with their office environments, or the laboratory experiment approach to examine the effects of noise on task performance.

One can use the sound preference approach to study the effects of noise on performance and satisfaction at the same time by examining the relations between performance and sound level preference. Presumably, one is satisfied with the sound level that one prefers.

Is the most preferred sound level also the most productive sound level? According to the arousal theory and the Yerkes-Dodson Law, one is most productive when one is optimally aroused, and the optimal arousal level is lower for a complex task than for a simple task. Empirically, Bryan and Tolcher (1976) showed that subjects preferred lower sound levels when working on a complex task (precis) than when working on a simple task (crossing-out letters). It is reasonable to propose that one may be most productive at one's most preferred sound level, which is likely to occur at the optimal arousal level for a particular task.

It is important to examine individuals' performance in relation to their sound level preferences. Zimring (1981) has stressed the importance of matching individuals' characteristics with features of their work environments; a misfit between an individual's needs and attributes of the physical environment can result in stress.

In conclusion, if we do work best at our most preferred acoustical environment, both the organization and its workers may benefit through matching features of the physical environment and individual preferences, possibly by assigning workers to a variety of settings within the office that have different background sound levels.

Summary

As summarized in this review, a considerable amount of research on office workers' perceptions of noise in their offices and on the effects of noise on task performance has been conducted. Yet most of the research has ignored any effects of individual differences in reaction to noise (both in terms of satisfaction-dissatisfaction level and task performance). One way of incorporating individual differences into noise research is to study individuals' preferred environments and to relate sound preferences to task performance.

Three studies were designed to test hypotheses in three areas: satisfaction-dissatisfaction with noise in the office, noise effects on task performance, and task performance in relation to sound level preference.

Questionnaire Survey

In the last twenty years, a number of attitude surveys of office workers have been conducted (e.g., Louis Harris & Associates, 1978; Sundstrom, et al., 1982a, b). With regard to the acoustic aspect of the office environment, disturbance by noise and lack of conversational privacy have been identified consistently as two major problems in the office, and in open-plan offices in particular.

In these surveys, researchers have examined the relationships between satisfaction with the workplace and such factors as noise level, noise source, job level, and office type <u>separately</u>. A review of these surveys has been included in the Literature Review on Noise Research section of this thesis and will not be repeated here.

Briefly, workplace satisfaction has been shown to relate to noise disturbance (e.g., Sundstrom et al., 1980), conversational privacy (e.g., Louis Harris & Associates), and office openness (Nemecek & Grandjean, 1973). Office openness is associated with aural distractions or noise disturbance (e.g., Man-environment Systems, 1978), conversational privacy (e.g., Hedge, 1981), and overall privacy (e.g., Dean, 1977). The relationships between job level and conversational privacy (e.g., Sundstrom et al., 1982a), aural distractions, and privacy (e.g., Hedge, 1981) have been investigated, but with mixed results.

The purpose of the present survey is to integrate the relationships between responses to office acoustic environment and several types of variables (organizational, physical environmental, individual characteristics, and environmental perception) that have been investigated separately in various surveys. This survey began as an exploratory study, but its data were used later to test a revision of Ferguson's (1983) causal model of employees' response to the office environment.

Models of Employees' Response to the Work Environment

Researchers have attempted to integrate the relations among these variables into conceptual models. One model, by Marans and Spreckelmeyer (1981), was in turn based on a model of satisfaction with residential environments (Marans & Rodgers, 1975, cited in Marans & Spreckelmeyer, 1981). That model suggested direct and indirect links between objective environmental attributes, individuals' subjective responses to these attributes (i.e., evaluations or assessments), overall environmental satisfaction, and specific behaviors.

In applying Marans and Rodgers's model to the evaluation of work environments, Marans and Spreckelmeyer (1981) used overall environmental satisfaction, job satisfaction, and job performance as three outcome measures.

Overall environmental satisfaction is dependent on the employee's position or job type, the organizational context, the employee's perception and assessment of specific attributes of the physical environment, and the physical attributes themselves. Perception and assessment of a particular environmental attribute are dependent on the standards against which the employee judges that attribute and on the physical attribute itself. The standards for comparison may include what one or one's co-workers have experienced, or what one aspires to.

Job performance is influenced by the employee's perception and assessment of specific environmental attributes, the attributes themselves, the employee's characteristics, and the organizational context. Finally, overall environmental satisfaction affects job satisfaction, which again is likely to be influenced by the characteristics of both the employee and the organization.

Based upon Marans and Spreckelmeyer's (1981) theoretical model, Ferguson (1983) developed a model of employees' response to the office environment. As the diagram below shows, his model consisted of four components: organizational, physical environmental, environmental perception, and responses to the environment component. Unlike Marans et al.'s model, he hypothesized that physical environmental attributes only indirectly influenced responses to the environment by shaping environmental perceptions.

```
Organizational      Physical       Environmental  Responses to
   Component --> Environmental-->  Perception --> Environment
                   Component       Component      Component
```

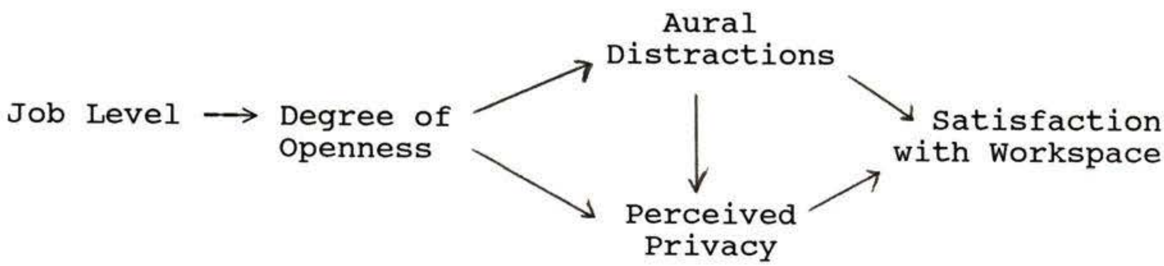
To evaluate his model, Ferguson selected variables that represented each component of his model. The organizational component was operationalized as job level, which frequently determines the size, type, and quality of one's office, and which may also influence one's response to open-plan offices (Sundstrom et al., 1982 a, b). The physical environmental variable was the degree of openness in offices. The environmental perception component was measured as aural distraction and perceived privacy; these two variables have been reported to be significantly correlated with the degree of office openness (e.g., Hundert & Greenfield, 1969; Nemecek & Grandjean, 1973). The response to the environment component was measured as satisfaction with the workspace. Ferguson believed that the relationship between degree of openness and satisfaction with the workplace reported in some studies (Sundstrom et al., 1980, 1982a) may be mediated by aural distraction and perceived privacy. In other words, there may be no direct effect of degree of office openness on workspace satisfaction.

Each variable in Ferguson's model was assessed with three to 13 questionnaire items. The questionnaire was distributed to 360 employees in eight organizations. These employees worked at all levels in their organizations. In addition, objective measures of each workspace's openness (including visual access, number of workers in the room, and accessibility) were obtained.

Ferguson used path analysis to test his causal model. Heise's (1969) theory-trimming approach was used to test the feasibility of the structural model. This technique involves deleting paths for which the path coefficients turn out to be both non-significant and negligible in magnitude. In Ferguson's study, paths were specified between all possible pairs of variables except between office openness and satisfaction.

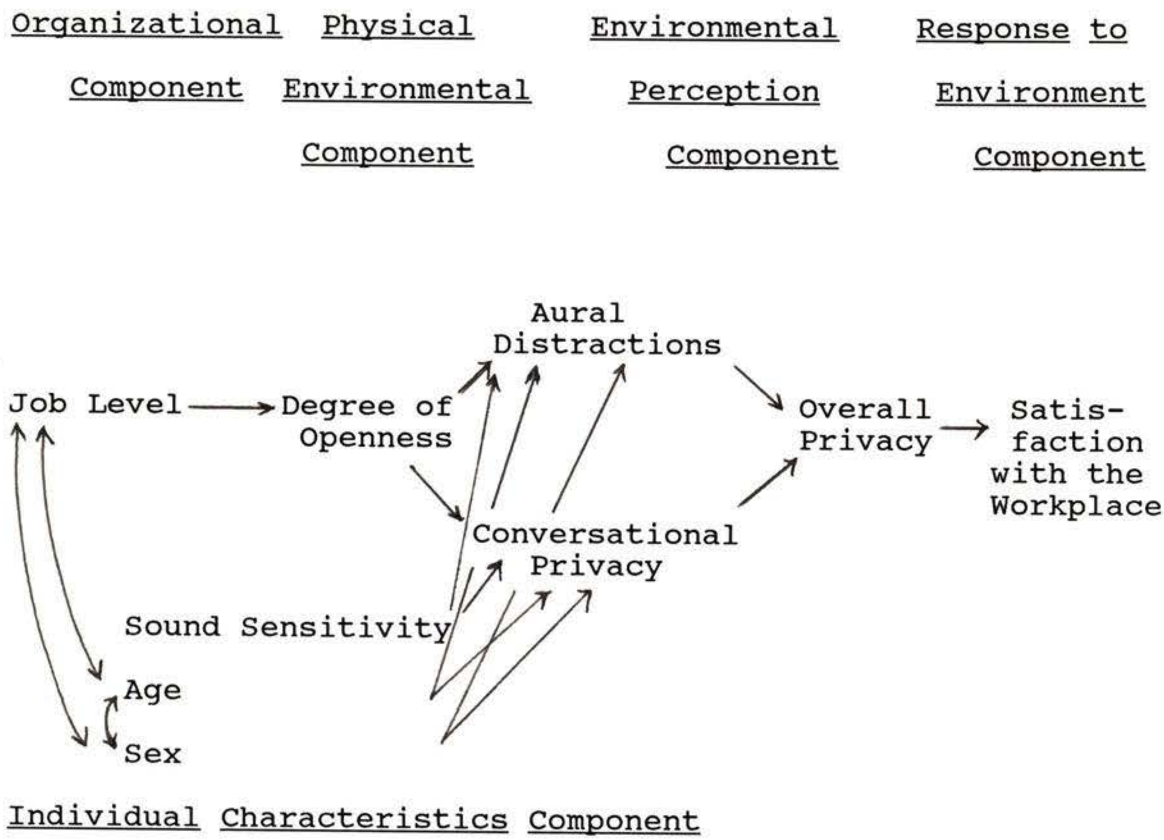
One result was a negligible direct influence of degree of openness on satisfaction with the workspace. The relationship between these two variables was, as hypothesized, mediated by distractions due to noise and by perceived privacy. Although other unidentified variables may also mediate the degree of openness and satisfaction relationship, aural distraction and perceived privacy had accounted for 54% of the variance in satisfaction with the workspace.

Applying the theory-trimming procedure resulted in the deletion of three paths: (1) from job level to aural distraction, (2) from job level to perceived privacy, and (3) from job level to satisfaction with the workspace. Job level had direct influence on the type of workspace an employee was assigned, but not on the employee's perception or satisfaction with the work environment. In short, Ferguson's data reflected the following model.



One possible influence on environmental perception, individual characteristics, is obviously missing from his model. Other models have proposed that individual characteristics influence environmental perception. For example, Wineman's model of stress response to environment (1982) states that personal characteristics influence perception and assessment of environmental stressors, and stress responses. In Maran and Spreckelmeyer's conceptual model for evaluating work environments (1981, described above), individual characteristics have been postulated to influence people's perception and response to the environment. Although Ferguson stated that the individual was one of the three key elements in his model, individual characteristics were omitted from his model.

The present study tests a revision of Ferguson's model. Individual characteristics variables, Sound Sensitivity, Age, and Sex, and an environmental perception variable, Conversational Privacy, are added to the model for two reasons. First, aural distraction and conversational privacy are, as described in the Literature Review on Noise Research, two aspects of perceived privacy: the former involves input from the environment and the latter output to others (Altman, 1975). Second, studies have provided evidence for great variability in sound sensitivity in individuals (Weinstein, 1980). Thus, it is worth investigating the relationships between individuals' characteristics and the other variables in the model. The diagram below shows the model to be tested.



Method

Respondents

128 office workers (managers, administrators, clerks, and secretaries) working on the University of Victoria campus participated in the survey. They worked in a variety of offices ranging from traditional private offices to large open-plan offices that housed 40 employees. Those who did not perform typical office work were excluded from the survey.

The Survey Instrument

A questionnaire (see Appendix A) was designed to explore office workers' reactions to noise in their work environments. It gathered information about the physical characteristics of the offices and employees' perceptions of the internal acoustical environment of their offices. Biographical data, self-reports of sound sensitivity, and information about their jobs were also obtained. Responses to the questionnaire items were indicated on Likert-type scales or in multiple response categories. Open-ended questions were included so that respondents could make comments and suggestions freely.

The variables in the proposed model were measured with responses to the following questionnaire items:

Job Level: Part II Question 4 "skill central to the job"

Office Openness: an index computed from the responses to Part I Question 1 "office type", Question 2 "number of other employees in the same office", Question 3 "the closest distance to neighbor", and Question 4 "the closest distance to a common place" (Oldham & Rotchford, 1983; Sundstrom et al., 1982b).

Sound Sensitivity: Part II Question 3 "self-rating of sound sensitivity"

Aural Distraction: Part I Question 8 Response A "distraction from work"

Conversational Privacy: Part I Question 13 "the ability to carry on a private conversation"

Overall Privacy: Part I Question 12 "rating of overall amount of privacy"

Satisfaction with the Acoustical Environment:
Part I Question 14 "rating of the acoustical environment"

Procedure

The heads of departments and administrative units were asked for their permission to approach their employees for participation in the survey. After permission had been granted, questionnaires were distributed to office workers in person. They were asked to complete the questionnaires anonymously and in their offices if possible. To ensure confidentiality, the questionnaires were collected in person within a day or were returned in the campus mail.

The data were collected in February, 1984. The response rate was over 80%.

Results

First, descriptive statistics of the variables were computed. Table 1 shows the percentage distributions of the responses to the questionnaire items.

Characteristics of the Respondents

Office Type and Job Level. The majority of the respondents were female (77%), or under 40 years old (57%). Sixty-six percent of the respondents worked in semi-open (i.e., large offices with partitions between work stations) or open-plan offices (i.e., ones with no partitions between work stations), and 27% worked in private offices. Sixty-six percent were clerks or secretaries, and 27% were managers or administrators. As shown in Table 2, most of the managers and administrators (71%) worked in private offices whereas the great majority of the clerks and secretaries (86%) worked in open-plan or semi-open offices.

Activities. As expected, a significantly larger percentage of managers and administrators spent their time on work that required creativity than did clerks and secretaries [Chi-squared(1) = 23.6, $p < .01$]; see Table 3). As shown in Table 4, they spent more time reading and writing than did clerks and secretaries (38% versus 19% of the time) [$t(117) = 4.81$, $p < .01$], and on face-to-face interactions (29% versus 19%) [$t(115) = 3.06$, $p < .01$]. On the other hand, a significantly higher percentage of clerks and secretaries spent their time on repetitive, routine forms of work [Chi-squared(1) = 12.63, $p < .01$] (see Table 3); they spent much more time on office machine operation than did administrators and managers (35% versus

5%) [$\underline{t}(116) = 7.16$, $\underline{p} < .01$]. Both spent as much time on the phone (19-20%) (see Table 4).

Sound Sensitivity. As Item 3 of Table 1 reveals, the noise sensitivity ratings are fairly normally distributed. Fifty-eight percent indicated that they were about average, 23% said that they were sensitive to noise, and 17% said that they were not.

Satisfaction with the Acoustical Environment

Disturbance by Noise. As shown in Item 9 of Table 1, the majority (61% of the respondents) felt that their offices were too noisy or far too noisy, whereas thirty-seven percent reported that it was just right for them. The mean rating of their satisfaction with the sound level was 3.70, with "1" indicating "far too quiet" and "5" indicating "far too noisy" (see Table 6).

Of the 78 respondents who felt their offices were "far too noisy" or "too noisy", distraction from work was the primary reason for noise disturbance (41%). Difficulty in hearing others was the second most important reason (35%); an analysis of the respondents' comments shows that difficulty in hearing others while on the phone was particularly problematic. Thirty-one percent reported a feeling of irritation as a reason for noise disturbance, and 21% said they had difficulty in making others hear them. As Table 5 shows, a significantly higher percentage of workers in open-plan and semi-open offices than in private offices were disturbed by noise, when job level was not partialled out.

Noises made by office machines and telephones, and co-workers' conversations were the major sources of distraction. To about two-thirds of the respondents, these noises were about and equally distracting (see Item 11 of Table 1). Thirty-six respondents mentioned that typewriters made noises that were particularly distracting. Another 16 listed computer printers, copying machines, and adding machines as distracting noise sources. A number of office workers reported general conversations in the hall to be distracting.

As Item 13 of Table 1 reveals, social conversations (gossip and non-gossip) were the most distracting of co-workers' conversations (28% and 37% respectively of the 100 respondents who responded). Distant, partially intelligible conversations were the next most distracting form of speech (26%). Work-oriented but irrelevant conversations were also quite distracting (25%). Work-oriented, relevant conversations were the least distracting (only 13%).

Music and laughter were the two office sounds that respondents liked; about 10% of the respondents found these sounds pleasant.

Privacy. As shown in Table 1, the ratings of Overall Privacy were approximately equally distributed among the five response categories. Forty-five percent of the respondents felt their overall privacy were "unsatisfactory" or "very unsatisfactory". The average rating was 3.19, when "1" indicated "very satisfactory" and "5" indicated "very unsatisfactory" (see Table 6). On average, workers felt the privacy level in their offices to be just adequate.

Nevertheless, conversational privacy was less satisfactory than was the overall amount of privacy. Forty-five percent of the respondents felt that they could never carry on personal conversations at their desks without being overheard. Twenty-seven percent reported that they could sometimes carry on personal conversations without being overheard. On a four-point scale with "1" indicating "always" and "4" indicating "never", the average rating was 3.06 (see Table 6). In general, workers felt that they could "sometimes" (a rating of 3) carry on personal conversations without being overheard.

General Satisfaction. About half (49%) the respondents found the acoustical environment of their offices "unsatisfactory "or "very unsatisfactory". Thirty-one percent rated it "satisfactory" or "very satisfactory" (see Table 1). On a five-point scale ranging from "1" (very satisfactory) to "5" (very unsatisfactory), the average rating was 3.30 (between "just right" and "unsatisfactory") (see Table 6).

Testing of the Causal Model

Next, path analysis was used to evaluate the proposed causal model. This technique provides a statistical means of testing a hypothesized causal model. It has the advantage over traditional correlational techniques in that it can distinguish between direct effects, indirect effects, and spurious effects. An overview of the path analysis technique (its purposes, history, assumptions, use, and limitations) is included as Appendix B.

Two assumptions are made in the analysis. First, it is assumed that the causal flow is one way, as shown in Figure 1. In other words, no feedback is allowed. Second, it is assumed that the measures have interval scale properties. This assumption may have been violated because the variables Job Level, Office Openness, and Aural Distraction were measured in the ordinal scale. But the consequences of violating this assumption are not severe (Billings et al., 1978).

In the proposed model, Job Level, Sound Sensitivity, Age, and Sex are exogenous variables, and the other variables are endogenous variables. As shown in Figure 1, the model is over-identified. In other words, some path coefficients were hypothesized to be zero. Table 7 displays the structural equations of the model.

The validity of the model is essentially assessed in its ability to reproduce or closely approximate the correlations among the variables. To reproduce the correlations among the variables, we need to know the path coefficients that represent the direct effects of one variable on another. A series of multiple regression analyses (SPSSX) is run so that the path coefficients for the paths in this relatively complex model can be computed. At each stage, all variables (expressed as Z-scores) assumed to be causes are treated as predictors, and the variable (also expressed in Z-scores) assumed to be the effect is treated as the criterion. The standardized beta weights that result are the path coefficients.

Thus, the first step in the analysis involved computing the standardized scores of the variables in the model. The Z-scores of the variable, Office Openness, was the sum of the Z-scores of Office Type, Number of Employees, Closest Distance to Neighbor, and Closest Distance to a Common Place.

For the proposed model, three multiple regression analyses were run:

(1) Office Openness, Sound Sensitivity, Age, and Sex on Aural Distraction,

(2) Office Openness, Sound Sensitivity, Age, and Sex on Conversational Privacy, and

(3) Aural Distraction and Conversational Privacy on Overall Privacy.

The coefficient for the path from Overall Privacy to Satisfaction with the Acoustical Environment was equal to their Pearson correlation coefficient (r) because Overall Privacy was the only cause in this link. The same was true of the path coefficient between Office Openness and Job Level.

The values of the path coefficients are displayed at Table 8, and a step-by-step computation is at Appendix C. The analysis showed significant direct effects ($p < .05$) of Job Level on Office Openness (.51), of Office Openness on Conversational Privacy (.15), of Age on Conversational Privacy (-.21), of Sex on Conversational Privacy (.48), of Sex on Aural Distraction (-.29), of Aural Distraction on Overall Privacy (-.22), of Conversational Privacy on Overall Privacy (.70), and of Overall Privacy on Satisfaction with the Acoustical Environment (.71).

In other words, the higher the job level, the less open the office. The less open the office, the more conversational privacy one has. The more conversational privacy one has, the more satisfied one is with overall privacy. The less aural distraction one has, the more overall privacy one has. The more satisfied one is with the overall privacy, the more satisfied one is with the general acoustical environment.

With regard to individual characteristics, females or younger employees perceived themselves as having less conversational privacy. Females also had greater aural distractions. Surprisingly, sound sensitivity had very little direct effect on either aural distraction or conversational privacy.

To assess the goodness of fit of the model, a comparison between the reproduced correlations (based on the proposed model) and the observed correlations (based on the data) was made. Kerlinger and Pedhazur (1973) has suggested a rule of thumb that the observed and the recomputed correlations must differ by no more than 0.05. If they do, the causal relationship should not be accepted. Table 10 shows that 22 of the 36 reproduced correlations differ from the observed correlations by no more than 0.05, 6 differ by 0.06 to 0.10, and the remaining 8 differ by more than .10.

A further step involved testing the goodness of fit of the proposed model using Specht's method (see the overview at Appendix B).

$$R^2_m = 1 - (1 - R^2_1)(1 - R^2_2).....(1 - R^2_p)$$

where R_i is the ordinary squared multiple correlation coefficient of i^{th} equation in a fully recursive model. Figure 2 shows a fully recursive model in which all paths between the possible pairs of variables are displayed. On substituting the values for R_1, R_2,...R_p,

$$1 - R2_m = (.753)(.916)(.582)(.336)(.444)$$
$$=.0609$$

For an over-identified model,

$$M = 1 - (1 - R_1^2)(1 - R_2^2).......(1 - R_p^2)$$

On substituting the values for R_1, R_2, ...R_p,

$$1 - M = (.743)(.917)(.594)(.345)(.05)$$
$$= .0698$$

The Q statistics, $[Q = (1 - R_m^2)/(1 - M)]$, is a measure of the goodness of fit; it ranges from 0 (no fit) to 1 (perfect fit). Because it is sample-independent, Pedhazur (1982) has suggested that it is best to set a subjective criterion for rejection of models (for example, if $Q < .95$). In this study, Q equals 0.872. According to Pedhazur's subjective criterion, the model should be rejected.

To assess the strength of the individual relationships, the correlation matrix (Table 10) was reexamined. The observed correlations between Aural Distraction and the variables Conversational Privacy, Overall Privacy, and Satisfaction with the Acoustical Environment matched poorly with their reproduced correlations (a difference of .16 to .22). These results suggest that there may be direct effects of Aural Distraction on Satisfaction with the Acoustical Environment, and of Aural Distraction on Conversational Privacy.

Job Level was hypothesized to affect Aural Distraction indirectly through Office Openness. The results suggest the contrary that there may be a direct effect of Job Level on Aural Distraction.

Sound Sensitivity was hypothesized to be unrelated to either Age or Sex. The analysis indicated otherwise; females or younger employees reported that they were more sound sensitive than males or older workers.

Based on the data, a new causal model is proposed (see Figure 3).

Discussion

In general, the results of this questionnaire survey are consistent with previous findings. Most managers and administrators had private offices, and most secretaries and clerks had open-plan or semi-open offices. As expected, managers and administrators spent more time reading, writing and thinking, whereas clerks and secretaries spent more time on office machine operations, and other repetitive type of work.

To the majority (60%) of office employees, particularly workers in open-plan offices, their offices were "too noisy" or "far too noisy". Distraction from work, difficulty in hearing others, and irritation were the primary reasons given for disturbance by noise.

Noises made by office machines and telephones, and co-workers' conversations were the major sources of distraction. Consistent with Purcell and Thorne's (1977) findings, irrelevant conversations in particular were the most distracting of all co-workers' conversations. Thus, it is useful to examine the degree of information relevance of background conversations on the performance of office tasks of different complexity. This will be the focus of Experiment 1.

The findings about the amount of privacy are also consistent with those of previous attitude surveys (e.g., Hedge, 1981; Louis Harris & Associates, 1978; Nemecek & Grandjean, 1973). About half the employees reported that the overall amount of privacy was either unsatisfactory or very unsatisfactory, and that they could never carry on personal conversations at their desk without being overheard. Consistent with previous findings (e.g., Sundstrom et al., 1982a), workers in open-plan offices in particular found the lack of privacy to be a problem. Females or younger employees were less satisfied with the privacy level in their offices.

Although the hypothesized causal model must be rejected on the basis of Pedhazur's (1982) criterion, the path coefficients between Job Level and Office Openness, between Conversational Privacy and Office Openness, between Overall Privacy and Aural Distraction, and Conversational Privacy, and between Overall Privacy and Satisfaction with the Acoustical Environment are significant. The direct effects between these variables are clear.

The mismatches in observed and reproduced correlation coefficients involve (1) Job Level and Aural Distraction, (2) Aural Distraction and the variables Conversational Privacy, Overall Privacy and Satisfaction with the Acoustical Environment, and (3) Sound Sensitivity and Age, Sex, and Satisfaction with the Acoustical Environment.

The results suggest that first, job level may affect aural distraction directly, in addition to affecting it indirectly through office openness. This finding is consistent with what Marans and Spreckelmeyer (1981) and Ferguson (1983) hypothesized, but is inconsistent with what Ferguson's data showed. It is likely that task or activity type mediates job level and aural distraction. Second, aural distraction may affect satisfaction with the acoustical environment directly, in addition to indirectly through overall privacy. Third, aural distraction may also affect conversational privacy directly.

Fourth, Sound Sensitivity had, surprisingly, a negligible direct effect on either Aural Distraction or Conversational Privacy. Griffiths and DeLauzun (1977) reported that their noise sensitivity self-ratings had low reliability over time. Using a simple three-point self-rating scale, Moreira and Bryan (1972) failed to find any correlations between sound sensitivity and age, sex, education, and job responsibility. As in these two previous studies, the self-rating scale used in this survey may not have been sensitive enough to pick up any subtle individual differences. Contrary to Moreira and Bryan's findings, this study shows that females, and younger workers are more sound sensitive.

Note that office openness and the three individual characteristics have accounted for only 8% of the variance in aural distraction (Table 9). Physical variables of the sound (e.g., sound level, degree of fluctuation in sound level, and type of sound) that may affect aural distraction were not specified in the model tested.

Limitations

As the questionnaire was not originally designed for testing the model, the validity of some variables may be questioned. All except the Office Openness variable were measured with single-item responses. The reliability of these measures is probably low (Nunnally, 1967). Aural

Distraction in particular was measured with a two-point scale, whether or not noise distracted the respondents from their work. If the reliability is low, it may account for the finding that there are negligible direct effects between aural distraction and other variables in the model.

As in many other attitude surveys, voluntary participation did not allow a random sample of office workers to be obtained. In addition, several variables, Job Level, Sex, Age, and Office Type tend to go together; the number of respondents in some categories (e.g., female managers) was so small that it made interpretation of the relations among some variables particularly difficult.

Given the small sample size, no firm conclusions can be drawn. Replications that employ larger sample sizes and multiple measures of the variables are needed.

Table 1

Percentage Distributions of Responses to the Questionnaire Items.

Item	Response	% (N=128)
1. Age	under 30	28.9
	31-40	28.1
	41-50	19.5
	over 50	17.2
	unknown	6.3
2. Sex	male	18.0
	female	77.3
	unknown	4.7
3. Sensitive to noise	yes	22.7
	about average	58.6
	no	17.2
4. Type of office	private	27.6
	semi-open (partitions between all stations)	3.9
	semi-open (partitions between some stations)	26.6
	open-plan	35.2
	other	7.0
5. Central skill	teaching/research	1.6
	managerial/administrative	27.3
	technical	0.8
	clerical/secretarial	65.6
	others	3.1
6. Nature of job	repetitive, routine	46.9
	requires deep thought and concentration	49.2
	requires creativity	27.3
	high confidentiality	44.5
	considerable verbal interaction with others	70.3
	others	3.9

7. A breakdown of daily activities	reading/writing	
	less than 15%	48.4
	less than 30%	70.3
	less than 55%	89.1
	less than 85%	100.0
	office machine operation	
	less than 15%	46.9
	less than 35%	68.8
	less than 60%	90.6
	less than 95%	100.0
	using the telephone	
	less than 20%	71.9
	less than 35%	89.8
	less than 50%	100.0
	face-to-face conversation	
	less than 20%	64.8
	less than 45%	87.5
	less than 80%	100.0
8. % of work time spent in the office	less than 50%	10.2
	less than 80%	45.3
	81-90%	21.1
	91-100%	33.6
9. Sound level	far too quiet	0.0
	too quiet	1.6
	just right	37.5
	too noisy	50.0
	far too noisy	10.9
10. Reasons for noise annoyance	distraction from work	40.6
	difficulty in hearing others	34.4
	difficulty in making others hear them	21.1
	feeling of irritation	30.5
	others	4.7
11. Sources of distraction	office machines	63.3
	telephone rings	69.5
	co-workers' conversation	66.4
	mechanical noises	38.3
	others	25.8

12. Rank order of noise sources in terms of distraction	office machines	rank	1	22.7
			2	19.5
			3	13.3
			4	4.7
	telephone rings	rank	1	27.3
			2	25.8
			3	10.2
			4	3.9
	co-workers' conversation	rank	1	25.8
			2	18.0
			3	14.8
			4	3.9
			5	1.6
	mechanical noises	rank	1	2.3
			2	8.6
			3	10.9
			4	12.5
			5	3.1
	others	rank	1	12.5
			2	4.7
			3	3.9
			4	0.8
			5	2.3
13. Distracting conversations	work-oriented, relevant			12.5
	work-oriented, irrelevant			25.0
	gossip			28.1
	non-gossip, social			36.7
	distant partially intelligible			25.8
	others			13.3
14. Privacy	very satisfactory			12.5
	satisfactory			18.0
	neutral			21.9
	unsatisfactory			21.9
	very unsatisfactory			23.4
15. Ability to carry on a personal conversation	always			7.8
	usually			18.8
	sometimes			26.6
	never			45.3

16. Rating of the acoustical environment	very satisfactory	3.9
	satisfactory	26.6
	neutral	18.8
	unsatisfactory	29.7
	very unsatisfactory	19.5

Table 2.

<u>Cross-tabulation of percentage of respondents by job position and office type</u>

Job position	Office type			
	private	open/semi-open	other	total
managerial/ administrative	71.4	17.1	11.4	100
secretarial/ clerical	8.3	85.7	6.0	100

Table 3.

Number and percentage of respondents in the specified job positions who used the specified skills

Skill	Job position: managerial/ administrative n	managerial/ administrative %	secretarial/ clerical n	secretarial/ clerical %	Chi-square (d.f. = 1)
repetitive, routine	5	14.3	60	64.3	12.63***
deep thought and concentration	23	65.7	40	42.9	2.66
creativity	21	60.0	11	11.9	23.60***
confidential matters	19	54.3	40	42.9	0.70
verbal interaction	29	82.9	61	65.5	1.07

Note.
*** $p < .01$

Total number of managers/administrators = 35.
Total number of secretaries/clerks = 93.

Table 4.

Percentage of respondents in the specified job positions who engaged in the specified activities

Activities	% of time	Job positions: managerial/ administrative	secretarial/ clerical	
reading/writing	0-25%	37.2	76.1	
	26-50%	34.3	16.8	
	51-75%	25.8	3.6	
	76-100%	2.9	3.6	
	mean	38.0	19.0	***
office machine operation	0-25%	94.4	41.6	
	26-50%	2.9	35.7	
	51-75%	2.9	15.5	
	76-100%	0.0	7.2	
	mean	5.0	35.0	***
face-to-face interaction	0-25%	57.3	77.4	
	26-50%	28.6	18.0	
	51-75%	8.6	4.8	
	76-100%	5.7	0.0	
	mean	29.0	19.0	***
telephoning	0-25%	77.2	76.3	
	26-50%	22.9	23.8	
	51-75%	0.0	8.0	
	76-100%	0.0	0.0	
	mean	19.0	20.0	

Note.
*** *t*-test significant at $p < .01$.

Table 5.

Number and percentage of respondents in the specified office type who gave a positive answer

Subjective effect	Office Type				
	private		open/semi-open		
	n	%	n	%	Chi-square (d.f. = 1)
distract from work	7	20.0	39	46.4	4.46**
difficult to hear others	3	8.6	37	44.0	9.25**
difficult to be heard	3	8.6	22	26.2	3.64*
irritable	5	14.3	30	35.7	3.85**

Note.
** $p < .05$
* $p < .10$.

Total number of respondents in private offices = 35.
Total number of respondents in open/semi-open offices = 84.

Table 6

Means and Standard Deviations of Sound Level, Overall Privacy, Conversational Privacy, and Satisfaction with the Acoustical Environment Ratings

Variable	Mean	Standard Deviations
Sound level[a]	3.70	0.68
Overall Privacy[b]	3.19	1.42
Conversational Privacy[c]	3.06	1.05
Satisfaction with the Acoustical environment[b]	3.30	1.25

Note:

[a] on a five-point scale, with "1" indicating "far too quiet" and "5" indicating "far too noisy".

[b] on a five-point scale, with "1" indicating "very satisfactory" and "5" indicating "very unsatisfactory".

[c] on a four-point scale, with "1" indicating "always" and "4" indicating "never".

Table 7.

Structural equations of the proposed model

$$Z_1 = e_1$$

$$Z_2 = e_2$$

$$Z_3 = e_3$$

$$Z_4 = e_4$$

$$Z_5 = p_{51} Z_1 + e_5$$

$$Z_6 = p_{65} Z_5 + p_{62} Z_2 + p_{63} Z_3 + p_{64} Z_4 + e_6$$

$$Z_7 = p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7$$

$$Z_8 = p_{86} Z_6 + p_{87} Z_7 + e_8$$

$$Z_9 = p_{98} Z_8 + e_9$$

Note.
See Figure 1 for a graphic representation of the model.

Table 8.

Path coefficients

$p_{51} = r_{15} = .507^{**}$

$p_{62} = .071$

$p_{63} = -.022$

$p_{64} = -.293^{**}$

$p_{65} = .082$

$p_{72} = .096$

$p_{73} = -.212^{**}$

$p_{74} = .477^{**}$

$p_{75} = .151^{**}$

$p86 = -.224^{**}$

$p_{87} = .704^{**}$

$p_{98} = r_{89} = .707^{**}$

Note:
** $p < 0.05$

See Appendix C for step-by-step computation of the path coefficients.

Table 9.

(a) Testing the Proposed Model: Results of a Series of Multiple Regression Analyses

Criterion	Predictors	R-squared
Office Openness	Job Level	.257**
Aural Distraction	Office Openness Sound Sensitivity Age Sex	.083**
Conversational Privacy	Office Openness Sound Sensitivity Age Sex	.406**
Overall Privacy	Aural Distraction Conversational Privacy	.655**
Satisfaction with the Acoustical Environment	Overall Privacy	.500**

(b) Results of a Series of Multiple Regression Analyses based on a Fully-recursive Model

Criterion	Predictors	R-squared
Office Openness	Job Level Sound Sensitivity Age Sex	.247**
Aural Distraction	Office Openness Sound Sensitivity Age Sex Job Level	.084*
Conversational Privacy	Office Openness Sound Sensitivity Age Sex Job Level	.418**
Overall Privacy	Aural Distraction Conversational Privacy Office Openness Sound Sensitivity Age Sex Job Level	.664**
Satisfaction with the Acoustical Environment	Overall Privacy Aural Distraction Conversational Privacy Office Openness Sound Sensitivity Age Sex Job level	.556**

Note.
** $p < .05$
* $p < .10$

Table 10.

<u>A comparison between observed and reproduced correlations</u>

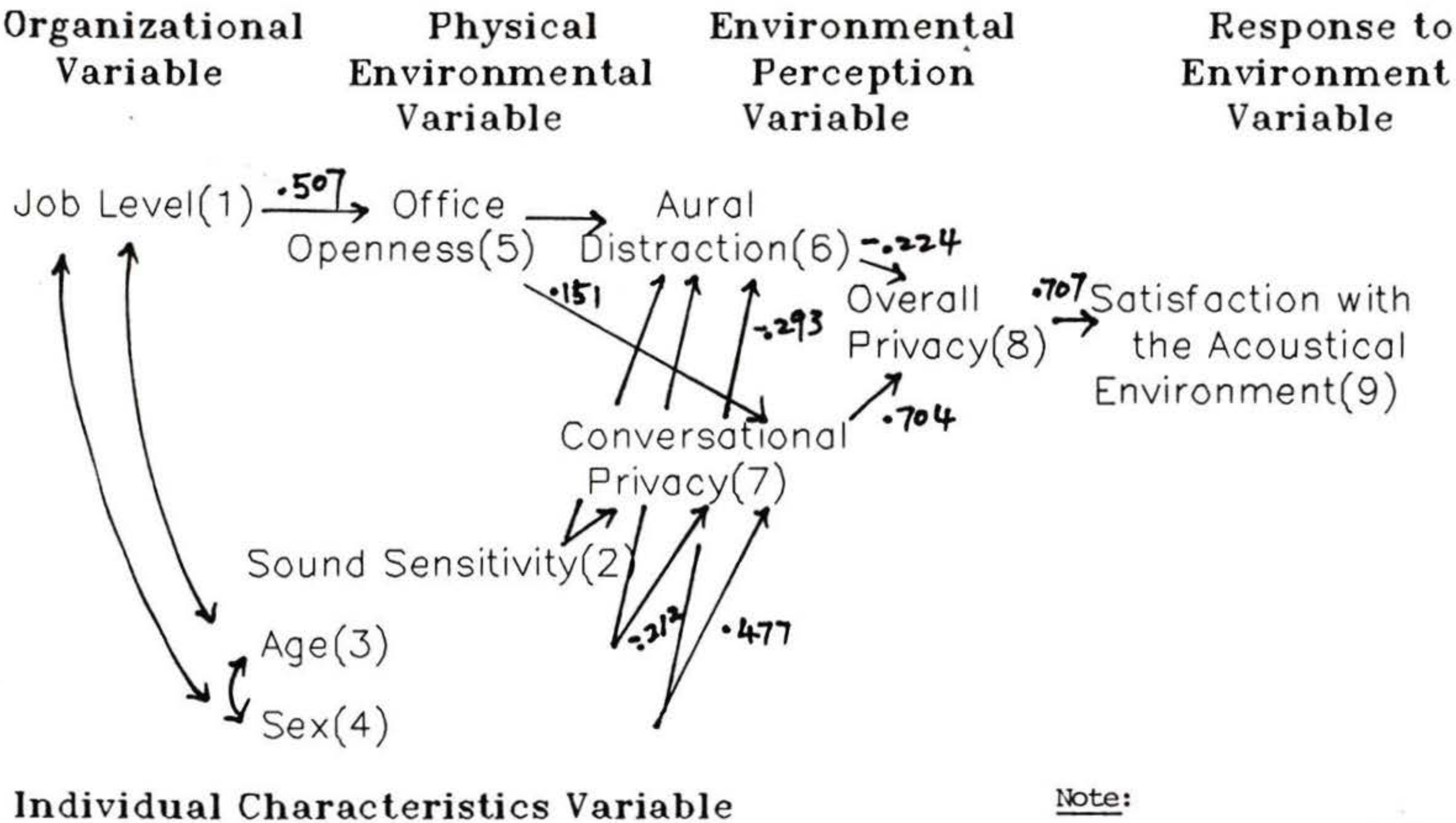
	Job Level	Noise Sensitivity	Age	Sex	Office Openness	Aural Distraction	Conversational Privacy	Overall Privacy	Satisfaction
	1	2	3	4	5	6	7	8	9
1		-.01	-.32	.63	.51	.07	.50	.43	.24
2	.00		.23	-.14	.04	.12	.00	-.02	-.09
3	-.32	.00		-.31	-.12	.08	-.36	-.29	-.18
4	.63	.00	-.31		.34	-.26	.58	.56	.45
5	.51	.00	-.16	.32		.03	.34	.20	.11
6	-.14	.07	.06	-.26	-.01		-.34	-.47	-.44
7	.45	.10	-.38	.59	.34	-.13		.78	.61
8	.34	.05	-.28	.47	.24	-.31	.73		.71
9	.24	.04	-.20	.34	.17	-.22	.52	.71	

<u>Note</u>:

Correlations are based on the Z-scores of variables.

The Z-score of Openness equals the sum of the Z-scores of the variables Office Type, Number of Employees, Closest Distance to Neighbors, and Closest Distance to a Common Place.

The observed correlations are shown in the upper half of the matrix. The reproduced correlations based on the proposed model are shown in the lower half of the matrix.



Note:

The numbers represent the path coefficients that are significant at $\underline{p} < .05$.

Figure 1. Proposed Causal Model of Employee Response to the Office Environment

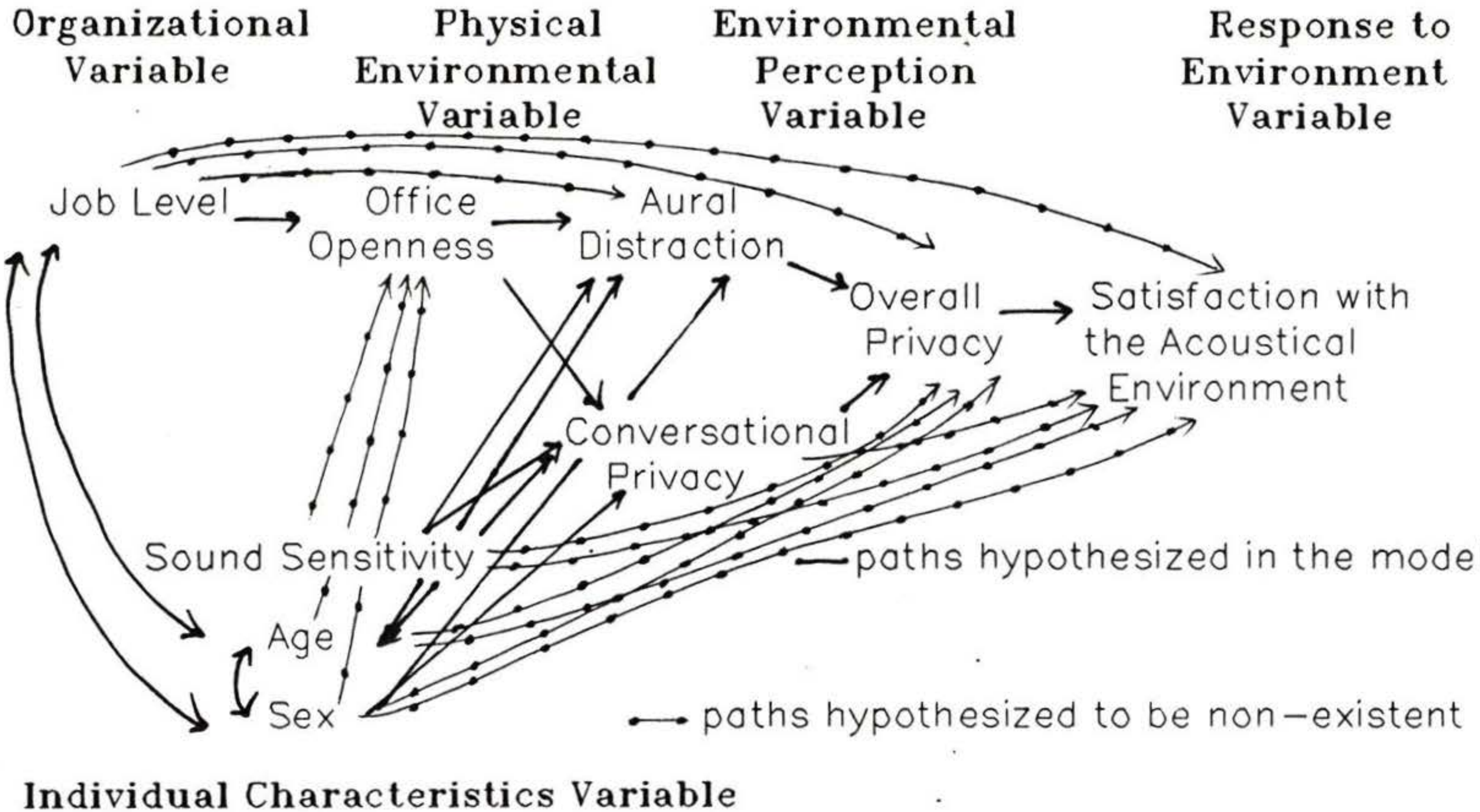


Figure 2. A Fully Recursive Causal Model

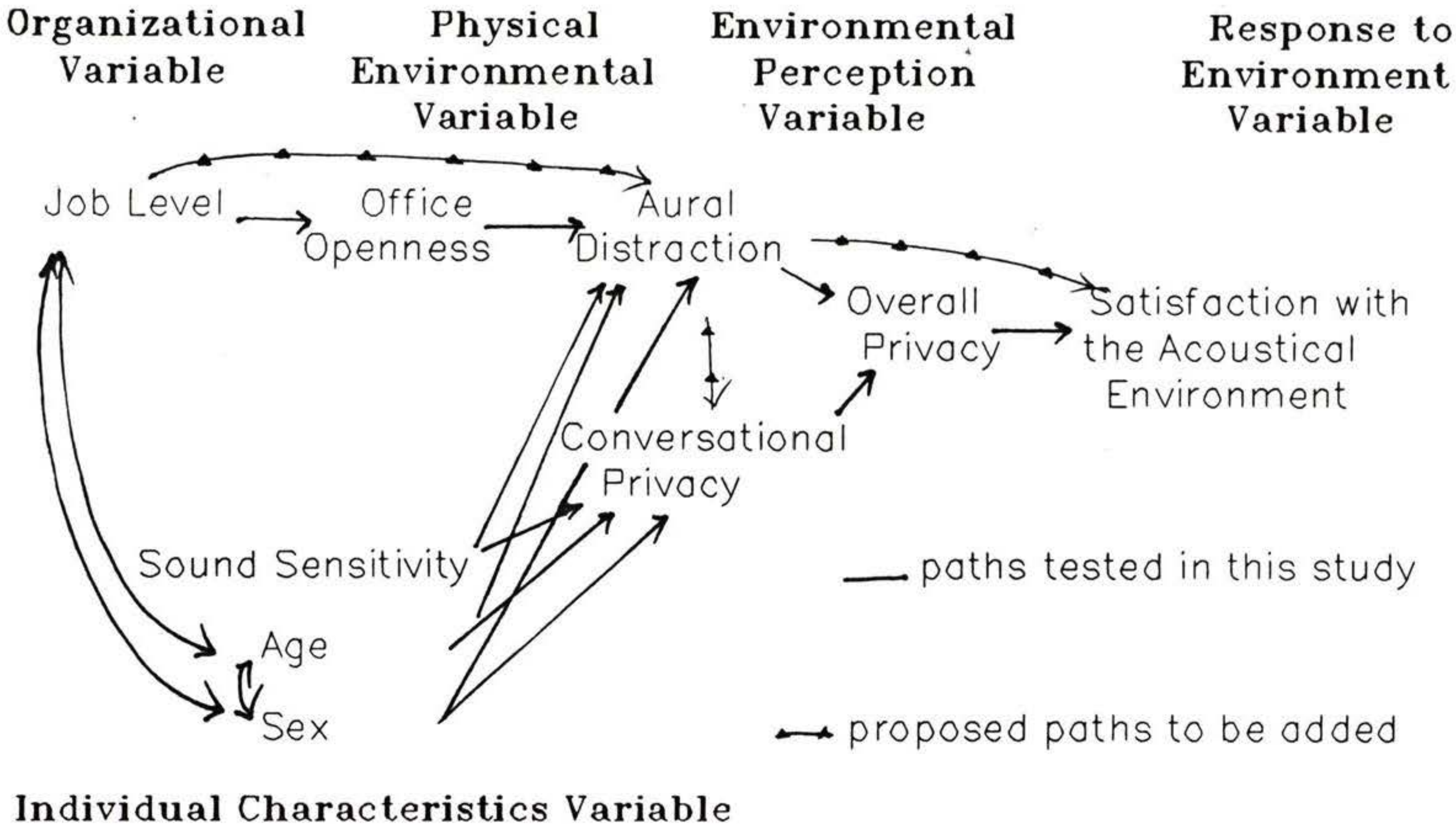


Figure 3. Proposed New Causal Model

Experiment 1

Speech is an important means of communicating with others, but may become a nuisance to people outside the conversation. All of us have, one time or another, been bothered by other people talking nearby when we want to concentrate on our work; we are concerned that the conversation may interfere with our work.

Indeed, conversations of neighboring employees have been reported in a number of attitude surveys to be a prime source of noise disturbance in offices (Boyce, 1974; Hedge, 1981; Keighley, 1970; Man-Environment Systems, 1978; Nemecek & Grandjean, 1973; Purcell & Thorne, 1977; Seal & Sylvester, 1982; Sundstrom et al., 1982a; Sundstrom & Sundstrom, 1986). Similarly, co-workers' conversations were a source of distraction to two-thirds of the respondents in the questionnaire survey just reported; about one-quarter ranked conversations as the most distracting noise source.

Apparently, office workers' reactions are associated with perceived work interference through distraction, reduction in concentration, or interruption in the train of thoughts, more than with mere emotional reponse as annoyance (Purcell & Thorne, 1977).

Is our work performance actually affected by background conversations we overhear? Despite self-reports of distractions by conversations, researchers have rarely studied the behavioral effects of speech or conversation on office task performance under well-controlled conditions.

In one study by Olszewski, Rotton, and Soler (cited in Rotton et al., 1978), non-German-speaking subjects were exposed to a German speech. The speech was presented in short bursts (a few seconds long) in either a fixed- or a random-intermittent schedule. No impairment in the performance of adding and comparing numbers was found. But after the speech had stopped, the subjects in the noise condition made more proofreading errors than those in the control group. This study had at least two problems. First, to non-German speakers, the German speech conveyed no meaning and was probably just another type of noise. Second, the speech was so discontinuous that perhaps it conveyed little meaningful information even to a German speaker.

To eliminate these problems, Rotton et al. (1978) investigated in a later experiment the effects of a loud, uninterrupted English speech on task performance. Their subjects were exposed to noise of either 80 dBA or 43 dBA presented in a random-intermittent schedule. At the same time, three-fourths of the subjects listened to a lecture tape on phobia played at 80 dB, and the remaining one-quarter did not. The results were that speech produced "behavioral aftereffects"; there were reductions in both frustration tolerance and social cue differentiation. After exposure to meaningful speech, subjects made fewer attempts to solve insoluble puzzles, and had difficulty discriminating qualities between stimulus persons. In their study, it was difficult to separate any speech effects from any noise effects because the subjects listened to both at the same time. As Rotton et al. suggested, research is needed to investigate the impact of speech on performance of tasks in everyday life, and to separate the effects of intensity from the effects of meaningfulness of overheard speech.

As in noise, speech or conversation may affect complex tasks and simple tasks differently. In one study, Weinstein (1978) examined the effects of familiar and meaningful speech (a tape-recording of radio news broadcasts) on proofreading performance. No difference in either speed or accuracy in detecting non-contextual errors (misspellings and typographical errors) between subjects in the noise condition and those in the quiet condition was found. However, subjects could not detect contextual errors (grammatical errors, missing words, and incorrect or inappropriate words) as accurately in noise as in quiet.

It should be noted that, in his study, subjects were told immediately before noise exposure to "just try to ignore it and do as well as you can". In everyday situations, however, we attend to conversations we overhear and filter out information selectively instead of simply ignoring all of it.

It is not clear from these three studies whether meaningful background conversations at normal speech levels affect the actual performance of office tasks of different complexity. Thus, the hypothesis that background conversations impair office task performance (Hypothesis 1) is tested in the present study.

Information Content

Some researchers (Boyce, 1974; Nemecek & Grandjean, 1973) have suggested that it is the information content of conversations rather than the noise level per se that is disturbing.

In Purcell and Thorne's (1977) study, talking unrelated to office workers and their immediate tasks in particular was considered an interruption. Examples were "discussions by officers nearby" and "telephone conversations by another officer". Their respondents did not, however, consider conversations related to their own work interruptions.

Similarly, social conversations (gossip and non-gossip) were most distracting to the respondents in the questionnaire survey just reported (28% and 37% of them respectively). Work-oriented but irrelevant conversations were quite distracting too (25%). Work-oriented, relevant conversations were the least distracting (13%). The results of these two studies suggest that irrelevant conversations are more disruptive than are relevant conversations.

On the contrary, both the arousal theory and the information overload theory (described in the Literature Review on Noise Research) suggest that during noise exposure, individuals narrow their focuses of attention; they ignore irrelevant cues first and attend selectively to cues that are relevant to the task they are working on. The information overload theory postuates further that the more meaningful is the noise, the greater will be the decrement in task performance. Based on these theories, relevant conversations should affect task performance more adversely than should irrelevant conversations.

Therefore, the degree of information relevance of background conversations is varied in the present study. Irrelevant conversations and relevant conversations are hypothesized to affect task performance to different extents (Hypothesis 2).

Information Rate and Stimulus Screening Ability

Perhaps different individuals process incoming environmental stimulation differently. Mehrabian (1976) has proposed that there are individual differences in stimulus screening, i.e., in the ability to block out irrelevant stimuli automatically and to habituate to distracting, irrelevant stimuli rapidly.

His Information Rate-Arousal Hypothesis (1977) has postulated that (1) arousal is a direct correlate of the information rate of stimulation, (2) individual differences in arousal responses are accentuated in high information rate settings, (3) these individual differences are due to differences in ability to attend selectively or to "hierarchize" the components of stimulation with respect to importance, and (4) there is an inverse relation between stimulus screening and arousability. In other words, screeners can rank the importance of various components of a complex stimulus situation, are less arousable than non-screeners, and are able to overcome the distraction that irrelevant stimuli cause non-screeners.

In an environment with a high information rate, non-screeners should be more aroused, be more prone to fatigue, and have more psychosomatic complaints than screeners should. Therefore, non-screeners are expected to perform poorly when the information rate is high. In Mehrabian's view, nonscreening reflects a general tendency of an individual to be more sensitive to both positive and negative environmental and interpersonal events. Stimulus screening is viewed as an automatic rather than an intentional process; cognitively mediated, intentional screening is specifically excluded.

Nonetheless, Baum, Davis, Calesnick, and Gatchel (1984) showed that differences in screening applied equally well to cognitively-based strategies of coping with high information rate settings. Their study of dormitory residents showed that screeners living in crowded long-corridor dormitories adapted to such high information rate settings more successfully than did non-screeners.

Information rate has been defined by Mehrabian and Russell (1974) as the amount of information per unit time. The information rate of stimulation consists of the following interrelated dimensions: complex-simple, dense-sparse, varied-redundant, moving-static, random-patterned, novel-familiar, or surprising-usual, with the first adjective in each pair denoting higher information rate.

Based on Mehrabian's conceptualization, it is hypothesized that screeners perform better than non-screeners in the presence of irrelevant information, and especially in high information rate settings (Hypothesis 3).

In summary, the folowing hypotheses are tested in this experiment:

(1) overhearing conversations impairs task performance,

(2) irrelevant conversations impair task performance to a different extent than do relevant conversations,

(3) screeners perform better than non-screeners when in the presence of irrelevant information, and especially in

high information rate settings, and

(4) background conversations lower satisfaction with the work setting.

Method

Research Design

A 2 (Information Rate) x 2 (Information Relevance) x 2 (Stimulus Screening) between-subjects factorial design with a single control group was used (Winer, 1971). Altogether there were eight experimental groups and one control group. Subjects in the control group heard no conversation.

Subjects

Sixty-one female clerks and secretaries working on campus were the subjects of this experiment. They worked in offices of various types and sizes, ranging from one-person private offices to large open-plan offices with over 40 workstations. Six graduate students took part in a pilot run.

Stimuli

The stimuli consisted of four fifty-minute tape recordings of conversations of two different speech rates and two different information contents. Information relevance was determined by the content of the conversations. The relevant conversation was a discussion between two females about the very tasks that the subjects were performing. The irrelevant conversation was an office social conversation between the same two individuals; it included such topics as shopping and a weekend outing. Excerpts of the transcripts of these conversations are in Appendix D. The conversations were recorded on audiotapes with a Revox A 700 tape recorder in a recording studio.

The speech rate (in words per minute) measures the total amount of information conveyed in a given oral segment per unit time (Emmert & Brooks, 1976). In this experiment, information rate was operationalized as the speech rate of a conversation. The original recordings of the two conversations (one with relevant content, and the other with irrelevant content) were copied at two different but realistic speech rates by means of a Lexicon Varispeech -- Speech Time Compressor/Expander (Model 27). The natural speeds of the conversations were 130-140 words per minute. The faster presentation (at about 200 words per minute) conveys more information in the same time period than does the slower one (at about 100 words per minute). Both the faster and the slower conversations had the pitch of normal conversations.

Rating Scale

Individual differences in stimulus screening ability were measured with Mehrabian's Stimulus Screening and Arousability Scale (1976) (Appendix E). It consists of 40 items in nine intercorrelated subgroups: (1) low general arousability, (2) rapid habituation (3) low arousability to sudden changes and events, (4) thermal screening, (5) low arousability in novel or changing settings, (6) auditory screening (e.g., "I don't react much to sudden loud sounds"), (7) tactual and kinesthetic screening, (8) olfactory screening, and (9) low arousability in multi-component or complex settings. The 40 items are balanced to control for response bias; one set of 20 items is positively worded, and a second set of 20 items is negatively worded. The response to each item is made on a nine-point rating scale, ranging from -4 (very strong disagreement) to +4 (very strong agreement). Mehrabian (1976) claimed that the rating scale had satisfactorily high internal consistency and was essentially free of social desirability bias.

Tasks

Subjects performed six simulated office tasks: filing, telephone number search, calculation, spelling, comprehension, and proofreading. These tasks were developed based on a survey of previous studies on clerical work (Farh & Scott, 1983; Monk & Conrad, 1979; Silverstone & Towler, 1984) and clerical aptitude tests (General Clerical Test, 1944-72; Guion, 1965).

More specifically, the filing, telephone number search, calculation, and comprehension tasks were modified from the

General Clerical Test. The spelling items were taken from a list of words commonly misspelled by college students. The proofreading task involved comparing a type-written copy (with errors) with a good handwritten copy of an article taken from a psychology journal and correcting the errors on the typewritten copy. The types of mistakes included omissions and reversals of letters or words, and typographical errors. A copy of the tasks is at Appendix F.

Procedure

Forty-four Department Heads and Heads of administrative units on campus were asked in writing for their permission to ask for voluntary participation from employees in their units (see Appendix G). After their letters of permission had been received, the clerks and secretaries in those units were approached in person. The purpose of the study and the requirements for participation were explained to them (see Appendix H). If they wished to take part, they signed up on a form so that they could be contacted for appointments later (see Appendix I).

After the subjects had signed up for the experiment, they were asked to complete Mehrabian's Stimulus Screening and Arousability Scale. Based on a median split of the scores, half of the 61 office workers (whose scores ranged from -27 to 87) was labelled screeners, and the other half (whose scores ranged from -140 to -28) was labelled non-screeners. The median score is very close to Mehrabian's (1976) scale mean norm of -24. Subjects in each category (screeners or non-screeners) were then assigned randomly to one of the four experimental conditions (the possible combinations of information relevance and information rate) or to the control group.

The experimental room was set up to simulate an office. It measured 4.6 by 6.1 metres, was carpeted, and was reasonally well sound insulated. The ambient noise level of the experimental room was about 30 decibels. There were three desks in the room, with several partitions (1.54 metres high) on one side (see the layout plan and the photographs in Appendices J & K). A reel-to-reel stereo tape recorder, two speakers and an amplifier (both made by an electronics technician) were placed in the space on the other side of the partitions. The speakers were placed at the subjects' head level when seated.

When the subjects arrived for the experiment, they were asked to take their seats at the desks, to make themselves comfortable, and then to read the instructions (see Appendix L). The experimenter then answered any questions that the subjects might have, went to the other side of the partitions, and turned on the tape recorder. Except in the control condition, subjects heard a conversation of two individuals in the background for the rest of the experimental session. The content and the speed of the conversation varied, depending on which experimental condition the subject(s) was(were) in. The tapes of these conversations were played at about 45-50 dBA, a level that normally occurs in offices (Keighley, 1970; Nemecek & Grandjean, 1973).

The experimenter then instructed the subjects to begin. The subjects performed the series of office tasks in the following order: (1) filing, (2) telephone number search, (3) calculation, (4) spelling, (5) comprehension, and (6) proofreading. Task performance was measured as Speed (the amount of time taken to complete each of the tasks), and Accuracy (the percentage of correct answers).

As soon as the subject(s) began to work on the first task, the experimenter started to time their work by turning on a digital stop watch in her pocket. She went into the adjoining control room where she watched the activities of the subjects through a one-way mirror. When a subject had finished one task, she put it back in the envelope and deposited it in her "out tray". She then picked up the next task from her "in tray". This procedure allowed the experimenter to monitor when a subject began and when she finished a task. The experimenter recorded the time taken for each subject to complete each of the tasks. Most subjects took about thirty to forty-five minutes to complete the six tasks.

At the end of the session, the subject was asked to report her level of satisfaction with the setting in a short questionnaire (see Appendix M). The questionnaire also contained a few items designed to check the experimental manipulations. When the subject had finished, she signed a consent form for the use of her data (Appendix N). The experimenter thanked her for her participation, and encouraged her to make any comments about the experiment.

Data were collected in February and March of 1985.

Results

The results are presented in three parts. The first section presents information about the setting up of the conditions for testing the hypotheses. The second section presents the results on performance, followed by the results on satisfaction.

Subject Loss

Sixty-one subjects completed Mehrabian's Stimulus Screening Scale. Six or seven subjects were originally assigned to each of the nine conditions. Unfortunately, five subjects in the experimental conditions dropped out because of heavy workload. They failed to take part in the experimental session when their task performance would be measured. Appointments were made with these subjects a few times, but were cancelled later.

Altogether 56 subjects took part in the experiment. Because of technical problems, three subjects in the experimental conditions did not hear the background conversation as planned. As a result, they were treated as subjects in the control group.

Manipulation Checks

The Extent to which the Conversation was Heard. The subjects were aware of the conversation in the background. In response to the question "Did you hear a conversation in the background while you were working on the tasks?", 18 subjects (39% of the 46 subjects in the experimental groups) indicated that they heard it all the time. Another 14 (30%) heard it most of the time; seven subjects (15%) heard it half the time; the remaining 7 (15%) heard it some of the time. When a rating of "1" was assigned to the response "heard it all the time" and a rating of "5" to "heard it none of the time", the average rating was 2.07 (most of the time).

Information Relevance. The responses to the question "How relevant was the content of the conversation to the tasks you performed?" were analyzed. As shown in Table 11, 52% of the 46 subjects in the Relevant experimental conditions reported that the conversation content was relevant to the tasks they performed, but 16% thought that it was irrelevant. On the other hand, 90% of those in the Irrelevant condition thought that the conversation was irrelevant.

Apparently, there was a gap between the degree of relevance as perceived by the subjects and as manipulated objectively. Nevertheless, if the subjects had heard both conversations, they would agree that the "relevant" conversation was more relevant than was the "irrelevant" one.

Information Rate. Similar results were obtained for the speeds of the background conversations (see Table 11). To forty-eight percent of the subjects in the High Information Rate condition, the conversation seemed faster than conversations they normally heard, whereas to 13% of the subjects, it was slower. Of those subjects in the Low Information Rate condition, 83% agreed that the background conversation was slower than conversations they normally heard.

Although some subjects in the High Information Rate condition did not find the conversation faster than the conversations they normally heard, the objective speech rates of the conversations were different.

The Sound Level of the Simulated Office. The simulated office was about as loud as the subjects' own offices. In response to the question "Was the environment during the study noisier, quieter, or about the same as the office in which you work everyday?", 70% of the 56 subjects indicated that it was about the same or a bit noisier. Six subjects said that it was very much noisier, 18 noisier, 14 about the same, 4 quieter, and 11 (7 in the control group) very much quieter. If a rating of "1" indicates "very much noisier" and a rating of "5" indicates "very much quieter", the average rating is 2.63 (about the same).

Reliability of Mehrabian's Stimulus Screening Scale

As shown in Appendix E, the scores of half of the items were reversed in direction before the total score of each subject was computed. For example, a response of +4 on Item 3 "My strong emotions in a situation carry over for one or two hours after I leave it." was recoded -4. A high score indicates good stimulus screening ability, and a low score indicates poor ability. The maximum total score is 160, and the minimum is -160.

The mean score of the 56 subjects in this experiment is -22, and the standard deviation is 44. Both are consistent with the scale norms (mean -24, standard deviation 39) (Mehrabian, 1976). The subjects in the experimental groups (mean score = -20) and in the control group (mean score = -29) did not differ in their stimulus screening abilities; their mean scores were not significantly different [$t(54) = -.058$, two-tailed $p = .56$].

The internal consistency of the scale was quite high (Cronbach's alpha = .93).

Next, the results on performance are presented.

Relationships between Accuracy and Speed.

Task performance was measured as both speed and accuracy. Table 12 presents the correlation coefficients between task speed and task accuracy. The only significant correlation was between proofreading speed and accuracy (r = .36, one-tailed p < .05); as expected, more accurate proofreading took longer to complete than did less accurate proofreading.

As shown in Table 13, the accuracy of each task correlated significantly with Overall Accuracy (r ranging from .38 to .68, one-tailed p < .05); the only exception was filing accuracy (r = .10). One plausible reason is that filing accuracy may have a ceiling effect; four of the eight experimental conditions had 100% accuracy. Among the tasks, calculation accuracy and proofreading accuracy were significantly correlated (r = .26, one-tailed p < .05), probably because calculation and proofreading are relatively complex tasks. So was calculation accuracy significantly correlated with accuracy in telphone number search (r = .22, one-tailed p < .05); both calculation and telephone number search involve working with numbers.

Similarly, Overall Speed was significantly correlated with the speed of each and every task (r ranging from .48 to .64, one-tailed p < .05) (Table 14). Unlike accuracy, the speeds of completion were significantly correlated with one another (*r* ranging from .22 to .46, one-tailed $p < .05$), except for (1) proofreading with filing, (2) both spelling and proofreading with telephone number search, calculation, or comprehension. These findings suggest that proofreading is quite different from the other tasks.

Performance

A multivariate analysis of variance (MANOVA) was used to analyze the data of the 56 subjects; Accuracy and Speed were the dependent measures, and Conversation Condition was the independent variable with nine levels (i.e., eight experimental groups and one control group). Where Accuracy and Speed are not significantly correlated, the univariate *F*-tests results are used to interpret the data. The following contrasts were designated in the MANOVA program:

1. information relevance: relevant vs. irrelevant
2. information rate: high vs. low
3. stimulus screening ability: screener vs. non-screener
4. the interaction of (1) and (2)
5. the interaction of (2) and (3)
6. the interaction of (1) and (3)
7. the interaction of (1), (2), and (3)
8. conversation: presence (experimental) vs. absence (control).

In addition to overall performance, the performance of each task was examined one by one so that any differential effects of background conversations on tasks of different complexity can be determined. Tables 15 to 21 display the means and standard deviations of Accuracy and Speed of the six tasks. The data were analyzed with six separate multivariate analyses. The results of the MANOVAs and the univariate F-tests are summarized in Table 22. Because the correlation coefficients between Accuracy and Speed of filing, telephone number search, calculation, spelling, or comprehension were very low and not significant (r ranging from -.20 to -.06, p ranging from .07 to .33), the results of univariate F-tests were examined as well.

Hypothesis 1. The control group was expected to perform better (faster and more accurate) than the experimental groups. The data did not provide enough evidence to reject the null hypothesis. As Overall Accuracy and Overall Speed were not significantly correlated ($n = 56$, $r = .03$, one-tailed $p < .05$), the univariate F-test results were examined.

As the last column of Table 15 reveals, the control group appeared to be more accurate than the experimental groups (mean = 93.8% vs. 91.3%), but the difference in the means of Overall Accuracy did not reach statistical significance [$F(1,47) = 3.41$, $p = .07$].

Table 15 also shows that the control group was not any faster than the experimental groups (mean = 537 vs. 513

seconds). The effect of Conversation on Overall Speed was not significant [$F(1,47) = 0.64$, $p = .43$].

Furthermore, background conversations did not affect either Accuracy or Speed of any of the six tasks. Even the most complex task, proofreading, was not significantly affected. Table 21 shows that the control group appeared to be more accurate than the experimental groups (83.7% vs. 75.1%). However, a MANOVA showed no significant main effect of Conversation on performance [Wilks lambda = .92, $F(2,46) = 1.92$, $p = .16$].

Hypothesis 2. Irrelevant conversations were expected to affect task performance differently than were relevant conversations. As Table 22 shows, of the six task speeds, only Spelling Speed was affected significantly by Information Relevance. The results of a MANOVA were that the Relevance main effect on productivity was significant [Wilks lambda = .88, $F(2,46) = 3.11$, $p < .05$]. Univariate F-tests showed that only Speed was significant [$F(1,47) = 5.14$, $p < 0.05$], but Accuracy was not. Subjects in the irrelevant information condition (308 seconds) spelled significantly more slowly than those in the relevant condition (254 seconds) (see Table 19).

Neither the overall performance nor the performance of the other five tasks were affected significantly by information relevance.

Hypothesis 3. Screeners were expected to perform better than non-screeners when in the presence of irrelevant conversations, and especially in high information rate settings. This hypothesis has received some support.

Overall Performance. A MANOVA showed that Information Relevance and Stimulus Screening in combination affected Overall Speed. Overall Accuracy was, however, not affected significantly.

Univariate *F*-tests showed that the Information Relevance by Stimulus Screening interaction on Overall Speed was significant [$F(1,47) = 4.70$, $p < .05$]. As predicted, screeners worked faster than non-screeners by an average of 46 seconds when irrelevant information was present (see Figure 4 and the third horizontal section of Table 15). Non-screeners, however, worked faster than did screeners by an average of 58 seconds when relevant information was present. Screeners worked faster (by an average of 30 seconds) when the information was irrelevant than when it was relevant. In contrast, non-screeners worked significantly faster (by an average of 74 seconds) when the information was relevant than when it was irrelevant [$t(21) = 6.30$, two-tailed $p < .05$].

It appears that screeners are better able to block out irrelevant information and, as a result, can work faster or at least are unaffected by the information under those circumstances. When relevant information is present, non-screeners can take in the information that help them work faster.

Calculation. Univariate *F*-tests showed that the three-way interaction effect of Information Relevance, Information Rate, and Stimulus Screening on Speed was significant [$F(1,47) = 4.26$, $p < .05$].

As shown in Figure 5, for both non-screeners and screeners, there was a difference in Speed between high information and low information rate conditions when the information was relevant. When the information was relevant, non-screeners calculated much faster when the information rate was high (389 seconds) than when it was low (601 seconds), whereas screeners calculated faster when the information rate was low (507 seconds) than when it was high (688 seconds). On the other hand, no such differences occurred when the information was irrelevant.

The pattern is not exactly as predicted. Screeners appeared to calculate faster than non-screeners when the the information was irrelevant (520 vs. 605 seconds), although the difference in speeds did not reach statistical significance [$F(1,47) = 3.37$, $p = .07$]. Similarly, when the information was irrelevant and the information rate was high, screeners seemed to calculate faster (496 seconds) than non-screeners (605 seconds), but their mean speeds were not significantly different.

As shown in Figure 5, the most important difference between screeners' and non-screeners' responses lies in the speed when the information was relevant and the information rate was high; screeners (688 seconds) were significantly slower than non-screeners (389 seconds) [$t(11) = 5.16$, two-tailed $p < .05$]. In addition, non-screeners seemed to be fastest in the relevant information, high information rate condition; the Least Significant Difference test (at $p < .05$) showed that the mean speed is significantly different from the mean speeds of the other three conditions.

Spelling. A MANOVA showed that Information Relevance and Stimulus Screening interacted to affect Spelling Speed. Consistent with prediction, screeners spelled faster than non-screeners when the information was irrelevant (281 vs. 333 seconds); on the other hand, non-screeners spelled faster than screeners when the information was relevant (223 vs. 274 seconds) (see Figure 6). Univariate F-tests showed that the interaction effect of Information Relevance and Stimulus Screening on Speed was significant [$F(1,47) = 5.33$, $p < 0.05$). Non-screeners spelled significantly faster when the information was relevant (223 seconds) than when it was irrelevant (333 seconds) [$t(21) = 8.02$, two-tailed $p < .05$].

In addition, Information Relevance, Information Rate, and Stimulus Screening in combination affected Spelling Accuracy. Univariate F-tests showed that the three-way interaction effect on Accuracy was significant [$F(1,47) = 4.38$, $p < .05$].

As shown in Figure 7, the pattern is not as expected. For non-screeners, there was a significant difference in Accuracy between High and Low Information Rate conditions when the information was irrelevant (96.7% vs. 87.0%) [$t(9) = 3.57$, two-tailed $p < .05$]. For screeners, such difference in Accuracy occurred when the information was relevant (96.7% vs. 89.3%).

This pattern may, in part, be due to the contrary to prediction Information Rate effect; both screeners and non-screeners were significantly more accurate when the information rate was high (94.8%) than when it was low (90.7%) [$F(1,47) = 5.29$, $p < .05$]. A plausible explanation will be provided in the Discussion section.

The performance of neither filing, telephone number search, comprehension, nor proofreading was affected significantly by information relevance, information rate, and stimulus screening in combination.

Summary

The background conversation did not affect the overall performance or the performance of any of the tasks significantly. Among the experimental groups, only spelling speed was lowered by irrelevant conversations more than by relevannt conversations. As hypothesized, screeners and non-screeners responded differently in different situations; non-screeners worked faster overall and on spelling when the information was relevant than when it was irrelevant, whereas screeners were less affected by information relevance. Screeners seemed to work faster than did non-screeners when the irrelevant conversation was present, especially on calculations and spelling, but not in high information rate settings as predicted. Contrary to prediction, low information rate seemed to be more disruptive of speed than did high information rate; a plausible explanation will be discussed later.

Finally, the results on satisfaction are presented.

Satisfaction

Background conversations were expected to lower the satisfaction level of subjects in the experimental groups (Hypothesis 4).

Satisfaction was measured with responses to the questions "Did the conversation make your work more enjoyable than if the room was silent?" (Enjoyability) and "How much did the conversation distract you from your work?" (Distraction). Subjects in the control group did not answer this question because they did not hear any conversation.

Enjoyability. Subjects in the experimental groups reported that the background conversation had made their work less enjoyable than when the room was silent. The response ratings ranged from "much more enjoyable" (1) to "much less enjoyable" (5). The mean Enjoyability rating of the subjects in all experimental conditions was 4.17 (less enjoyable) (See Table 23).

Distraction. The response ratings of distraction ranged from 1 "very much" to 5 "not at all". The mean distraction rating of the subjects in all experimental conditions was 2.85, indicating that the subjects found the conversation fairly distracting (see Table 24).

The Enjoyability and Distraction ratings were not significantly correlated ($n = 46$, $r = -.22$, $p = .07$). To determine if any of the experimental conditions lowered satisfaction more than others, two analyses of variance were performed. The dependent measure was Enjoyability or Distraction, and the independent variables were Information Rate, Information Relevance, and Stimulus Screening. No significant main or interaction effects was found.

Discussion

Subjective Effects

This experiment has showed clearly that background conversations are fairly distracting; they make office employees' work less enjoyable than when in quiet. These findings about office workers' subjective feelings are consistent with those reported in a number of attitude surveys, including the questionnaire survey just reported. Other people's talking is a prime source of noise disturbance in the office. As in Purcell and Thorne's (1979) study, subjects believe that background conversations have detrimental effects on their performance.

Behavioral Effects

Whether background conversations actually affect office workers' performance is less definite. Goldstein and DeJoy (1980) have concluded that few performance decrements occur under continuous noise below 80 dB that lacks special meaning. Sundstrom and Sundstrom (1986) have also concluded that predictable or regular noise has little adverse effect on the performance of routine clerical or mental tasks.

This experiment has failed to show that background conversations (that have meaning) at lower than 80 dB affect the overall accuracy or the overall speed of several office tasks. This finding is inconsistent with office workers' subjective feelings that they find background conversations fairly distracting. One plausible explanation is that subjects try to compensate any detrimental effects of distraction by working harder than they normally do. Consequently, they may be able to maintain the same level of performance, but at the expense of greater effort.

The hypothesis that irrelevant conversations affect task performance differently than do relevant conversations has received very limited support; only spelling speed was significantly affected. This finding suggests that office workers' perceived effects may be more accurate than what the arousal theory and the information overload theory propose.

Individual Differences

More importantly, it appears that individuals with different stimulus screening abilities are affected differently by background conversations under different circumstances. The hypothesis that screeners perform better than non-screeners when irrelevant information is present has received limited support. Non-screeners worked significantly faster overall and on spelling when the information was relevant than when it was irrelevant. Screeners seemed to work faster than did non-screeners when irrelevant information was present. When relevant information was present, however, non-screeners seemed to work faster than screeners on those same tasks.

It appears that screeners can block out irrelevant information and as a result, can work faster or at least are unaffected by the information. When relevant information is present, non-screeners can take in the information that helps them work faster.

The hypothesis that screeners perform better than non-screeners in high information rate settings is not supported. In fact, the results are contrary to prediction. One plausible explanation for the unexpected findings is that speech rate does not validly measure information rate. As Mehrabian (1974) pointed out, no exact measure of information rate is generally available.

Objectively, the faster presentation of the conversations contains more information per unit time than does the slower one. The speech rates of the conversations are within the normal speech rate range. That the conversation was faster than normal to some subjects implies that some subjects may have difficulty following the background conversation. Consequently, the conversation did not convey any meaning and was merely a noise to them. When the speech rate was low, the subjects could listen to the conversation and may have found it more distracting. As a result, the fast conversation did not distract them as much as did the slow one. Unfortunately, we do not know if the subjects in the high information rate condition thought that the conversation was too fast to be comprehensible while also working.

Validity and Reliability of the Rating Scale

Conceptually, Mehrabian's Stimulus Screening and Arousability Scale seems to be the most relevant scale to use in this experiment. The internal consistency of the scale was quite high ($r = .93$), but only three items measured auditory screening and the internal consistency of these items was lower ($r = .71$). A valid and reliable scale that measures auditory screening specifically may be more desirable.

Mehrabian's scale may require further validation. In Baum et al.'s (1984) study of dormitory residents, subjects' scores on Mehrabian's scale were compared with responses to an open-ended question about the ways they would deal with a demanding situation. Seventy-one percent of the subjects in the top quartile on Mehrabian's scale gave responses that seemed typical of screeners, such as "make priorities, and the stuff on the bottom of the list doesn't get done". Seventy-seven percent of those in the bottom quartile gave responses that seemed typical of non-screeners, such as "I would try to get out of the situation and possibly go crazy if I couldn't".

In response to a similar open-ended question, the great majority of the subjects in this study provided "screeners' responses" even though their scores on Mehrabian's scale were low (indicating that they were non-screeners). This finding suggests that Mehrabian's scale may have low construct validity. Or perhaps office workers have learned to rank demands more readily than have the college students in Baum et al.'s study. Moreover, some subjects commented that the items were vaguely and poorly worded.

Had a larger sample size been obtained, it would have been possible to divide subjects into three categories on the basis of their stimulus screening scores (upper, middle, and lower). Only those subjects in either the upper (screeners) or the lower category (non-screeners) would be used. If this were done, a clearer distinction between subjects' stimulus screening type could be made.

Relationships between Task Accuracy and Task Speed

This experiment has shown that accuracy and speed of several office tasks are not related. The only exception is proofreading, which is presumably the most complex of the tasks; more accurate proofreading implies slower proofreading. In general, task speeds are significantly correlated with one another. On the other hand, task accuracies are not related to one another.

Accuracy in filing may have a ceiling effect, as suggested by 100% accuracy in several experimental conditions. It is desirable to make the task more difficult, if at all possible, so that there will be greater variability in subjects' performance.

Limitations

There are a number of limitations to the findings of this experiment. The most obvious problem is the small sample size. Great effort was expended on recruiting office workers to be subjects of the experiment. Permission to approach workers were denied by some heads of departments and administrative units. In other offices, workers were not allowed to participate in the experiment during office hours. A small number of office workers felt that they were indispensable and could not take an hour off.

Because of a heavy workload, several office workers dropped out after they had completed only the stimulus screening scale. The loss of subjects has made the number of subjects in the experimental conditions unequal, and consequently has created additional difficulties in data interpretation.

Overall, background conversations at normal speech levels do not have any significant adverse effects on office task performance. As in many laboratory studies of noise on performance, subjects were exposed to noise (background conversation in this case) for a short period of time (30-45 minutes in this experiment). Whether prolonged exposure to background conversations has any detrimental effect on performance is not clear.

Evident from the results of this experiment, it is difficult to operationalize information relevance and information rate. In this experiment, information relevance was determined by the conversation content. A good percentage of the subjects in the information relevant condition, however, did not perceive the information to be relevant to the tasks they performed. If they have listened to both conversation, they will agree that one is more relevant than the other. Intuitively, whether a piece of information is relevant depends very much on an individual's present concerns. One wonders if perceived relevance may be a better operational definition of information relevance than objective relevance.

As for information rate, this study has shown clearly that speech rate alone may be an inaccurate measure of information rate. One may try varying the redundancy, predictability, and familiarity of content in addition to varying the speech rate (Mehrabian, 1974). The relative information rates of a number of conversations may be determined by independent judges before the conversations are used as stimuli in experiments.

Future research should focus on valid operationalization of the constructs of information relevance and information rate, and on the development of more sensitive rating scales to measure individual characteristics.

Table 11.

Responses to the Manipulation Check Items

A. "How relevant was the content of the conversation to the tasks you performed?"

		Frequency of response			
		Relevant	Neutral	Irrelevant	Total
Experimental Condition	Relevant	13	8	4	25
	Irrelevant	0	2	19	21

B. "Did the conversation seem faster, slower or about the same as conversations you normally hear?"

		Frequency of response			
		Faster	Neutral	Slower	Total
Experimental Condition	Faster	11	9	3	23
	Slower	0	4	19	23

Table 12.

Correlation Coefficients between Accuracy and Speed

Task	r
filing	-.08
telephone number search	-.06
calculation	-.07
spelling	-.20 *
comprehension	-.17
proofreading	.36 **
average	.03

Note

$N = 56$

** $p < .05$; * $p < .10$

Table 13.

Correlation Coefficient Matrix of Accuracy of Tasks

	Task					
Task	1	2	3	4	5	6
1 filing						
2 telephone number search	.13					
3 calculation	.15	.22**				
4 spelling	-.10	.04	-.07			
5 comprehension	.02	.08	-.01	.05		
6 proofreading	-.10	.15	.26**	.14	-.05	
average	.10	.46**	.42**	.38**	.53**	.68**

Note

$N = 56$

** $p < .05$; * $p < .10$

Table 14.

Correlation Coefficient Matrix of Speed of Tasks

	Task					
Task	1	2	3	4	5	6
1 filing						
2 telephone number search	.44**					
3 calculation	.23**	.42**				
4 spelling	.46**	.18*	.20*			
5 comprehension	.38**	.22*	.32**	.14		
6 proofreading	.04	-.06	.02	.29**	.18*	
average	.48**	.53**	.64**	.53**	.60**	.62**

Note

N = 56

** $p < .05$; * $p < .10$

Table 15.

Means and Standard Deviations of Overall Performance

		Relevant		Irrelevant		Total	
		Accu-racy (% correct)	Speed (sec.)	Accu-racy (% correct)	Speed (sec.)	Accu-racy (% correct)	Speed (sec.)
High Information Rate							
Non-screeners	N	7	7	6	6	13	13
	mean	92.3	438	92.5	527	92.4	479
	s.d.	2.7	72	2.3	73	2.4	83
Screeners	N	6	6	4	4	10	10
	mean	91.2	552	91.0	490	91.1	527
	s.d.	3.3	80	3.5	68	3.2	78
total	N	13	13	10	10	23	23
	mean	91.8	490	91.9	512	91.9	500
	s.d.	2.9	93	2.8	70	2.8	83
Low Information Rate							
Non-screeners	N	5	5	5	5	10	10
	mean	89.0	523	92.0	572	90.5	547
	s.d.	5.9	132	2.9	78	4.7	105
Screeners	N	7	7	6	6	13	13
	mean	89.6	513	92.3	508	90.8	511
	s.d.	3.6	70	4.6	44	4.1	57
total	N	12	12	11	11	23	23
	mean	89.3	517	92.1	537	90.7	527
	s.d.	4.5	95	3.7	67	4.3	82

Total (Experimental groups)								
	Non-screeners	N	12	12	11	11	23	23
		mean	90.9	473	92.3	547	91.6	509
		s.d.	4.4	105	2.5	75	3.6	97
	Screeners	N	13	13	10	10	23	23
		mean	90.4	531	91.8	501	91.0	518
		s.d.	3.4	74	4.0	52	3.7	66
	total	N	25	25	21	21	46	46
		mean	90.6	503	92.0	525	91.3	513
		s.d.	3.9	93	3.2	68	3.6	82
Control group								
	Non-screeners	N					5	5
		mean					94.7	541
		s.d.					5.2	49
	Screeners	N					5	5
		mean					92.8	534
		s.d.					4.6	104
	total	N					10	10
		mean					93.8	537
		s.d.					4.7	77
All subjects								
	Non-screeners	N					28	28
		mean					92.1	515
		s.d.					4.0	91
	Screeners	N					28	28
		mean					91.3	521
		s.d.					3.8	72
	Total	N					56	56
		mean					91.7	518
		s.d.					3.9	81

Table 16.

Means and Standard Deviations of Filing Task Performance

		Relevant Accuracy (% correct)	Relevant Speed (sec.)	Irrelevant Accuracy (% correct)	Irrelevant Speed (sec.)	Total Accuracy (% correct)	Total Speed (sec.)
High Information Rate							
Non-screeners	N	7	7	6	6	13	13
	mean	98.6	123	98.3	130	98.5	126
	s.d.	3.8	10	4.1	18	3.8	14
Screeners	N	6	6	4	4	10	10
	mean	100.0	148	100.0	122	100.0	137
	s.d.	0.0	50	0.0	19	0.0	41
total	N	13	13	10	10	23	23
	mean	99.2	134	99.0	127	99.1	131
	s.d.	2.8	35	3.2	18	2.9	29
Low Information Rate							
Non-screeners	N	5	5	5	5	10	10
	mean	98.0	137	100.0	159	99.0	148
	s.d.	4.5	12	0.0	55	3.2	39
Screeners	N	7	7	6	6	13	13
	mean	98.6	130	100.0	136	99.2	133
	s.d.	3.8	22	0.0	38	2.8	29
total	N	12	12	11	11	23	23
	mean	98.3	133	100.0	146	99.1	139
	s.d.	3.9	18	0.0	45	2.9	34

Total (Experimental groups)								
Non-screeners	N	12	12	11	11	23	23
	mean	98.3	129	99.1	143	98.7	136
	s.d.	3.9	13	3.0	40	3.4	29
Screeners	N	13	13	10	10	23	23
	mean	99.2	138	100.0	130	99.6	135
	s.d.	2.8	37	0.0	31	2.1	34
total	N	25	25	21	21	46	46
	mean	98.8	134	99.5	137	99.1	135
	s.d.	3.3	28	2.2	36	2.8	31
Control group							
Non-screeners	N					5	5
	mean					100.0	142
	s.d.					0.0	48
Screeners	N					5	5
	mean					100.0	125
	s.d.					0.0	19
total	N					10	10
	mean					100.0	134
	s.d.					0.0	35
All subjects							
Non-screeners	N					28	28
	mean					98.9	137
	s.d.					3.1	32
Screeners	N					28	28
	mean					99.6	133
	s.d.					1.9	32
Total	N					56	56
	mean					99.3	135
	s.d.					2.6	32

Table 17.

Means and Standard Deviations of Telephone Number Search Performance

		Relevant Accuracy (% correct)	Relevant Speed (sec.)	Irrelevant Accuracy (% correct)	Irrelevant Speed (sec.)	Total Accuracy (% correct)	Total Speed (sec.)
High Information Rate							
Non-screeners	*N*	7	7	6	6	13	13
	mean	98.6	535	95.0	678	96.9	601
	s.d.	3.8	73	5.5	240	4.8	179
Screeners	*N*	6	6	4	4	10	10
	mean	95.0	588	90.0	514	93.0	559
	s.d.	5.5	65	8.2	153	6.7	108
total	*N*	13	13	10	10	23	23
	mean	96.9	560	93.0	612	95.2	583
	s.d.	4.8	72	6.7	217	5.9	151
Low Information Rate							
Non-screeners	*N*	5	5	5	5	10	10
	mean	98.0	626	96.0	556	97.0	591
	s.d.	4.5	120	5.5	110	4.8	115
Screeners	*N*	7	7	6	6	13	13
	mean	91.4	593	95.0	539	93.1	568
	s.d.	6.9	90	8.4	78	7.5	86
total	*N*	12	12	11	11	23	23
	mean	94.2	607	95.5	546	94.8	578
	s.d.	6.7	100	6.9	90	6.7	98

Total (Experimental groups)								
Non-screeners	N	12	12	11	11	23	23
	mean	98.3	573	95.5	622	97.0	597
	s.d.	3.9	101	5.2	194	4.7	152
Screeners	N	13	13	10	10	23	23
	mean	93.1	591	93.0	529	93.0	564
	s.d.	6.3	77	8.2	107	7.0	94
total	N	25	25	21	21	46	46
	mean	95.6	582	94.3	578	95.0	580
	s.d.	5.8	88	6.8	162	6.2	126
Control group							
Non-screeners	N					5	5
	mean					98.0	566
	s.d.					4.5	184
Screeners	N					5	5
	mean					96.0	624
	s.d.					5.5	202
total	N					10	10
	mean					97.0	595
	s.d.					4.8	185
All subjects							
Non-screeners	N					28	28
	mean					97.1	591
	s.d.					4.6	154
Screeners	N					28	28
	mean					93.6	575
	s.d.					6.8	118
Total	N					56	56
	mean					95.4	583
	s.d.					6.0	136

Table 18.

Means and Standard Deviations of Calculation Performance

		Relevant		Irrelevant		Total	
		Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)
High Information Rate							
Non-screeners	N	7	7	6	6	13	13
	mean	96.2	389	94.4	605	95.4	489
	s.d.	6.5	110	7.8	234	6.9	203
Screeners	N	6	6	4	4	10	10
	mean	95.6	688	93.3	496	94.7	611
	s.d.	5.4	327	5.4	137	5.3	275
total	N	13	13	10	10	23	23
	mean	95.9	527	94.0	561	95.1	542
	s.d.	5.8	273	6.6	200	6.1	239
Low Information Rate							
Non-screeners	N	5	5	5	5	10	10
	mean	93.3	601	94.7	606	94.0	603
	s.d.	4.7	141	5.6	89	4.9	111
Screeners	N	7	7	6	6	13	13
	mean	98.1	507	97.8	536	97.9	520
	s.d.	3.3	91	3.4	103	3.2	93
total	N	12	12	11	11	23	23
	mean	96.1	547	96.4	567	96.2	557
	s.d.	4.5	119	4.6	99	4.4	108

Total (Experimental groups)							
Non-screeners	N	12	12	11	11	23	23
	mean	95.0	478	94.5	605	94.8	539
	s.d.	5.8	160	6.5	175	6.0	176
Screeners	N	13	13	10	10	23	23
	mean	96.9	591	96.0	520	96.5	560
	s.d.	4.4	240	4.7	112	4.4	194
total	N	25	25	21	21	46	46
	mean	96.0	537	95.2	565	95.7	549
	s.d.	5.1	210	5.6	151	5.3	184
Control group							
Non-screeners	N					5	5
	mean					98.7	515
	s.d.					3.0	84
Screeners	N					5	5
	mean					97.3	510
	s.d.					6.0	250
total	N					10	10
	mean					98.0	513
	s.d.					4.5	176
All subjects							
Non-screeners	N					28	28
	mean					95.5	534
	s.d.					5.8	162
Screeners	N					28	28
	mean					96.7	551
	s.d.					4.6	201
Total	N					56	56
	mean					96.1	543
	s.d.					5.2	181

Table 19.

Means and Standard Deviations of Spelling Performance

		Relevant		Irrelevant		Total	
		Accu-racy (% correct)	Speed (sec.)	Accu-racy (% correct)	Speed (sec.)	Accu-racy (% correct)	Speed (sec.)
High Information Rate							
Non-screeners	N	7	7	6	6	13	13
	mean	90.7	263	96.7	271	93.5	266
	s.d.	6.1	72	2.6	37	5.5	57
Screeners	N	6	6	4	4	10	10
	mean	96.7	299	96.3	246	96.5	278
	s.d.	4.1	70	4.8	51	4.1	66
total	N	13	13	10	10	23	23
	mean	93.5	279	96.5	261	94.8	271
	s.d.	5.9	71	3.4	42	5.1	60
Low Information Rate							
Non-screeners	N	5	5	5	5	10	10
	mean	92.0	191	87.0	408	89.5	299
	s.d.	8.4	36	10.4	175	9.3	165
Screeners	N	7	7	6	6	13	13
	mean	89.3	252	94.2	304	91.5	276
	s.d.	6.7	51	3.8	88	5.9	72
total	N	12	12	11	11	23	23
	mean	90.4	227	90.9	351	90.7	286
	s.d.	7.2	54	8.0	138	7.4	119

Total (Experimental groups)								
Non-screeners	N	12	12	11	11	23	23
	mean	91.3	223	92.3	333	91.7	281
	s.d.	6.8	68	8.5	134	7.5	115
Screeners	N	13	13	10	10	23	23
	mean	92.7	274	95.0	281	93.7	277
	s.d.	6.7	63	4.1	78	5.7	68
total	N	25	25	21	21	46	46
	mean	92.0	254	93.6	308	92.7	279
	s.d.	6.6	67	6.7	112	6.6	93
Control group							
Non-screeners	N					5	5
	mean					92.0	323
	s.d.					7.6	68
Screeners	N					5	5
	mean					93.0	317
	s.d.					8.4	108
total	N					10	10
	mean					92.5	320
	s.d.					7.5	85
All subjects							
Non-screeners	N					28	28
	mean					91.8	288
	s.d.					7.4	108
Screeners	N					28	28
	mean					93.6	284
	s.d.					6.1	76
Total	N					56	56
	mean					92.7	286
	s.d.					6.7	93

Table 20.

Means and Standard Deviations of Comprehension Performance

		Relevant		Irrelevant		Total	
		Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)
High Information Rate							
Non-screeners	*N*	7	7	6	6	13	13
	mean	91.8	381	95.2	386	93.4	383
	s.d.	13.9	73	11.7	63	12.5	65
Screeners	*N*	6	6	4	4	10	10
	mean	85.7	502	85.7	456	85.7	483
	s.d.	12.8	108	20.2	180	15.1	134
total	*N*	13	13	10	10	23	23
	mean	89.0	437	91.4	414	90.1	427
	s.d.	13.2	107	15.4	120	13.9	110
Low Information Rate							
Non-screeners	*N*	5	5	5	5	10	10
	mean	85.7	536	91.4	459	88.6	498
	s.d.	10.1	278	7.8	100	9.0	201
Screeners	*N*	7	7	6	6	13	13
	mean	89.8	489	92.9	521	91.2	504
	s.d.	10.8	86	7.8	137	9.3	108
total	*N*	12	12	11	11	23	23
	mean	88.1	509	92.2	493	90.1	501
	s.d.	10.3	181	7.5	120	9.1	151

Total (Experimental groups)								
	Non-screeners	N	12	12	11	11	23	23
		mean	89.3	446	93.5	419	91.3	433
		s.d.	12.4	193	9.8	86	11.2	149
	Screeners	N	13	13	10	10	23	23
		mean	87.9	495	90.0	495	88.8	495
		s.d.	11.4	92	13.6	150	12.1	118
	total	N	25	25	21	21	46	46
		mean	88.6	472	91.8	455	90.1	464
		s.d.	11.7	148	11.6	124	11.6	136
Control group								
	Non-screeners	N					5	5
		mean					91.4	486
		s.d.					19.2	138
	Screeners	N					5	5
		mean					91.4	428
		s.d.					12.8	89
	total	N					10	10
		mean					91.4	457
		s.d.					15.4	114
All subjects								
	Non-screeners	N					28	28
		mean					91.3	443
		s.d.					12.5	146
	Screeners	N					28	28
		mean					89.3	483
		s.d.					12.1	114
	Total	N					56	56
		mean					90.3	463
		s.d.					12.2	132

Table 21.

Means and Standard Deviations of Proofreading Performance

		Relevant		Irrelevant		Total	
		Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)	Accuracy (% correct)	Speed (sec.)
High Information Rate							
Non-screeners	N	7	7	6	6	13	13
	mean	78.1	937	75.6	1093	76.9	1009
	s.d.	11.5	253	10.7	285	10.8	269
Screeners	N	6	6	4	4	10	10
	mean	74.4	1084	80.8	1109	77.0	1094
	s.d.	17.5	201	14.0	434	15.7	292
total	N	13	13	10	10	23	23
	mean	76.4	1005	77.7	1099	77.0	1046
	s.d.	14.0	234	11.7	329	12.8	276
Low Information Rate							
Non-screeners	N	5	5	5	5	10	10
	mean	66.7	1046	82.7	1242	74.7	1144
	s.d.	25.4	318	9.2	250	19.9	289
Screeners	N	7	7	6	6	13	13
	mean	70.5	1106	73.9	1016	72.1	1064
	s.d.	10.8	254	13.2	160	11.6	212
total	N	12	12	11	11	23	23
	mean	68.9	1081	77.9	1119	73.2	1099
	s.d.	17.4	270	12.0	227	15.4	246

Total (Experimental groups)								
Non-screeners	N	12	12	11	11	23	23
	mean	73.3	982	78.8	1160	75.9	1068
	s.d.	18.5	273	10.2	268	15.0	280
Screeners	N	13	13	10	10	23	23
	mean	72.3	1096	76.7	1053	74.2	1077
	s.d.	13.8	222	13.2	282	13.4	245
total	N	25	25	21	21	46	46
	mean	72.8	1041	77.8	1109	75.1	1072
	s.d.	15.9	249	11.5	273	14.1	260
Control group							
Non-screeners	N					5	5
	mean					88.0	1214
	s.d.					6.9	248
Screeners	N					5	5
	mean					79.3	1197
	s.d.					6.4	139
total	N					10	10
	mean					83.7	1206
	s.d.					7.8	189
All subjects							
Non-screeners	N					28	28
	mean					78.1	1094
	s.d.					14.6	276
Screeners	N					28	28
	mean					75.1	1099
	s.d.					12.5	232
Total	N					56	56
	mean					76.6	1096
	s.d.					13.6	252

Table 22.

A Summary of the Significant Effects of Information Rate, Information Relevance and Stimulus Screening Type on Performance.

A. Overall performance

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
experimental vs. control	1.94	.16	accuracy	3.41	.07*
			speed	0.64	.43
relevance by screening	2.30	.11	accuracy	0.03	.87
			speed	4.70	.04**

B. Telephone number search

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
screening	3.23	.05*	accuracy	5.23	.03**
			speed	0.93	.34

C. Calculation

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
relevance by screening	1.71	.19	accuracy	0.11	.74
			speed	3.37	.07*
rate by screening	2.50	.09**	accuracy	2.31	.14
			speed	2.86	.10*
relevance by rate by screening	2.10	.13	accuracy	0.03	.85*
			speed	4.26	.05**

D. Spelling

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
relevance	3.11	.05*	accuracy	0.48	.49
			speed	5.14	.03**
rate	2.66	.08**	accuracy	5.29	.03**
			speed	0.60	.44
rate by relevance	4.97	.01*	accuracy	0.53	.47
			speed	10.12	.01**
relevance by screening	2.61	.08**	accuracy	0.20	.65
			speed	5.33	.03**
relevance by rate by screening	2.39	.10**	accuracy	4.38	.04**
			speed	1.11	.30

E. Comprehension

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
rate	1.61	.21	accuracy	0.07	.93
			speed	3.20	.08*

F. Proofreading

Effect	Multivariate test $F(2,46)$	p		Univariate test $F(1,47)$	p
expt. vs. control	1.92	.16	accuracy	3.13	.08*
			speed	2.02	.16

Note.
** $p < .05$;
* $p < .10$

Table 23.

Means and Standard Deviations of Enjoyability Ratings

		Relevant	Irrelevant	Total
High Information Rate				
Non-screeners	N	7	6	13
	mean	4.14	4.00	4.08
	s.d.	1.07	0.89	0.95
Screeners	N	6	4	10
	mean	4.00	3.75	3.90
	s.d.	1.26	0.96	1.10
total	N	13	10	23
	mean	4.08	3.90	4.00
	s.d.	1.11	0.88	1.00
Low Information Rate				
Non-screeners	N	5	5	10
	mean	4.80	4.20	4.50
	s.d.	0.45	0.45	0.53
Screeners	N	7	6	13
	mean	3.57	5.00	4.23
	s.d.	1.13	0.00	1.09
total	N	12	11	23
	mean	4.08	4.64	4.35
	s.d.	1.08	0.50	0.88
Total				
Non-screeners	N	12	11	23
	mean	4.42	4.09	4.26
	s.d.	0.90	0.70	0.81
Screeners	N	13	10	23
	mean	3.77	4.50	4.09
	s.d.	1.17	0.85	1.08
total	N	25	21	46
	mean	4.08	4.29	4.17
	s.d.	1.08	0.78	0.95

Note. Responses to "Did the conversation make your work more enjoyable than if the room was silent?" :

Rating scale: "1" indicates "much more enjoyable",
"2" indicates "more enjoyable",
"3" indicates "no effect",
"4" indicates "less enjoyable", and
"5" indicates "much less enjoyable".

Table 24.

Means and Standard Deviations of Distraction Ratings

		Relevant	Irrelevant	Total
High Information Rate				
Non-screeners	N	7	6	13
	mean	2.57	3.00	2.77
	s.d.	0.79	0.89	0.83
Screeners	N	6	4	10
	mean	3.00	3.25	3.10
	s.d.	1.26	1.50	1.29
total	N	13	10	23
	mean	2.77	3.10	2.91
	s.d.	1.01	1.10	1.04
Low Information Rate				
Non-screeners	N	5	5	10
	mean	2.00	3.00	2.50
	s.d.	1.41	0.71	1.18
Screeners	N	7	6	13
	mean	3.00	3.00	3.00
	s.d.	1.16	0.89	1.00
total	N	12	11	23
	mean	2.58	3.00	2.78
	s.d.	1.31	0.77	1.09
Total				
Non-screeners	N	12	11	23
	mean	2.33	3.00	2.65
	s.d.	1.07	0.77	0.98
Screeners	N	13	10	23
	mean	3.00	3.10	3.04
	s.d.	1.15	1.10	1.11
total	N	25	21	46
	mean	2.68	3.05	2.85
	s.d.	1.14	0.92	1.05

Note. Responses to "How much did the conversation distract you from your work?" on a five-point rating scale ranging from 1 (very much) to 5 (not at all).

Figure 4. Overall Speed as a Function of Information Relevance and Stimulus Screening

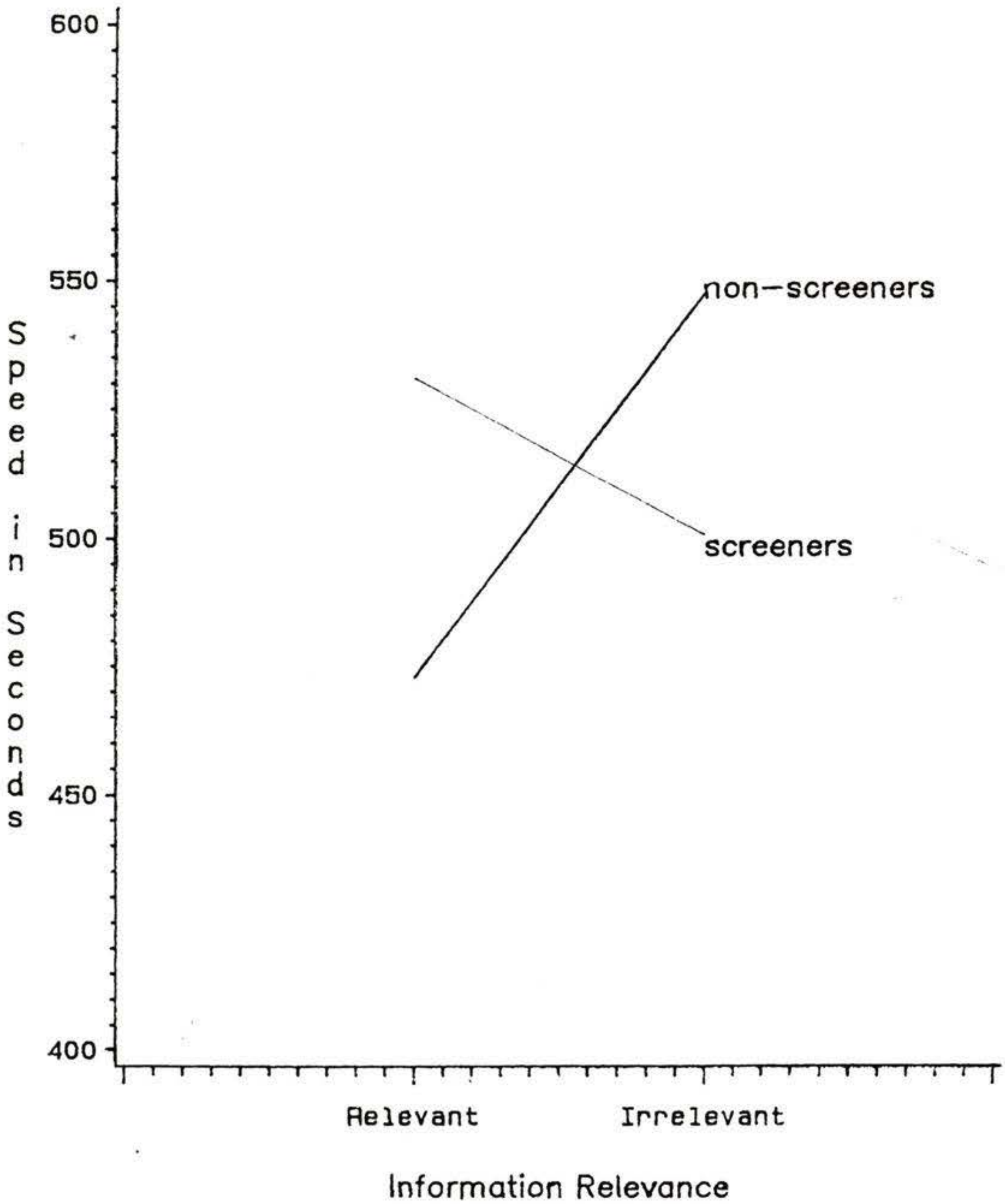


Figure 5. Calculation Speed as a Function of Information Relevance, Information Rate, and Stimulus Screening

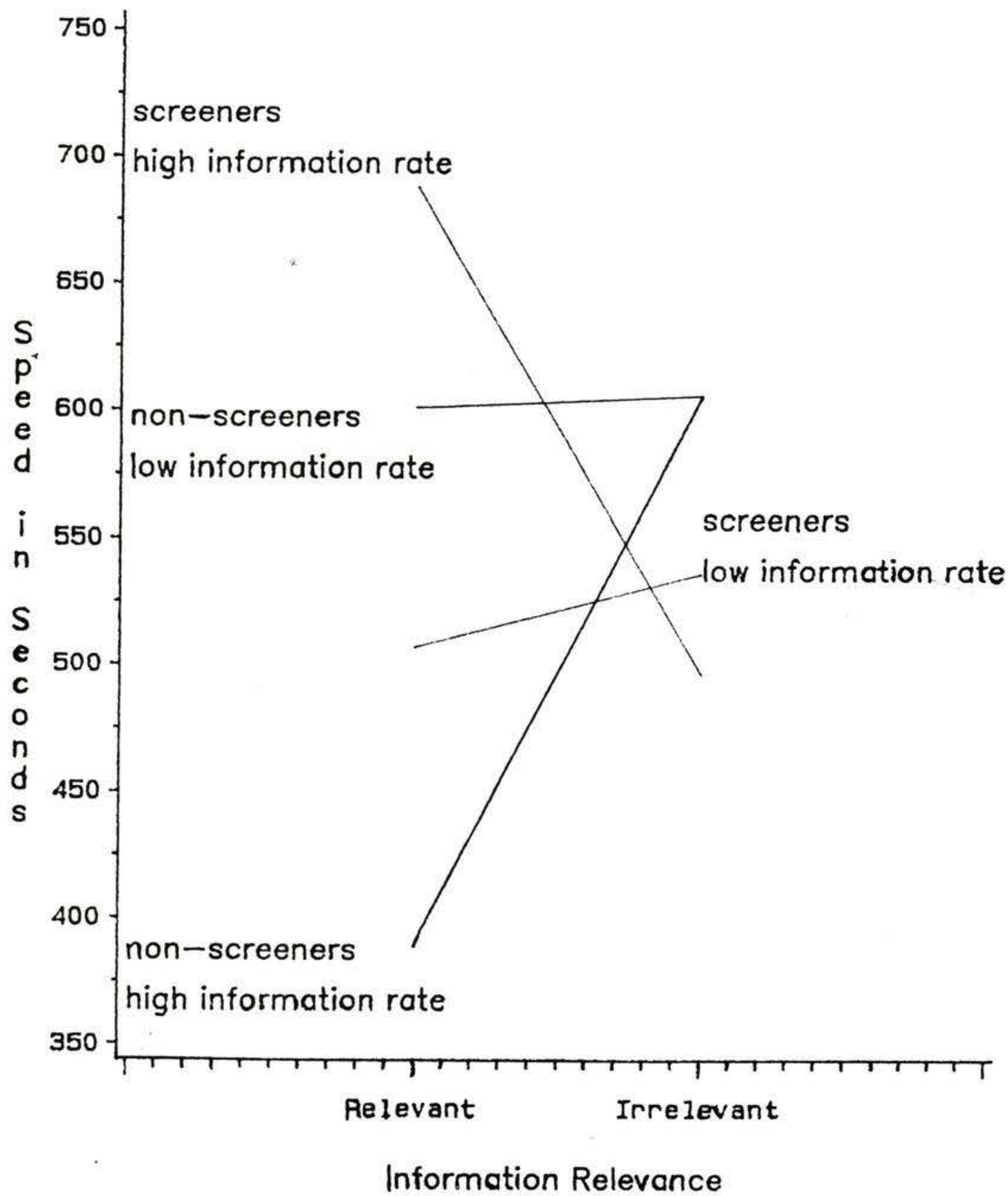


Figure 6. Spelling Speed as a Function of Information Relevance and Stimulus Screening

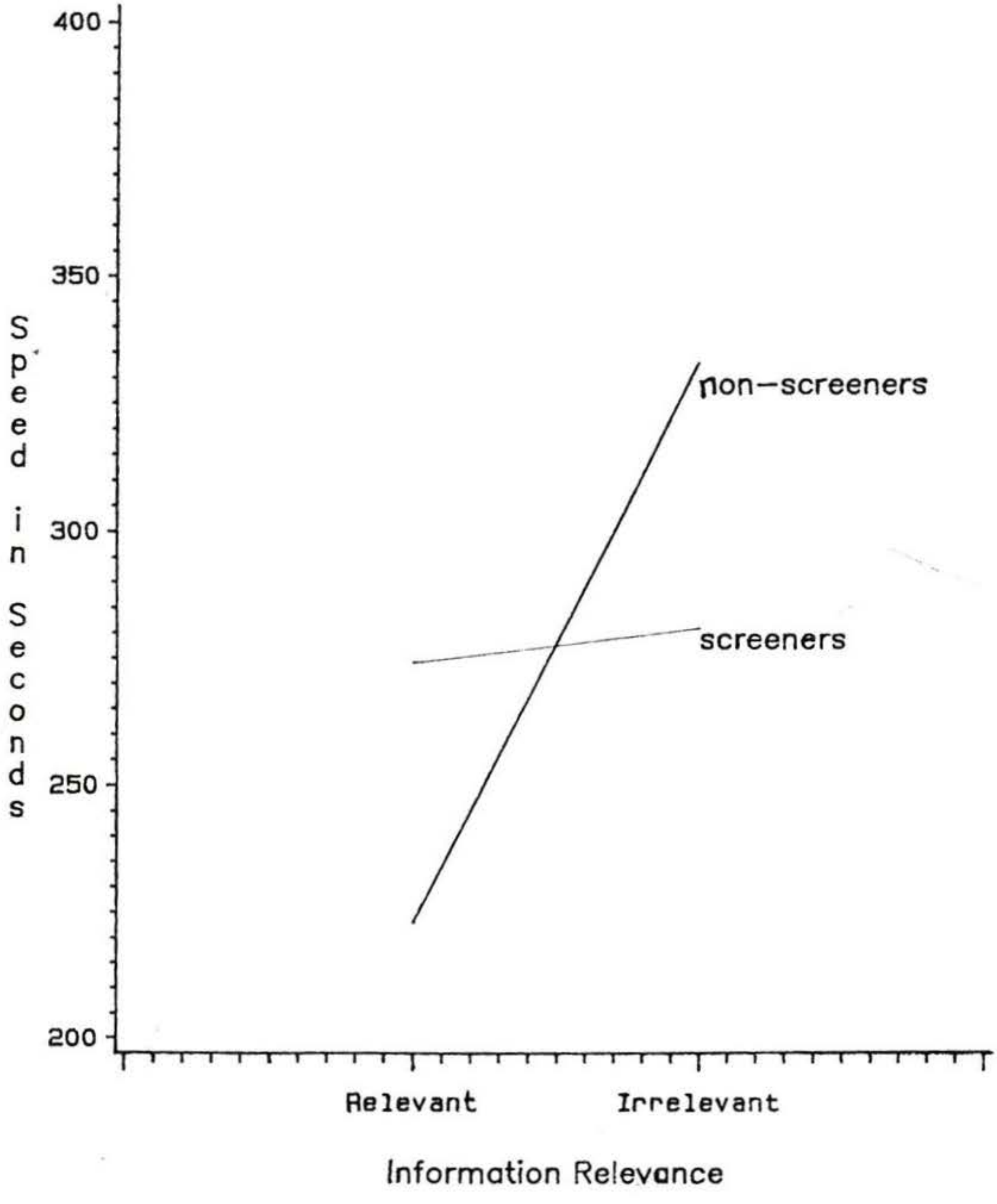
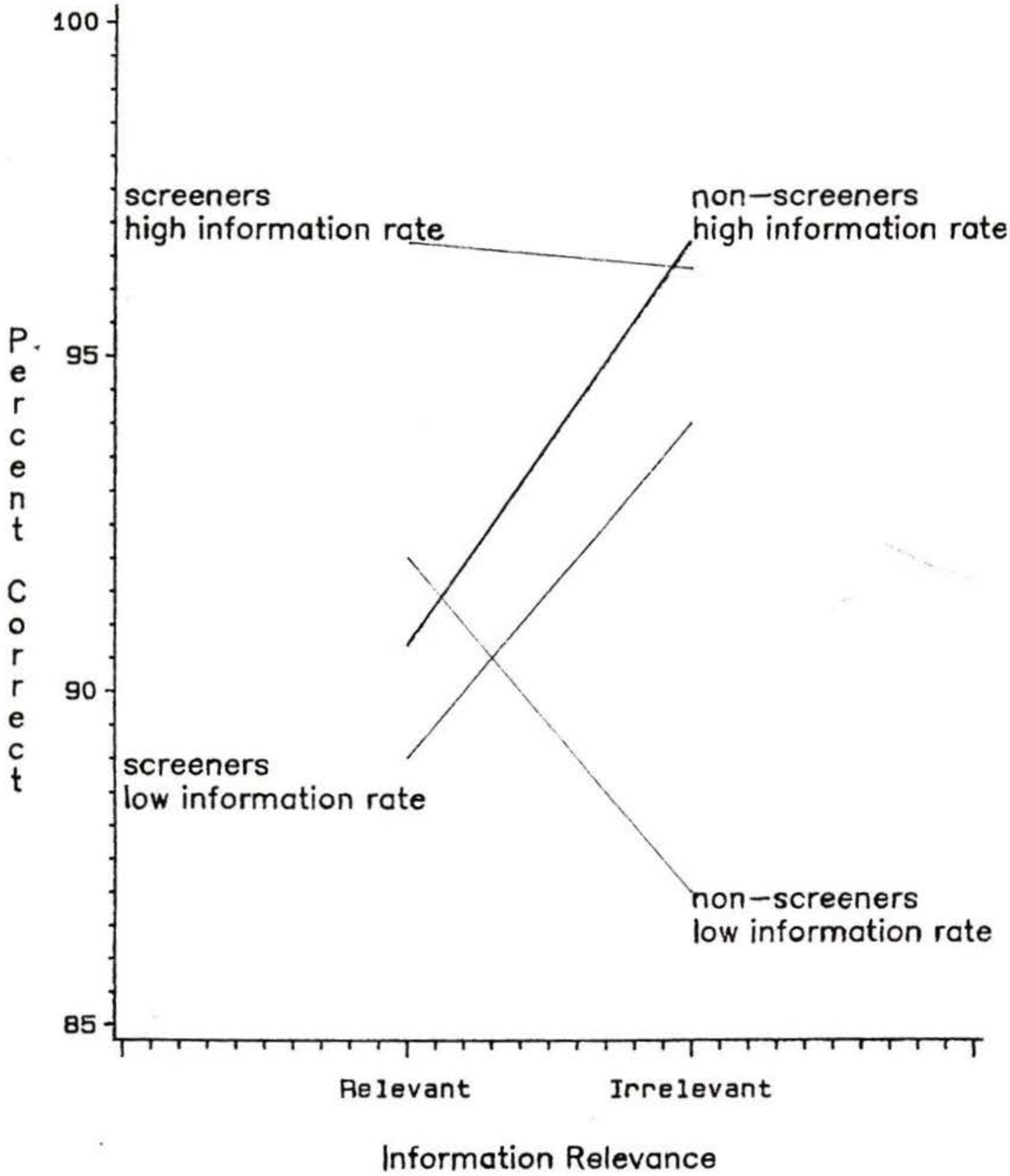


Figure 7. Spelling Accuracy as a Function of Information Relevance, Information Rate, and Stimulus Screening



Experiment 2

In our daily lives, we notice that some people like to work in a relatively noisy background whereas others prefer a quiet environment. For example, in a study of college library use (Sommer, 1966), some students liked to study in the large busy study halls where they could hear and see other students, whereas others hid themselves among the stacks or behind study carrels. In offices, some workers enjoy being in the bustling workplace, but others may want to work in a quiet secluded corner. If these preferences reflect individuals' performance, then we work best at the sound level we like best.

But do we actually work best in an acoustic environment that we prefer? According to the arousal theory and the Yerkes-Dodson Law, one is most productive when one is optimally aroused, and the optimal arousal level is lower for a complex task than for a simple task. Empirically, Bryan and Tolcher (1976) showed that subjects preferred lower sound levels while working on a complex task than working on a simple task. The least demanding task (i.e., crossing out letters) had the highest listening level (69 dBA), whereas the tasks requiring most concentration (i.e., mental arithmetic and precis) required the lowest listening level (53 dBA). It is reasonable to propose that one may be most productive at one's most preferred sound level, which is likely to occur at the optimal arousal level for a particular task.

If we do work best in an acoustic environment that we prefer, both the organization and its workers could benefit from matching the physical environment and individual preferences by assigning workers to a variety of settings within the office that have different background sound levels. Thus, it is an important question to ask and to be answered.

In research on human response to noise, researchers have used either the laboratory experimental approach to investigate the effects of noise on task performance (e.g., Glass & Singer, 1972), or the questionnaire survey approach to examine office workers' satisfaction with their office environments (e.g., Louis Harris & Associates, 1978). An alternative approach to understanding the impact of office noise and to determining an acceptable acoustic environment is allowing individuals choice over their environments, that is, to let them adjust the ambient sound to what they consider acceptable or satisfactory.

In the present study, an integrative approach is used to study the effects of office noise on performance and satisfaction at the same time: the relations between performance and sound level preference in individuals are examined. It addresses the questions of whether individuals perform best at their most preferred level of office sounds, and whether personality mediates the relation between noise and performance.

A number of studies in which subjects are asked to choose their preferred environments have appeared in the acoustics literature. Researchers have attempted to determine preferred levels of a variety of noises while subjects work on various tasks (e.g., Bryan & Tolcher, 1976), or of speech and other desirable auditory signals such as television or radio program (e.g., Pols, van Heusden & Plomp, 1980; Rice, Sullivan, Charles, Gorden & John, 1974; van den Eijk & van Ierland, 1965).

In a few studies, researchers have examined task performance in relation to different *types* of individuals (e.g., introverts and extraverts in Geen, 1984), or the relation between performance and preferred sound level *across* individuals (e.g., Bryan & Tolcher, 1976). Nevertheless, individuals' performance in relation to their sound level preferences has not been investigated.

Performance at Preferred Level of Noise

Bryan and Tolcher (1976) examined preferred sound level in relation to noise type. Subjects solved arithmetic problems in a background of four types of noise in a sequence (white noise, traffic noise, pop music, and 50% intelligible conversation). They found that conversation (presumably with the highest information content) had the highest preferred level (66 dBA), and white noise had the lowest level (49 dBA).

Interestingly, Bryan and Tolcher's (1976) study showed no significant correlation between preferred sound level and accuracy of performance or amount of work done at the preferred sound level. In other words, one who preferred to work at literally deafening levels in excess of 90 dB performed no worse than one who chose a level of 30 dB when in one's preferred environment.

Unfortunately, Bryan and Tolcher did not investigate individuals' performance in relation to sound level by measuring their subjects' performance at different sound levels. Therefore, it remains unclear whether individuals perform best at their most preferred sound level. Is the most comfortable acoustical environment the most productive for an individual? This study is designed to answer this question.

Performance and Annoyance

Most office workers believe there is a connection between job performance and personal satisfaction with the workplace (Louis Harris & Associates, 1978). Whether an objective effect exists is less clear.

There is some evidence that performance and annoyance are related. In one study by Bryan (cited in Bryan & Tolcher, 1976), subjects working on mental tasks in 60-80 dBA of noise performed more poorly if they were annoyed by that noise. The present study provides some information about the relation between noise annoyance and actual productivity.

Individual Differences

Some evidence suggests that extraverts prefer higher levels of stimulation than do introverts. In Geen's (1984) study, subjects performed their best (required fewer trials to reach criterion in a paired-associate learning task) when stimulated by white noise at an intensity level chosen by another subject of their own personality type (introvert or extravert). Extraverts chose an average level 17 decibels higher than did introverts. Introverts and extraverts receiving noise at a level chosen by members of similar personality type were equally aroused, as measured by their pulse rates and skin resistance responses. At the same level of noise, introverts were more aroused than extraverts. Introverts had poorer performance when the noise level was higher than the optimal level for their type, but showed no significant decrement when the noise was at a lower level. Extraverts, however, did more poorly both when the noise level was higher than the optimal level of their type and when it was lower.

Similar differences between the preferred sound levels of introverts and extraverts were reported in a few other studies. Bryan and Tolcher (1976) found differences of the same order (18 dB) between the preferred sound levels of introverts and extraverts. Similar findings were reported in Elliot (1971): there was a difference of 32 dB between highly extraverted and highly introverted school children; Hockey (1972) found a difference of 10 to 15 dB between highly extraverted and highly introverted adults carrying out a vigilance task in noise.

Similarly, in a field study of study habits and introversion-extraversion, Campbell and Hawley (1982) found that students studying in the noisier parts of the library were, on the average, more extraverted than students studying in quieter locations.

Other than the introvert-extravert personality type, several studies have demonstrated that people differ in their general sensitivity to noise, and that this characteristics may be responsible for part of the variability in reported annoyance by noise (Griffiths & Delauzun, 1977; Keighley, 1966). Psychologists have devised special rating scales to measure individual differences in reaction to environmental stimulation. One of them is Weinstein's (1978) noise sensitivity scale, which is used in this study.

In sum, two hypotheses are tested in this study: (1) individuals perform best at their most preferred sound level, and

(2) individual differences in noise sensitivity or introversion-extraversion may affect the relation between noise and performance.

Workers are asked to select the most preferred sound level. They work in five experimental sessions during which the background office noise level is varied. Their productivity is measured, and the self-reports of their feelings toward the work environment are analyzed. A shortened version of Eysenck's introversion-extraversion scale (Wilson, 1978) and a modified version of Weinstein's (1978) noise sensitivity scale are used as measures of an individual's reaction to noise.

Method

Research Design

A within-subject repeated measures design was used, with sound intensity level as the independent variable and productivity as the dependent variable. Productivity was measured as both speed (number of keystrokes per hour) and accuracy (number of errors made per hour). Sound intensity level was measured on the A-weighting decibel scale.

Sound

The sound intensity level factor had five levels: (1) ambient level (48 dBA), (2) 52 dBA, (3) 56 dBA, (4) 60 dBA, and (5) 63 dBA. All these levels are within the normal range of sound levels in offices (Nemecek & Grandjean, 1973). To control for possible order effects, the sound levels were presented in five different orders. Subjects were assigned randomly to one of the following five orders of presentation:

(1) 48 dBA, 52 dBA, 56 dBA, 60 dBA, and 63 dBA;

(2) 63 dBA, 48 dBA, 52 dBA, 56 dBA, and 60 dBA;

(3) 56 dBA, 60 dBA, 63 dBA, 48 dBA, and 52 dBA;

(4) 52 dBA, 60 dBA, 48 dBA, 56 dBA, and 63 dBA; or

(5) 60 dBA, 52 dBA, 63 dBA, 56 dBA, and 48 dBA.

Each subject indicated which one of the five sound levels she preferred the most, and which one(s) she found annoying.

Subjects

Data-entry workers were chosen to be the subjects of this study for two reasons. First, their work is monotonous, and their work performance can be easily and reliably measured. Second, data-entry tasks such as typing, using word-processors, and entering information into record files represent what many office workers do for large parts of their days. The findings of this study may be generalizable to keyboard tasks carried out by many office workers.

About 100 female full-time data-entry operators of the Medical Services Plan, B.C. Ministry of Health, who work at Blanshard Building (ground floor) in Victoria, were asked for their voluntary participation in this study. Their work is highly monotonous, involving entering medical data into the computer. They work in two shifts, the day or the evening shift. They are allowed to use headphones to listen to the radio, cassette tapes, or audio channels on the television.

Over 40 operators indicated interest in taking part in the study when they were first approached in May, 1987. The great majority of these interested operators were in the day shift. Unfortunately, data had to be collected in July and August, 1987 when a number of operators were on summer vacation. As a result, only 28 of them were available for the study. One subject was employed in a pilot run.

Stimuli

Office noise was generated through an audio tape of general office noise, including telephone rings, sounds of furniture movement, the use of office equipment and, occasionally, human speech. The recording was made in a large accounting office. A cassette tape recorder (Sony FC-3700), two pressure-zone microphones, and a metallic bias tape (Maxell XLII 90) were used for recording. The two microphones were placed three feet apart so that a more realistic stereo effect could be obtained. The actual sound intensity level of the office was about 60 to 65 dBA as measured by a precision sound level meter (Bruel & Kjaer

Type 2203) at the time recording was made. Incidentally, this demonstrates that the loudest test condition (63 dBA) was not abnormally loud.

Because familiarity with the contents of the tape recording may reduce any effect of noise on performance, five versions of the original recording were made. The original tape recording of 45 minutes each side was divided into three segments. The tape was re-recorded onto five normal bias tapes (Sony LNX 120) at the same recording level with the three segments in different orders. For example, one tape had the last segment at the beginning, followed by the second segment and then the first segment. A second tape had the first segment at the beginning, followed by the last segment and then the second segment. Normal bias tapes were used because hour-long metallic bias tapes are not manufactured. As a result, five one-hour tape recordings that had exactly the same but apparently different content were produced.

To ensure that the five tape recordings were equivalent in their sound levels, statistical distributions of the sound levels of the recordings were determined manually. This procedure involves taking sound pressure level measurements at predetermined time intervals over a specified observation period. The length of the observation period must be adequate to describe the variation in sound level. The percentage of time that any specified sound level is exceeded can be determined (Broch, 1971; Michael & Bienvenue, 1983). The same procedure was followed in this study. The tapes were played in an acoustically well-insulated room. The sound levels at the same location were measured at 15-second intervals with a precision sound level meter (Bruel & Kjaer Type 2203). The median sound levels of the five tape recordings were computed, and the levels were within a one-decibel range.

The first-minute segment of one of the tape recordings was selected. This segment had a sound level pattern similar to that of the hour-long tape recording. This same segment was recorded five times onto a blank tape, with a short pause in between segments. The resulting tape (the "Preference Tape") was used in the selection of preference level phase of the study.

Equipment and Set-up

A corner of the data-entry operators' normal workroom (about 15 by 46 metres with 4 metres ceiling) was isolated to become the test room (3.7 by 5.5 metres with the same ceiling height). Two sound-insulated walls were constructed so that the ambient sound level was reduced from 54 to 40 dBA. This step was necessary both to prevent disturbance to operators who had chosen not to participate in the study and to maximize control of the sound intensity level in the room. See Appendix O for a picture of the workroom.

Two rows of three Mohawk data-entry machines, the same as those normally used by the operators, were in the test room. Because the data-entry machines and the striking of the keys made some noise (48 dBA when the machines were on and 54 dBA at the operators' ears when six operators were typing), acoustic covers for the machines and the keyboards designed to reduce the noise were constructed.

The acoustic cover was essentially a box built of plywood and lined with a layer of corrugated foam. Its top front portion was made of clear plexiglas so the operator could see the screen and the keyboard. Its front opening, through which the operator inserted her hands, was covered with two layers of velvet. The velvet reduced the noise transmitted to the surroundings from 54 dBA to 48 dBA and at the same time allowed free arm movement inside the cover. A ventilation vent at the upper back of the acoustic cover allowed heat to dissipate. A photograph of the acoustic cover is in Appendix P.

The test room had large glass window panes on one side and was carpeted. Two speakers (Bose 201) were placed on one wall 7 feet above the floor and 9 feet apart. A stereo amplifier (Sony TA-400) and a cassette tape recorder (Sony FC-3700) were used to play the tapes. A layout plan of the test room is at Appendix Q.

The office noise segment on the "Preference Tape" (described earlier) was used to calibrate the sound levels. The sound levels at six 10-second intervals were measured, and the median level was computed. The volume control of the amplifier was adjusted until the median level of the segment measured 48 dBA, 52 dBA, 56 dBA, 60 dBA, or 63 dBA respectively. These positions were marked on a prepared dial attached to the volume control knob of the amplifier. The sound levels at the six workstations were similar to one another; their median levels were within a one-decibel range.

Rating Scales

A modified version of Weinstein's (1978) noise sensitivity scale (see Appendix R) and a shortened version of Eysenck's introversion-extraversion scale (Wilson, 1978) (see Appendix S) were used as measures of the subjects' reaction to stimulation.

Weinstein's scale consists of 21 statements in Likert-type scale format, with an emphasis on emotional reactions and behavioral disruptions rather than on noise as an environmental problem. Two examples of the statements are "I am easily awakened by noise" and "It wouldn't bother me to hear the sounds of everyday living from neighbors". The reliability of the scale is good. In Weinstein's earlier work, the Kuder-Richardson reliability of the scale has ranged from .84 to .87 in three samples of students and adults. The nine-week test-retest reliability in a previous sample of 72 students was .75.

In the modified scale, two items on the original scale, "I am more aware of noise than I used to be" and "Even music I normally like will bother me if I am trying to concentrate", were excluded because they were designed to measure changes in noise sensitivity over time. Three items that measured sensitivity to detection of sounds were added to the original scale. They included, "I like to drive with my radio on", "I can always tell when it starts to rain or snow in the night", and "I often hear sounds that others don't notice".

Procedure

An open letter addressed to the data-entry operators was circulated by the supervisors in early May, 1987. The purpose of the experiment (to study the effects of office noise on productivity) was explained to them. It was emphasized that participation was voluntary.

The experimenter met with various management personnel to work out some details of the study. The test room and six acoustic covers for the machines were built in July. When it was ready, operators were asked to confirm their willingness to participate. Once the final list of subjects was made up, they were scheduled for the experiment.

Each subject was handed an information sheet (see

Appendix T) which included the dates, time, and a special operator number that she would use in the experiment. Subjects were scheduled to work in the test room in groups of six (except for Group 4, which had 3 operators) for six one-hour sessions at the same time of the day for six consecutive workdays. They were asked to do only data-entry of doctors' claims during the test sessions. To reduce the possibility that the sounds they were listening to previously affected productivity during the test sessions, those operators who usually used headphones at work were asked not to do so for 15 minutes before and during the test sessions.

During the first session, each subject determined her most preferred sound level. First, the experimenter demonstrated the five sound levels at which the office noise tape would be played in different sessions by playing the short tape segment on the Preference Tape at five different sound levels (48, 52, 56, 60, and 63 dBA respectively) while the subjects were working. They were then asked to mark on the sheet (Appendix U) in front of them (1) the sound level that they preferred the most, and (2) the level (or levels) they found annoying. Next, they were asked to complete the noise sensitivity scale and the introversion-extraversion scale. Subjects used the remainder of the session to become accustomed to working inside the acoustic covers and to the test situation in general. They were asked to work at their normal work speed. The experimenter left the room and returned when the one-hour session was over.

During the next five sessions, different versions of the office noise tape were played at five different sound levels during the five sessions. The same version of the tape was played to all groups on the same day.

Each subject completed a post-session questionnaire. This questionnaire (Appendix V for Sessions 2-5 and Appendix W for Session 6) contained items about the subject's sound level preference, her feelings toward the background noise, and how long it took her to get used to working inside the acoustic covers.

During the test sessions, each subject used her special operator number to start the machine. This enabled the number of keystrokes that each subject keyed in each session to be compiled on the productivity record. The data entered in each session were verified by other operators outside the test sessions. The number of errors made in each test session was monitored in a separate productivity record kept by the supervisor. Information about the subject's normal work speed and accuracy was also obtained from the subject's supervisor.

Results

Subjects

Twenty-eight subjects took part in the study. One subject who apparently had claustrophobia dropped out of the study after the first session. Another one dropped out after the second session because of illness. Three subjects missed the last session and another three missed the last two sessions because they were on vacation. Only twenty subjects completed all six experimental sessions. The data of one subject was discarded because she made an unusually large number of errors (55) in one session. As a result, the data of nineteen subjects were analyzed.

Ninety percent of the 28 subjects used headphones at work for one to seven hours a day, or 4.2 hours a day on average. Only three subjects did not used headphones at all. Those who did listened to music (64% of the subjects) or the radio (82%), and a small percentage listened to soap operas (11%) or television game shows (18%). The number of hours that subjects used their headphones was not related to which sound level they chose. The correlation coefficient between the number of hours of reported headphone use and preferred sound level was not significant ($n = 26$, $r = -.03$, $p > .44$).

Manipulation of Sound Levels

Manipulation of the sound level factor was successful. Subjects were asked to rate the loudness of each sound level on a five-point scale (ranging from "far too loud", "slightly too loud", "just comfortable", "slightly too soft" to "far too soft"). The 19 subjects who took part in all sessions perceived an increase in loudness as the sound level increased from the lowest level (Level 1, 48 dBA) to the highest level (Level 5, 63 dBA). A multivariate analysis of variance (SPSSX) showed a significant Sound Level effect on Loudness Ratings [$F(4,14) = 75.2$, $p < 0.001$].

Selection of Preferred Sound Level

During the first session, the subjects chose Sound Level 1 (10 subjects), Level 2 (12), or Level 3 (6) to be the most preferred sound level. None chose Levels 4 or 5.

Unfortunately, when this preferred sound level was compared with (1) the sound level(s) that the subject found "just comfortable" in the subsequent one-hour session(s), and (2) the sound level played at the session that the subject found most comfortable, a fair degree of disagreement among the three measures was uncovered (see Table 25). Only 11 out of the 24 subjects (whose data were available) reported that the background noise level chosen as most preferred in the first session was comfortable in the experimental session in which they heard the same sound level. Thirteen out of 21 subjects matched the preferred sound level they chose in the first session with the corresponding session correctly. This is not surprising, considering that the subjects were exposed to the noise segments for a very short time (one-minute only) in the first session.

Therefore, a revised preferred sound level was assigned to each subject in the following manner. Where the "just comfortable" sound level(s) was(were) consistent with the sound level played at the "most comfortable" session but was different from the preferred sound level chosen in the first session, the sound level indicated by the two congruent measures was selected. Where the three measures disagreed with one another, the sound level that the subject rated "just comfortable" was selected. This measure was considered the most valid of the three because the judgment was made at the end of each one-hour session. Subjects had more time in an actual work situation to judge their preferences for the sound levels. The revised preferred sound level (see Table 25) was used in the subsequent data analyses.

Based on this procedure, 12 of the 26 subjects preferred Sound Level 1, 11 chose Sound Level 2, and 3 chose Sound Level 3. Of the 19 subjects who completed all sessions, 9 subjects chose Sound Level 1, 7 chose Sound Level 2, and 3 chose Sound Level 3.

Reliability of the Rating Scales

Weinstein's Noise Sensitivity Scale. The scores on thirteen items were reversed in direction before the total score of each subject was computed (see Appendix R).

For each item, a score of 6 indicates great sensitivity, and a score of 1 indicates low sensitivity.

The internal reliability of the scale was only fair; Cronbach's alpha was 0.64. An item analysis (SPSSX) showed that seven items had their corrected item-total correlations lower than 0.20. These items (see Appendix R) which poorly measured noise sensitivity were discarded. The internal reliability of the revised scale of 15 items was higher; Cronbach's alpha was 0.76.

The maximum total score of the revised scale is 90, and the minimum is 15. A higher total score indicates greater sensitivity to noise. The mean total score of the 19 subjects who completed all sessions was 59 (or 3.93 per item), and the standard deviation was 9.26. The range was from 40 to 86.

Eysenck's Introversion-extraversion Scale. As shown in Appendix S, each 'yes' response to an Extravert item or each 'no' response to an Introvert item was given a score of 1. The scores of all items were summed up to give the total score. A high total score indicates high extraversion, and a low score indicates high introversion.

The internal reliability of the scale was low; Cronbach's alpha was 0.47. As in the noise sensitivity scale, several items had low corrected item-total correlations (less than 0.20). These ten items (see

Appendix S) were discarded. The internal reliability of the revised scale of ten items was recomputed. The value of Cronbach's alpha was raised to 0.72.

The maximum total score of the revised scale is 10, and the minimum is 0. The mean score of the 19 subjects who completed all sessions was 4.84, and the standard deviation was 2.41. The range was from 0 to 9.

Relation between Noise Sensitivity, Introversion-Extraversion, and Sound Level Preference

Consistent with previous findings, introverts in this study preferred lower sound levels than did extraverts. The revised most preferred sound level correlated significantly with the introversion-extraversion scores (n = 19, r = .37, one-tailed p < .05). However, preferred sound level was not significantly correlated with noise sensitivity (n = 19, r = .04, p = .44).

Does noise-sensitivity correlate with introversion? This study showed no clear relationship between noise sensitivity and introversion-extraversion (n = 19, r = -.29, p = .11).

Productivity

The first hypothsis states that individuals perform best at the sound level they most prefer. In particular, the data-entry workers in this study were expected to work faster and to make fewer errors when the background sound level was at the most preferred level than when it was at other less-preferred sound levels. Productivity was measured in speed (number of keystrokes per hour) and accuracy (number of errors made per hour). Across the five sound level conditions, the mean speed of 19 subjects was 14821 keystrokes per hour, and the standard deviation was 2567 keystrokes per hour. The mean accuracy was 4.95 errors per hour, and the standard deviation was 1.84 errors per hour.

Order of Presentation. The first analysis was run to detect if order of presentation affected productivity. As Speed was not significantly correlated with Accuracy (r = .02, p = .47), the effects of noise on speed and on accuracy were analyzed separately. Two separate multivariate analyses of variance (SPSSX) were performed on the data, with Speed at the five sound levels and Accuracy at the five sound levels as the respective dependent variables, and Order of Presentation of sound levels as the independent variable.

Table 26 shows the means and standard deviations of Productivity as a function of Order of Presentation and Sound Level. Order of Presentation did not affect either Speed or Accuracy. The results of the MANOVAs showed no significant Order by Sound Level interaction effect [Speed: Wilks lambda = .31; $F(12,29)$ = 1.37; p = .23; Accuracy:

Wilks lambda = .37, $F(12,29) = 1.13$, $p = .37$], or Order main effect [Speed: $F(3,15) = 1.96$, $p = .17$; Accuracy: $F(3,15) = .62$, $p = .61$].

Productivity as a Function of Sound Level Preference. Next, the hypothesis that productivity at the most preferred sound level was higher than that at other sound levels was tested. First, productivity at the five sound levels was plotted separately for subjects who preferred Sound Level 1, 2, or 3 respectively. As shown in Figures 8 and 9, and Table 27, the peak levels of Speed and of Accuracy did not occur at the subjects' most preferred sound levels. Note that the number of subjects in each Preferred Sound Level condition was small.

To increase the sample size, the data of 19 subjects were collapsed across sound levels in the following manner; productivity below, at, and above the most preferred sound level were computed. Obviously, subjects who preferred the lowest sound level did not have data for below the most preferred sound level. The mean speeds below, at, and above the most preferred sound level were 13632 ($n = 10$), 14840, and 14914 ($n = 19$) respectively. The number of errors made was 4.63 per hour below, 4.51 per hour at the most preferred sound level, and 5.06 per hour above (see Table 28).

As Figure 10 reveals, there is no clear evidence that productivity peaks at the most preferred sound level, although subjects were slower below the most preferred sound level (13632 keystrokes) than either at or above the most preferred level.

Productivity and Individual Characteristics

Did individual differences in noise sensitivity or introversion-extraversion modify any relationship between productivity and sound level preference?

To answer this question, subjects were divided into a more noise-sensitive group (a score of 61-86 on the noise sensitivity scale) and a less noise-sensitive group (a score of 40-57); they were also divided into introverts (a score of 0-4 on Eysenck's scale) and extraverts (a score of 6-9).

Multivariate analyses of variance (SPSSX) were performed on the data of subjects who preferred either Sound Level 2 or 3; Noise Sensitivity or Introversion-extraversion was the independent variable, and Speed or Accuracy below, at, and above the most preferred sound level were the dependent measures. In addition, the productivity of all subjects below, at, and above the most preferred sound level were computed.

Noise-sensitivity and Speed. As shown in Figure 11, those who preferred either Sound Level 2 or 3 was fastest at the most preferred sound level. The average speed was 13761 keystrokes per hour below the most preferred sound level, 14983 at the most preferred sound level, and 14425 above the most preferred sound level (see Table 29). The results of a MANOVA were that the Sound Level Preference effect was only marginally significant [Wilks lambda = .39, $F(2,5) = 3.98$, $p < .10$]. Univariate F-tests showed that the quadratic trend was significant [$F(1,6) = 8.42$, $p < .05$]. For these individuals, average speed was apparently a quadratic function of sound level preference, with the peak speed at the most preferred sound level.

When all subjects were considered, the pattern became less clear (see Figure 11 and Table 29). Whereas less noise-sensitive subjects showed a quadratic pattern, more noise-sensitive no longer did. They were slower when the sound level was below the most preferred level than when at other levels.

Noise Sensitivity and Accuracy. Of those who preferred Sound Level 2 or 3, the more noise-sensitive and the less noise-sensitive subjects seemed to have very different patterns of Accuracy. Figure 12 shows that noise-sensitive subjects displayed an inverted U-shape pattern, with lowest accuracy at the most preferred sound level, whereas the less noise-sensitive subjects had a U-shape pattern, with greatest accuracy at the most preferred sound level. However, the interaction between Sound Level Preference and Noise Sensitivity did not reach statistical significance.

When all subjects were taken together, less noise-sensitive subjects still showed a U-shaped pattern. On the other hand, more noise-sensitive subjects showed a linear pattern, with lowest accuracy above the most preferred sound level (see Figure 12 and Table 29).

Introversion-extraversion and Speed. Figure 13 shows the speed patterns of the 4 most introverted subjects and of the 5 most extraverted subjects. Those who preferred either Sound Level 2 or 3 produced the most at the most preferred sound level. They produced, on average, 14113, 15478, and 15024 keystrokes per hour below, at, and above the most preferred sound level respectively (Table 30). A multivariate analysis of variance showed that there was a significant Sound Level Preference effect [Wilks lambda = .37, $F(2,6) = 5.14$, $p < .05$]. Univariate F-tests showed that there was a significant quadratic trend [$F(1,7) = 11.93$, $p < .05$]. For these individuals, average speed was a quadratic function of sound level preference, with the peak speed at the most preferred sound level.

The pattern became less clear when the subjects who chose either Sound Level 1, 2 or 3 were taken together. The subjects were slower below the most preferred sound level (14113 keystrokes per hour) than at (15441 keystrokes per hour) or above the most preferred sound level (15487 keystrokes per hour) (see Figure 13 and Table 30).

Introversion-extraversion and Accuracy. As Figure 14 shows, those introverts and extraverts who preferred either Sound Level 2 or 3 seemed to have different accuracy patterns.

When all subjects were taken together, the pattern became clearer. Apparently, introverts showed a U-shape pattern, with greatest accuracy at the most preferred sound level, whereas extraverts showed an inverted U-shaped pattern, with least accuracy at the most preferred sound level (see Figure 14).

Productivity and Sound Level

Overall, sound level did not affect productivity significantly. Multivariate analyses of variance showed that productivity at the five sound levels were not significantly different [Speed: Wilks lambda = .61, $F(4,11) = 1.72$, $p = .21$; Accuracy: Wilks lambda = .97, $F(4,11) = .09$, $p = .98$].

Noise-sensitivity. Nevertheless, more noise-sensitive subjects were more accurate than less noise-sensitive subjects. Mean accuracy across all sound levels correlated significantly with the noise sensitivity score ($n = 19$, $r = -.40$, one-tailed $p < .05$). Figure 15 and Table 31 show that more-sensitive subjects were significantly more accurate than less-sensitive subjects at the lowest sound level (48 dBA) and at the two highest sound levels (60 and 63 dBA) (Scheffe test at $p < .05$).

Annoyance

Sound Levels that Subjects Found Annoying. To find out how annoyance was related to sound level, the sound level conditions that subjects found annoying were compiled. The majority of the 26 subjects who responded found Sound Level 4 (60 dBA) and Level 5 (63 dBA) annoying; eight subjects (29%) found only Level 5 annoying, and 14 (50%) found both Levels 4 and 5 annoying. On the other hand, 2 subjects found both Level 1 (48 dBA, too quiet) and Level 5 annoying, and 1 subject found Levels 3 (56 dBA), 4, and 5 annoying. Three subjects did not find any level annoying.

Noise Annoyance and Productivity. To determine if annoyance affected actual productivity, the average productivity at sound levels that subjects found annoying, and the average productivity at levels that they did not find annoying were compared.

The data fail to show any significant effect of annoyance on productivity. Two multivariate analyses of variance were performed on the data, with Average Speed or Average Accuracy at "annoyed" and at "not annoyed" as the respective dependent measures. No significant differences were found between the mean speed at "annoyed" condition and the mean speed at "not annoyed" conditions (14713 versus

14663 keystrokes per hour). Nor was the difference in mean accuracy significant (5.46 versus 4.50 errors per hour) (see Table 32).

Are individuals of different noise sensitivity affected differently by noise annoyance? The average speed and the average accuracy of 7 noise-sensitive and 7 less noise-sensitive subjects were compared. Two separate multivariate analyses of variance were run, with Average Speed or Average Accuracy at "annoyed" and at "not annoyed" sound level conditions as the respective dependent measures. The independent variable was Noise Sensitivity with two levels.

The results were that the Noise Sensitivity main effect was significant [$F(1,13) = 8.19$, $p < .05$]. More noise-sensitive subjects made fewer errors than did less noise-sensitive subjects (4.23 vs. 6.44 errors per hour). So was the Noise Sensitivity by Annoyance condition interaction effect significant [$F(1,13) = 4.63$, $p < .05$]. Unexpectedly, less noise-sensitive subjects made the most errors when they were annoyed (7.91 errors per hour), significantly more than noise-sensitive subjects (3.76 errors) [$t(12) = 3.15$, $p < .05$] and when subjects were not annoyed (noise-sensitive: 4.70 errors; less noise-sensitive: 4.97 errors) (see Table 33).

<u>Self-reported Feelings toward the Background Noise</u>

In response to the question "Which sounds in the tape recording were pleasant to you?", about one-quarter of the 26 subjects who responded found typewriter sounds, telephone rings, background conversation, and the general background noise at low levels (48-56 dBA) pleasant. With the increase in sound level, fewer and fewer subjects (at 63 dBA, 3 only) found these sounds pleasant any more.

About three-quarters of the subjects found the sounds made when stamping, stapling, paper shredding, opening and closing of file drawers annoying, even when the sound levels were low. Apparently, the sudden change in pitch or volume in these sounds was annoying. For example, one subject said, "slamming drawers, thumping of date stamp, the squeaking of file cabinet, opening and closing -- made me want to oil it". Typewriters sounds, phone rings, and loud talking were also annoying.

When asked about what sounds distracted them, fewer subjects (about half) responded. Of those who responded, talking and sudden noises were mentioned most frequently. Some comments were "Talking -- I was listening to their conversation" and "paper tearing, date stamp, the sudden noise was distracting".

Very few subjects perceived any deleterious effect when the sound level was at either Level 1, 2 or 3 (i.e., 48-56 dBA). But at Sound Levels 4 and 5 (60-63 dBA), about half of the subjects reported that the noise either disrupted their concentration on their work, made them feel tense, irritable, tired, or gave them headaches. Quite a few said that they tried to block the noise out.

A Comparison between Normal Productivity and Productivity During Test Sessions

To determine whether the novel test situation had any effect on productivity, productivity during the test sessions and productivity during normal work period were compared. In the test sessions, the subjects keyed in 14821 keystrokes per hour (standard deviation 2567 keystrokes), on average 2022 keystrokes per hour faster than they normally do (12800 keystrokes per hour on average).

Normally, accuracy was evaluated on an eight-point rating scale, ranging from "1 = excellent" to "8 = poor". In the test sessions, the operators were less accurate (1.16 points lower on the rating scale) than in the normal work situation (an average rating of 4 = satisfactory plus). A doubly multivariate analysis of variance (SPSSX) showed a significant difference in the means in productivity (Speed and Accuracy) during the test sessions and in normal work conditions [Wilks lambda = .30, $F(2,17) = 20.10$, $p < 0.01$]. Univariate F-tests showed that both Speed and Accuracy were significant [Speed: $F(1,18) = 22.30$, $p < 0.01$; Accuracy: $F(1,18) = 9.45$, $p = 0.01$].

Subjects worked faster than they do normally. It is tempting to conclude that this was the Hawthorne effect -- the result of the awareness of being observed. The evidence is, however, not conclusive for two reasons. First, although the subjects worked faster, they were less accurate than they are normally. this finding suggests that accuracy is more susceptible to noise than speed is. Second, the normal work speed is averaged over the whole day and over a whole month, whereas the work speed measured during the study was averaged over five hours in the morning when the arousal level was presumably high.

To determine whether and how much the use of acoustic covers might have affected the validity of the study, the amount of time that subjects took to become accustomed to working inside the acoustic covers was analyzed. Nine out of the 19 operators indicated that it was not a problem at all or that it took them no time to adjust to it. On the other hand, six subjects felt that they could never get used to it. The remaining four said that it took them two to three days. Except for these four subjects, the novel work situation (including any Hawthorne effect) should not have affected the internal validity of the experiment because each subject used herself as the standard of comparison. In addition, the orders of presentation of sound levels were counterbalanced; as reported earlier, no significant order of presentation effect was found.

Discussion

Productivity

The results of this study offer limited support for the hypothesis that individuals perform best at the sound level they prefer the most. Performance is, however, not related to sound preference level alone, but personality as well. Of those who preferred 52-56 dBA, work speed was affected by sound level preference in the predicted manner for those who scored on either end of the introversion-extraversion scale and perhaps for the most noise-sensitive and the least noise-sensitive as well. These subjects worked fastest when the background sound was at the most preferred sound level.

The quadratic pattern does not hold when the data of all subjects are considered, although it is apparent that subjects produced less below the most preferred sound level than at the most preferred sound level.

Subjects who preferred the lowest sound level (48 dBA) did not produce more at the most preferred sound level than at other sound levels. One plausible explanation is that some of these operators may have chosen an even lower sound level had it been available. Thus, the speed at the actual most preferred sound level might have been higher than the speed indicated in this study.

As for accuracy, noise-sensitive operators are clearly more accurate than are less noise-sensitive ones, and particularly at both ends of the sound level continuum.

In addition, more-noise-sensitive and less-noise-sensitive operators seem to show different patterns of accuracy in relation to sound level preference condition. Introverts and extraverts also seem to show opposite patterns. The results of the analyses showed no significant interaction effect of personality and sound level preference. Because of the small sample size in this study, the results may be due to chance alone; further replications with larger sample sizes may reveal clearer effects.

Preferred Sound Level and Individual Characteristics

The finding that extraverts prefer higher sound levels than do introverts is consistent with previous findings (e.g., Bryan & Tolcher, 1976, Geen, 1984). However, the noise sensitivity scores were not significantly correlated with preferred sound levels. This confirms Bryan and Tolcher's (1976) findings, although they used a different noise sensitivity measure. This study suggusts that the internal consistency of the noise sensitivity rating scale is only fair. Clearly, a good rating scale that measures noise sensitivity has yet to be developed or refined.

Another issue is whether and how much noise sensitivity changes over time. Although Moreira and Bryan (1971) showed that the test-retest reliability of scores over a two-month period was quite high ($\underline{r}$ = .85), Griffiths and Delazun

(1977) reported that their three-point sound sensitivity rating scale had low test-retest reliability ($\underline{r}$ = .35).

There is some variability in the sound levels chosen, although all subjects prefer the lower levels (48-56 dBA). The range of preferred sound levels is consistent with the preferences of introverted students in Geen's (1984) study (55 dBA). However, it is much lower than the mean preferred listening level of white noise (69 dBA) while doing a crossing-out task in Bryan and Tolcher's (1976) study, and the mean level (72 dB) that extraverted students chose in Geen's (1984) study.

It seems obvious that which sound level one prefers is dependent upon the duration of noise exposure. A comparison among the preferred sound levels selected in this study on three different occasions indicates clearly that individuals will select a lower most preferred sound level when the noise exposure period is longer. Previous studies have used much shorter durations of noise exposure (from less than a minute up to 10 minutes) than did this experiment; thus, the preferred sound levels in those studies are higher than the levels chosen in this study.

Moreover, the subjects in the two studies above were mostly young male college students. Females, or older adults may prefer lower sound levels; as this study and Bryan and Tolcher's second experiment showed, adults chose lower sound levels than did students.

Annoyance

Subjects' self reports of their feelings toward the background noise are generally consistent with those in previous studies (Keighley, 1970; Purcell et al., 1977). Operators generally find sudden loud sounds and sounds with constantly changing pitch or volume annoying; some operators find these sounds distracting or believe they have deleterious effects on their work performance.

Contrary to common belief, this study has shown that productivity is not affected by perceived annoyance with noise. The period of noise exposure was, however, relatively short. Although Bryan (cited in Bryan & Tolcher, 1976) showed that subjects solving mental arithmetic problems performed more poorly if they were annoyed by that noise, the noise level used in his study (at 60-80 dBA) was beyond the typical office noise level range and was higher than the levels used in this study. In addition, the task used in the present study was less mentally demanding than Bryan's task (solving mental arithmetic problems).

The less noise-sensitive subjects in this study were least accurate at the "annoyed" sound level conditions. This finding is very surprising. Perhaps it is because, although they are not easily annoyed by noise, they are more adversely affected by the annoyance when they finally do become annoyed.

Internal Validity

Great efforts were made to ensure that the study had internal validity. First, the same task, data-entry of doctors' claims, was done by all subjects during the test sessions. Second, to control for any possible effect due to variations in arousal level throughout the day, each subject worked at the same time of the day during the test sessions. Third, the sound levels were presented to groups of subjects in different orders; no order of presentation effect on productivity was found.

Problems and Limitations

Reducing the noise made by the data-entry machines and the keyboards, and bringing the ambient noise level down to the desired level (40 dBA) represents the biggest practical problem. In the end, the ambient sound level was brought down to about 48 dBA, several decibels below the sound level in the operators' normal workroom. Nevertheless, subjects did not have the opportunity to choose sound levels much lower than their everday level. Thus, the range of sound levels used was not wide enough to permit exposure to levels well below the preferred levels of all subjects. This has posed the most serious limitation to the findings of this study. The hypothesis may receive greater support had the range of sound levels been wider.

To reduce the noise emitted by the machines and the keyboards, acoustic covers were used. Self-reports indicate that it took some individuals longer than others to get used to the novel situation. As described in the Results section, no significant differences in productivity was found between different orders of sound level presentation. Ideally, however, the learning curves of the subjects should have been plotted; testing should not have begun until the subjects had reached the asymtotae on their learning curves. In the field setting, it was difficult to make these arrangments because the management was concerned about work scheduling.

Giving subjects freedom to choose their preferred sound levels has the advantage of permitting a wide range and continuity in sound levels. In this study, constraints imposed by the host organization did not allow individual testing of subjects. Consequently, the subjects were asked to choose one of five sound levels instead. It would have been more satisfactory had each subject been able to adjust the sound level to her most preferred level and to have her productivity at various sound levels measured.

Obviously, the small sample size implies that the data may not be stable and may not have enough statistical power to detect small effect sizes.

The subjects in this study were exposed to noise for a relatively short time period. The effects of sound level preference and individual characteristics on productivity are likely to be more pronounced in a normal work situation.

Strengths

Despite the problems discussed above and the resulting limitations, this study should have considerable external validity. The sound levels used in this experiment were deliberately kept within the range of sound levels that are typical of offices, and the tape recording was made in an actual office. Although the findings of this study may not have direct application to the work unit involved, they should apply to many situations in which data-entry workers (and perhaps word-processing clerks) work in a general office with other office workers. In contrast to numerous laboratory experiments of noise effects on performance, this study represents a step toward the goal of conducting externally valid studies without sacrificing internal validity.

Conclusions

This study has offered weak support for the hypotheses. Within a narrow office noise level range, some workers are fastest at the most preferred sound level than at other sound levels. For data-entry work, noise-sensitive individuals are more accurate than are less noise-sensitive individuals, and particularly at low sound levels and at high sound levels. Workers with different levels of noise-sensitivity or introversion-extraversion seem to show different accuracy patterns, although the small sample size in this study does not allow one to draw any firm conclusions.

Table 25.
Reliability of Sound Level Preferences

Initial Preferred Sound Level a	"Just Comfortable" Sound Levels b	Most Comfortable Sound Level c	Revised Preferred Sound Level (used in data analyses) d
2	1	2	1
1	1, 2	1	1
1	1, 2	1	1
1	1	1	1
2	2	2	2
1	-	1	1
2	1, 2, 3	2	2
3	2	1	2
1	1	-	1
3	1, 2	1	1
3	2	2	2
2	2	2	2
2	2	2	2
3	2	2	2
1	-	1	1
2	1	-	1
2	1	1	1
1	2	-	2
2	-	-	2
1	1	-	1
3	2	3	2
3	1, 2, 3	3	3
2	3	3	3
1	2	1	2
2	1	1	1
2	2, 3	3	3

Note.

a The preferred sound level that subjects chose in the first session. The selection was made on the basis of one-minute sound segments.

b The sound level(s) that the subject rated "just comfortable" immediately after each one-hour session was over.

c The sound level played in the one-hour session that the subject found most comfortable. The assessment was made at the end of the sixth session.

d The revised preferred sound level used in the data analyses.

Table 26.
Means and Standard Deviations of Productivity as a Function of Order of Presentation of Stimuli and Sound Level Conditions a

Productivity

Keystrokes per hour

Order of Presentation	N		Sound level 1	2	3	4	5	total
1	6	mean	15403	15630	14993	15251	15091	15274
		s.d.	1052	1640	1745	2327	2233	
2	2	mean	15979	18421	18298	17551	16961	17442
		s.d.	1695	1597	363	3020	1124	
3	5	mean	12100	12692	13330	13625	13032	12956
		s.d.	1739	3891	3508	3406	3068	
5	5	mean	13569	14115	15015	14310	15531	14508
		s.d.	1891	2799	2923	2644	3134	
total	18	mean	14040	14703	14904	14793	14849	14658
		s.d.	2077	3093	2811	2818	2778	

Errors per hour

	N		Sound level 1	2	3	4	5	total
1	6	mean	4.24	4.36	6.60	6.57	7.01	5.76
		s.d.	4.11	2.75	5.44	4.12	4.86	
2	2	mean	8.49	2.50	3.52	2.69	2.06	3.85
		s.d.	3.25	3.54	3.51	3.80	2.91	
3	5	mean	3.61	7.14	3.73	5.02	3.74	4.65
		s.d.	4.46	3.84	0.88	2.19	2.33	
5	5	mean	3.43	6.00	3.93	4.31	7.77	5.09
		s.d.	1.96	3.76	2.10	3.50	5.56	
total	18	mean	4.31	5.38	4.72	5.08	5.79	5.05
		s.d.	3.69	3.48	3.54	3.39	4.53	

Note. The sound level condition ranges from 1 (the lowest sound level) to 5 (the highest).

a The data of subjects for Order 4 (except one) were incomplete.

Table 27.
Means and Standard Deviations of Productivity as a Function of Preferred Sound Level Condition and Sound Level Condition

Speed (Keystrokes per hour)

Preferred Sound Level	N		Sound level 1	2	3	4	5	total
1	9	mean	15039	15486	15764	15360	15051	15340
		s.d.	1626	2088	1936	2023	2243	
2	7	mean	13127	14011	13664	14327	14275	13881
		s.d.	2886	4370	3510	3741	3101	
3	3	mean	14431	15189	16178	15098	16402	15460
		s.d.	769	2914	2857	3258	3838	

Accuracy (Errors per hour)

Preferred Sound Level	N		Sound level 1	2	3	4	5	total
1	9	mean	4.20	4.91	5.05	5.88	4.75	4.96
		s.d.	3.51	3.75	4.17	4.46	4.96	
2	7	mean	4.67	5.13	5.36	4.55	5.67	5.08
		s.d.	4.53	3.42	3.62	1.66	4.04	
3	3	mean	2.75	6.27	3.98	2.57	7.53	4.62
		s.d.	2.38	3.86	2.91	2.24	5.31	

Note. The sound level condition ranges from 1 (the lowest sound level) to 5 (the highest).

Table 28.
Means and Standard Deviations of Productivity Below, At, and Above Preferred Sound Level for All Subjects

	Average at below most preferred sound level (N = 10)		At most preferred sound level (N =19)		Average at above most preferred sound level (N =19)	
	Key-strokes	Errors	Key-strokes	Errors	Key-strokes	Errors
mean	13632	4.63	14840	4.51	14914	5.06
s.d.	2639	3.82	3005	3.25	2764	2.52

Table 29.
Means and Standard Deviations of Productivity Below, At, and Above Preferred Sound Level for Noise Sensitive and Less Noise Sensitive Subjects

Participant type	n		Average at below most preferred sound level: Key-strokes	errors	At most preferred sound level: Key-strokes	errors	Average at above most preferred sound level: Key-strokes	errors
Preferred Sound Level 2 or 3 (52 - 56 dBA)								
Less Noise Sensitive	4	mean	14917	6.93	16553	4.33	15892	6.13
		s.d.	2194	4.75	3340	2.06	3133	3.02
More Noise Sensitive	4	mean	12605	2.94	13414	5.45	12958	4.20
		s.d.	1621	1.26	1806	4.96	1453	2.36
Total	8	mean	13761	4.93	14983	4.89	14425	5.17
		s.d.	2172	3.86	2999	3.57	2752	2.72
Preferred Sound Level 1 (48 dBA)								
Less Noise Sensitive	4	mean			14922	5.59	14543	6.74
		s.d.			1324	3.81	2176	2.63
More Noise Sensitive	4	mean			15220	2.30	15960	4.78
		s.d.			2283	3.11	1385	1.35
Total	8	mean			15071	3.95	15251	5.76
		s.d.			1735	3.67	1851	2.20

Participant type		Average at below most preferred sound level		At most preferred sound level		Average at above most preferred sound level	
		Key-strokes	errors	Key-strokes	errors	Key-strokes	errors
<u>All Subjects</u>							
Less Noise-Sensitive	mean	14917	6.93	15737	4.96	15217	6.44
	s.d.	2194	4.75	2508	2.91	2599	2.64
	N	4		8		8	
More Noise-Sensitive	mean	12605	2.94	14317	3.88	14459	4.49
	s.d.	1621	1.26	2136	4.19	2074	1.81
	N	4		8		8	
Total	mean	13761	4.93	15027	4.42	14838	5.46
	s.d.	2172	3.86	2367	3.53	2305	2.41
	N	8		16		16	

Table 30.
Means and Standard Deviations of Productivity Below, At, and Above Preferred Sound Level for Introverts and Extraverts

Personality type	n		Average at below most preferred sound level Key-strokes	errors	At most preferred sound level Key-strokes	errors	Average at Above most preferred sound level Key-strokes	errors
Preferred Sound Level 2 or 3 (52 - 56 dBA)								
Introverts	4	mean	13791	6.61	15657	3.74	15172	4.58
		s.d.	2803	3.46	3962	2.69	3485	2.33
Extraverts	5	mean	14370	3.96	15336	5.62	14906	5.51
		s.d.	2097	3.74	2885	3.89	3251	2.91
Total	9	mean	14113	5.14	15478	4.79	15024	5.10
		s.d.	2288	3.67	3175	3.35	3140	2.55
Preferred Sound Level 1 (48 dBA)								
Introverts	4	mean			15608	1.49	16183	3.92
		s.d.			2383	1.55	1387	1.03
Extraverts	2	mean			14936	6.55	16182	3.34
		s.d.			220	0.50	773	4.35
Total	6	mean			15384	3.18	16182	3.72
		s.d.			1881	2.88	1129	2.12

Personality type		Average at below most preferred sound level		At most preferred sound level		Average at Above most preferred sound level	
		Key-strokes	errors	Key-strokes	errors	Key-strokes	errors
<u>All Subjects</u>							
Introverts	mean	13791	6.61	15632	2.62	15677	4.25
	s.d.	2803	3.46	3027	2.36	2515	1.70
	N	4		8		8	
Extraverts	mean	14370	3.96	15221	5.88	15270	4.89
	s.d.	2097	3.74	2365	3.21	2745	3.15
	N	5		7		7	
Total	mean	14113	5.14	15441	4.14	15487	4.55
	s.d.	2288	3.67	2650	3.17	2537	2.41
	N	9		15		15	

Table 31.
Means and Standard Deviations of Error Rate as a Function of Noise-sensitity Type and Sound Level Conditions

			Errors per hour				
			Sound level				
	N		1	2	3	4	5
Less Noise-Sensitive	8	mean	6.26	5.37	4.93	6.43	8.11
		s.d.	4.05	2.99	4.11	4.13	4.44
More Noise-Sensitive	8	mean	2.30	5.21	5.86	3.89	4.09
		s.d.	2.44	3.93	3.69	2.42	4.21

Note. The sound level condition ranges from 1 (the lowest sound level) to 5 (the highest).

Table 32.
Means and Standard Deviations of Productivity at "Annoyed" versus at "Not Annoyed" Sound Levels

	"Annoyed" sound levels		"Not-annoyed" sound levels	
	Keystrokes	Errors	Keystrokes	Errors
mean	14713	5.46	14663	4.50
s.d.	2752	3.01	2732	2.07

Note.
n = 17

Table 33.
Means and Standard Deviations of Productivity at "Annoyed" versus at "Not Annoyed" Sound Levels for Noise Sensitive and Less Noise Sensitive Participants

Participant type	n		"Annoyed" sound levels		"Not-annoyed" sound levels	
			Keystrokes	Errors	Keystrokes	Errors
Less Noise Sensitive	7	mean	14766	7.91	15148	4.97
		s.d.	2695	2.84	2370	2.30
More Noise Sensitive	7	mean	14349	3.76	14289	4.70
		s.d.	1659	2.03	2075	1.51
Total	14	mean	14557	5.84	14718	4.83
		s.d.	2161	3.20	2186	1.87

Figure 8. Speed as a Function of Preferred Sound Level and Sound Level Condition

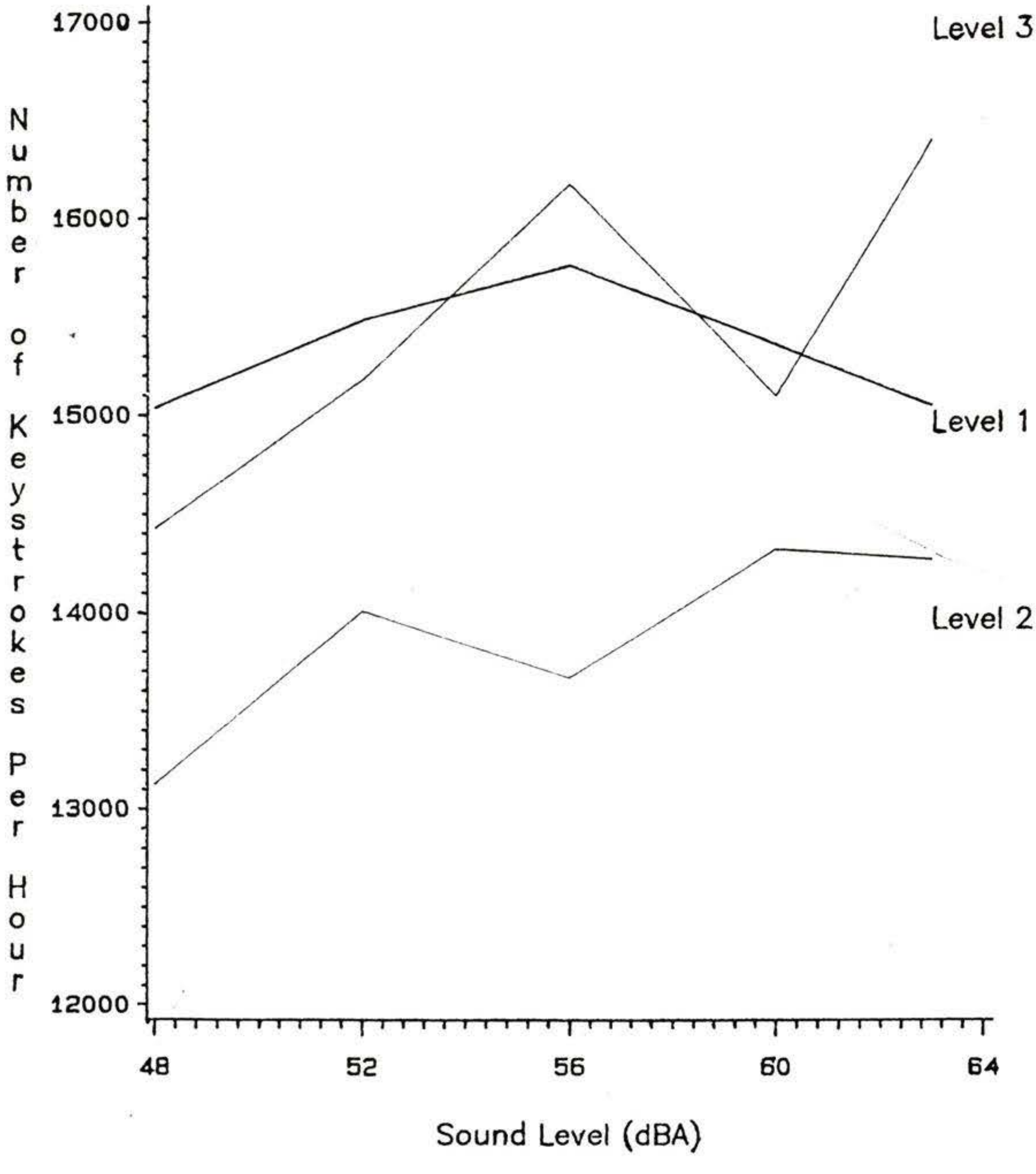


Figure 9. Accuracy as a Function of Preferred Sound Level and Sound Level Condition

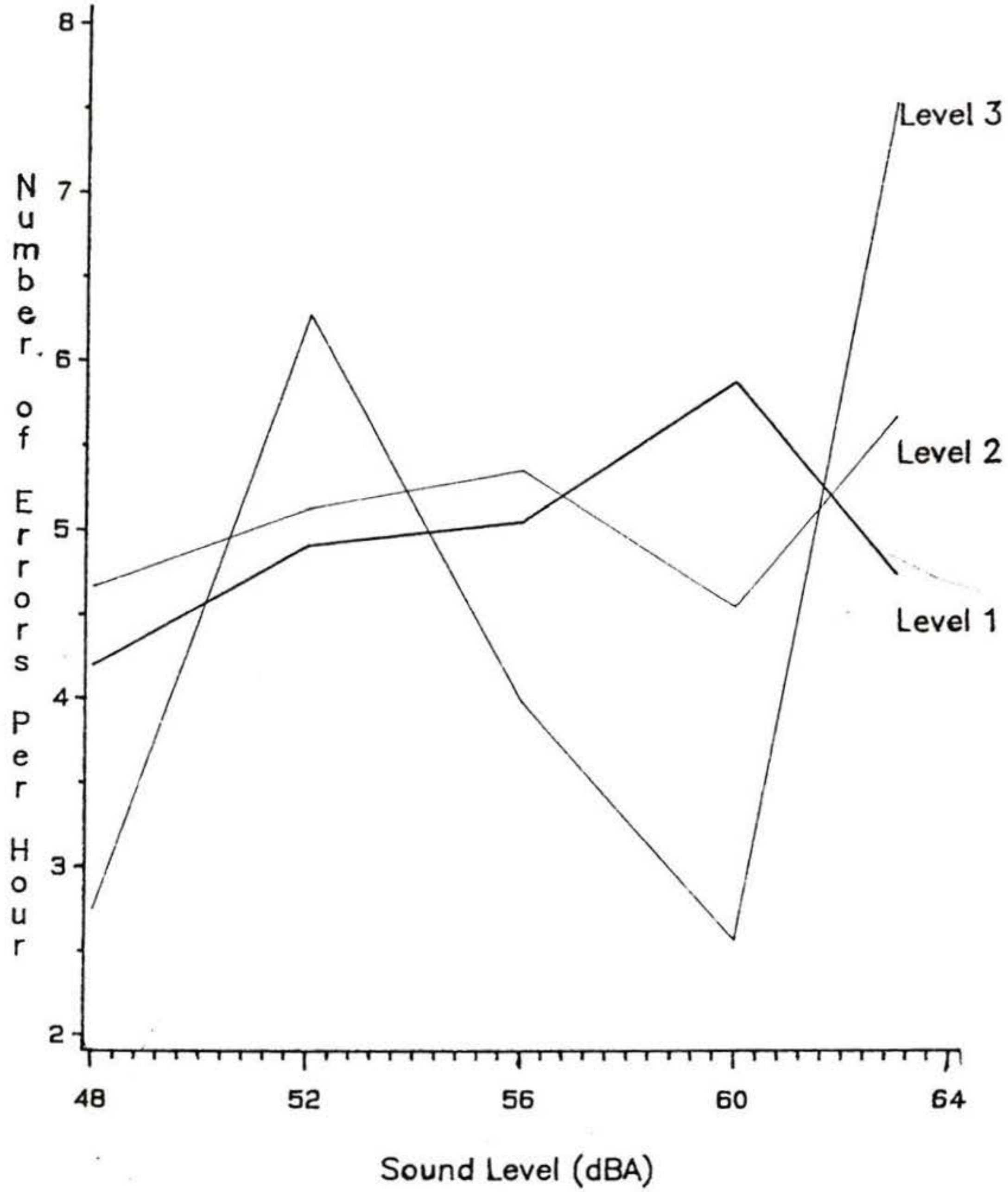


Figure 10. Average Speed Below, At, and Above Preferred Sound Level for All Subjects

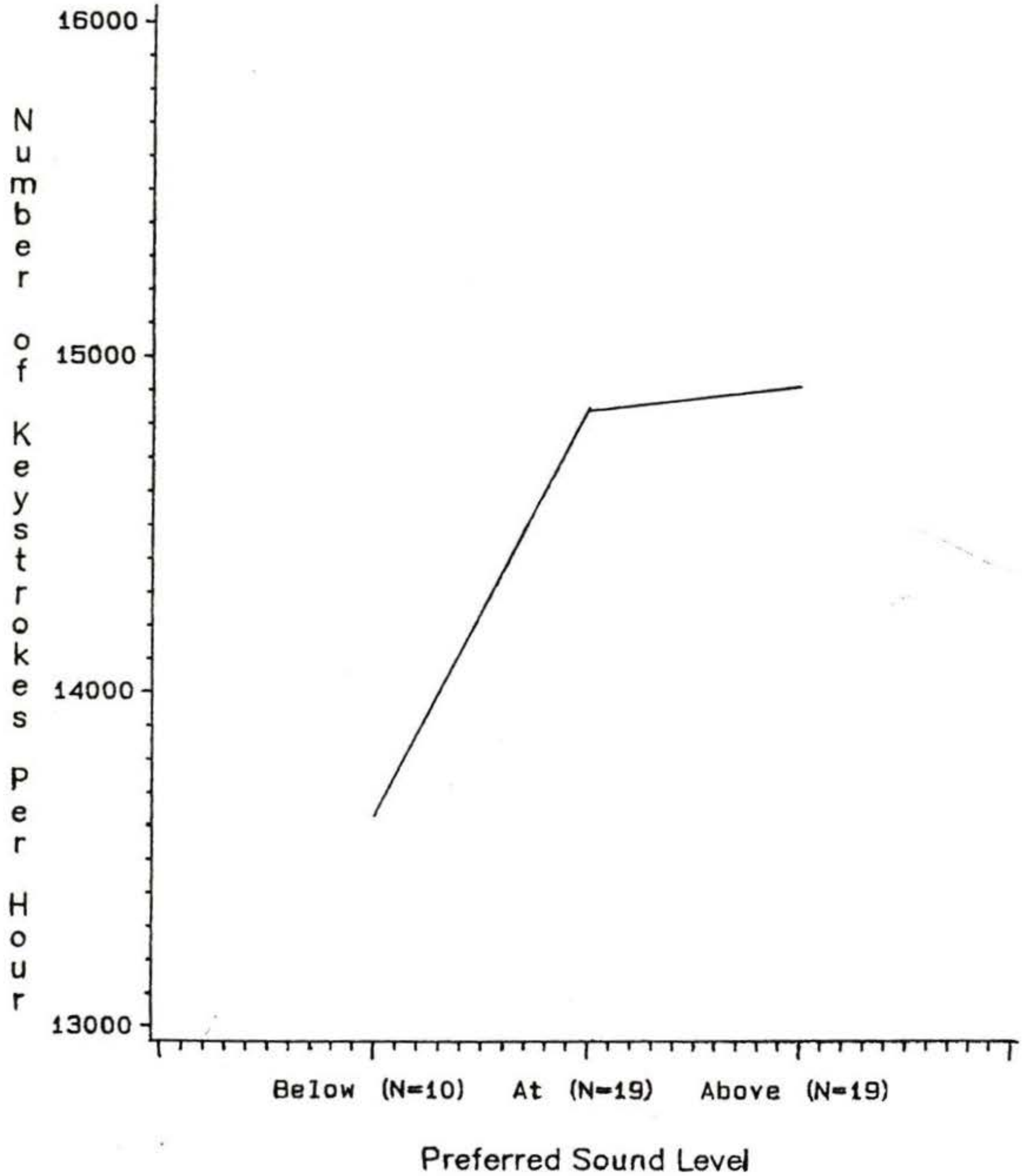


Figure 11. Average Speed Below, At, and Above Preferred Sound Level for More and for Less Noise-sensitive Subjects

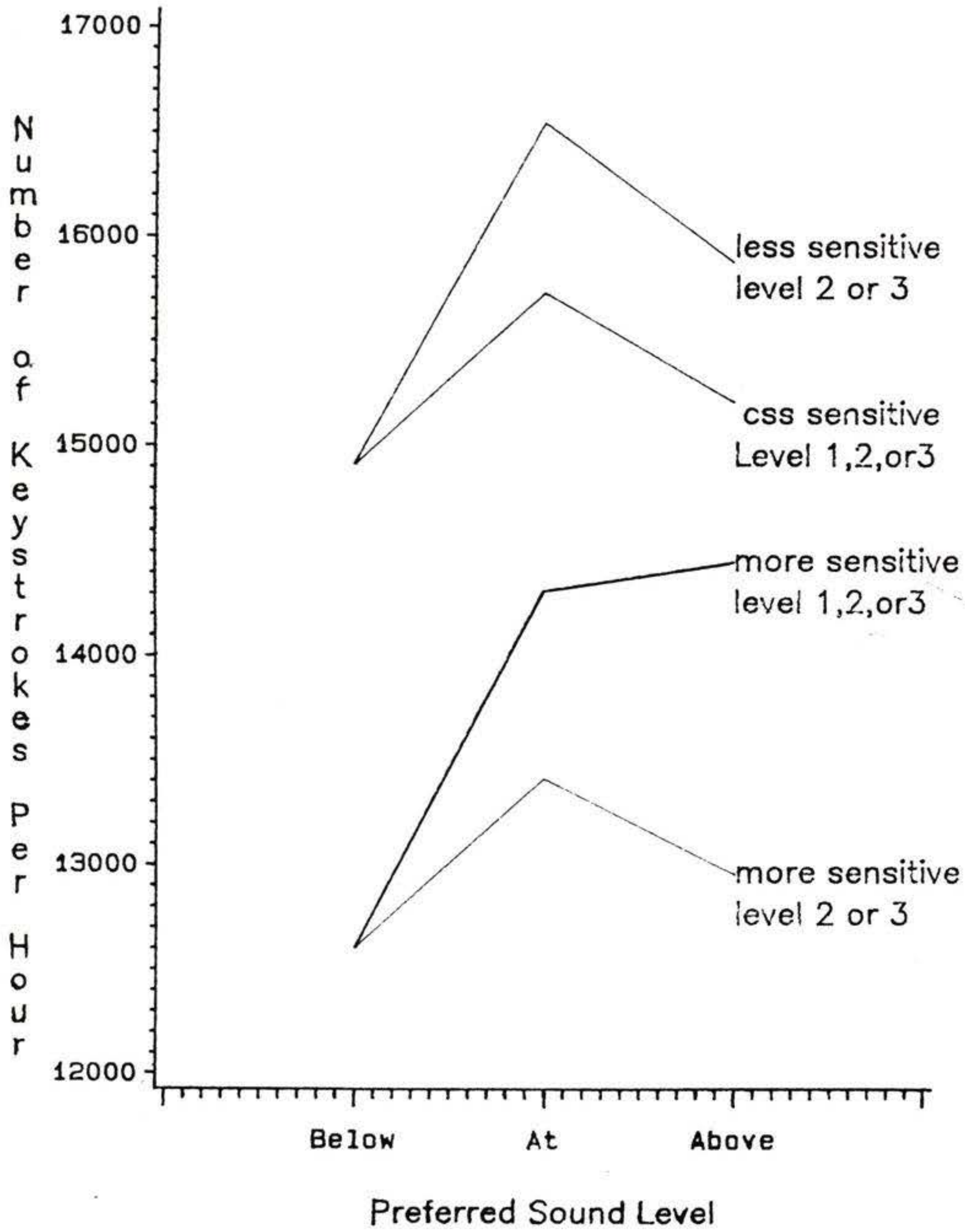


Figure 12. Average Accuracy Below, At, and Above Preferred Sound Level for More and for Less Noise-sensitive Subjects

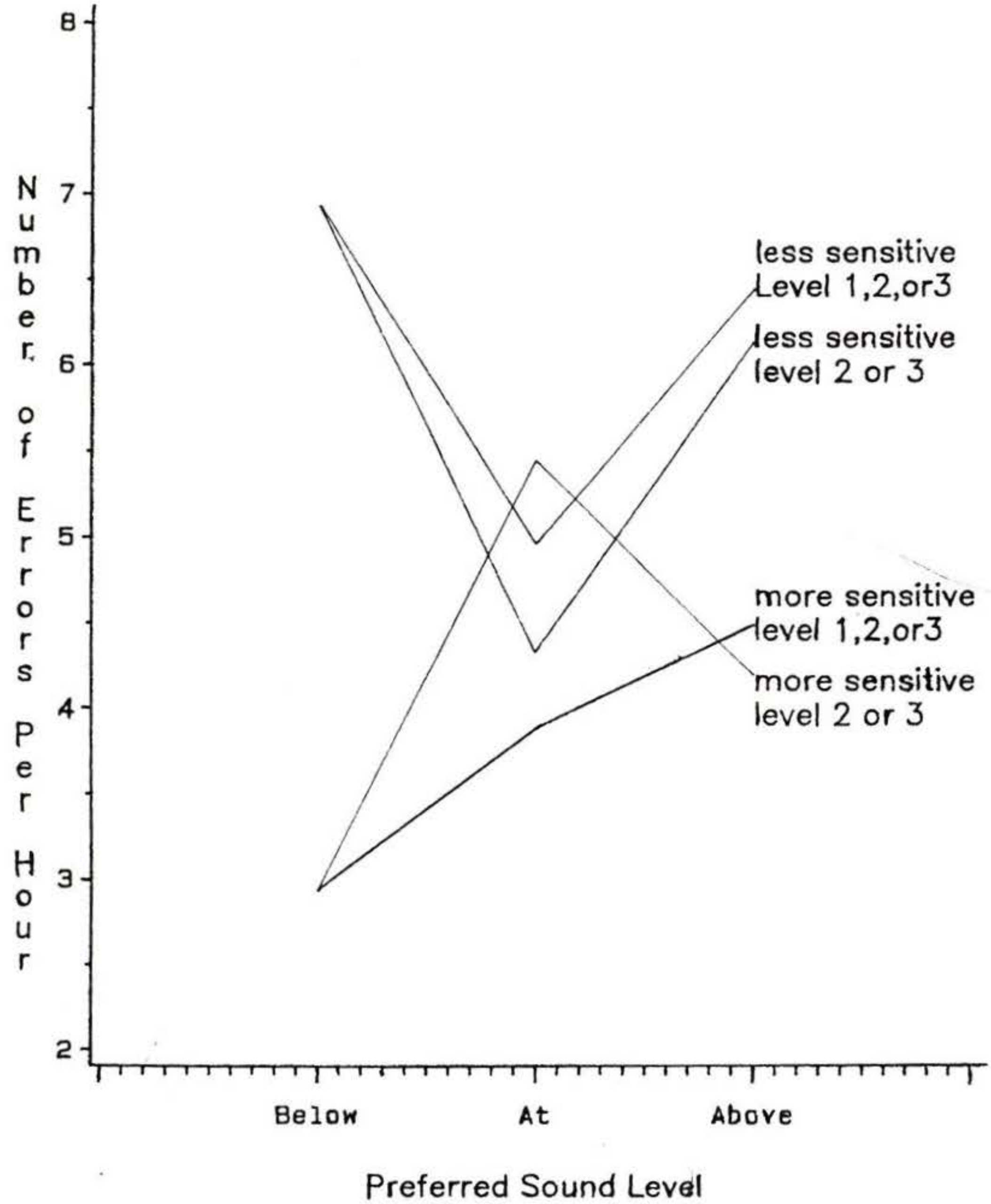


Figure 13. Average Speed Below, At, and Above Preferred Sound Level for Introverts and for Extraverts

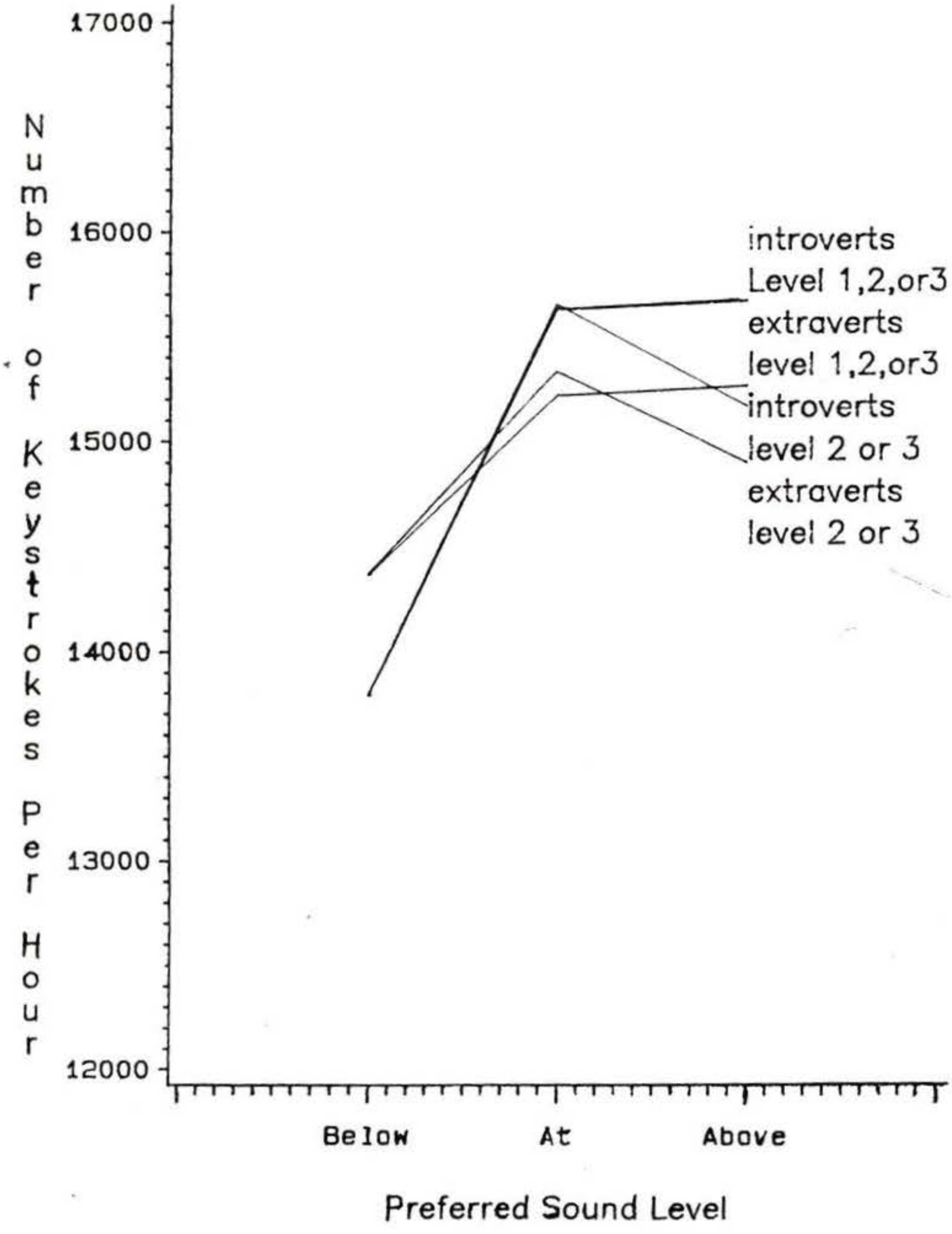


Figure 14. Average Accuracy Below, At, and Above Preferred Sound Level for Introverts and for Extraverts

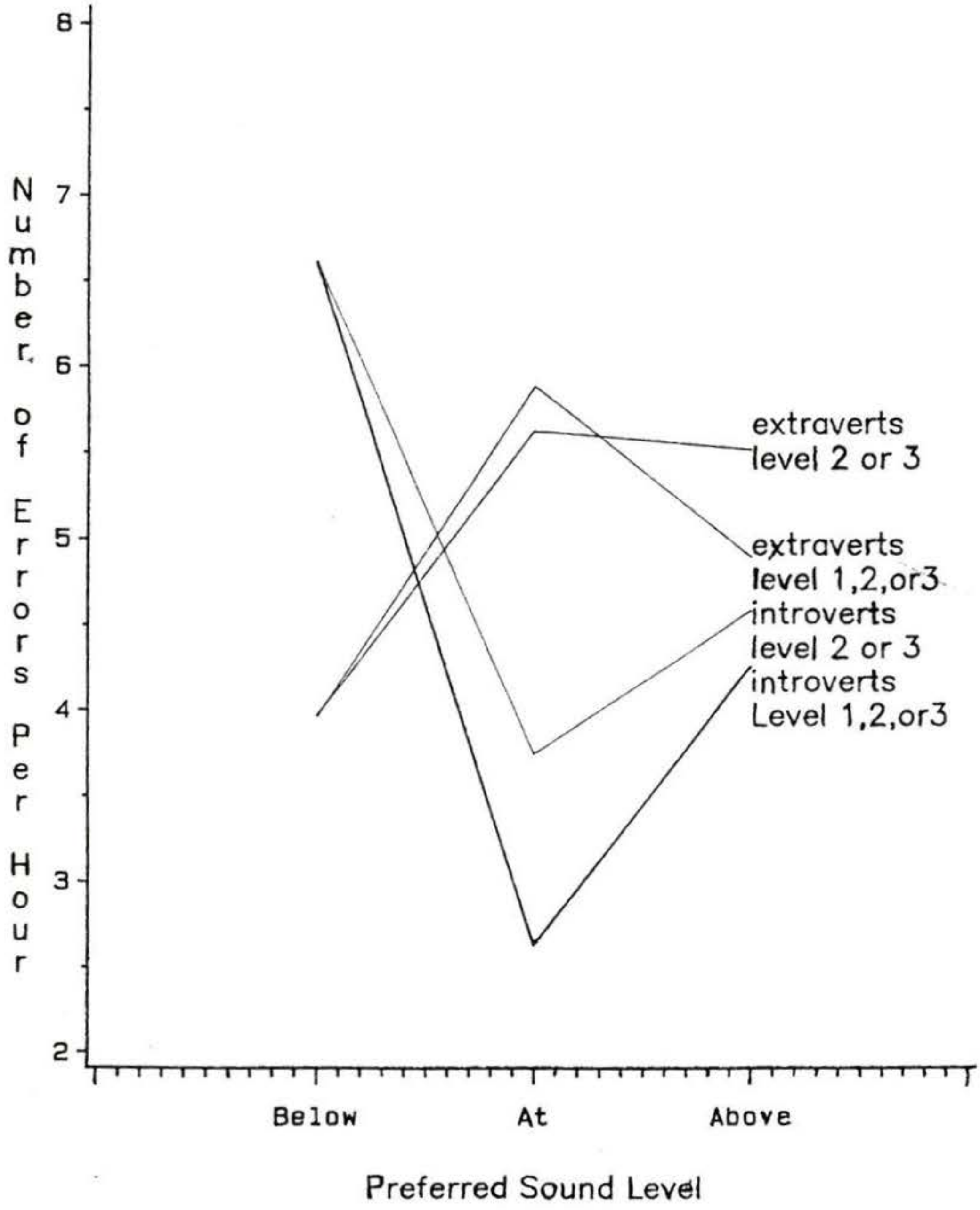
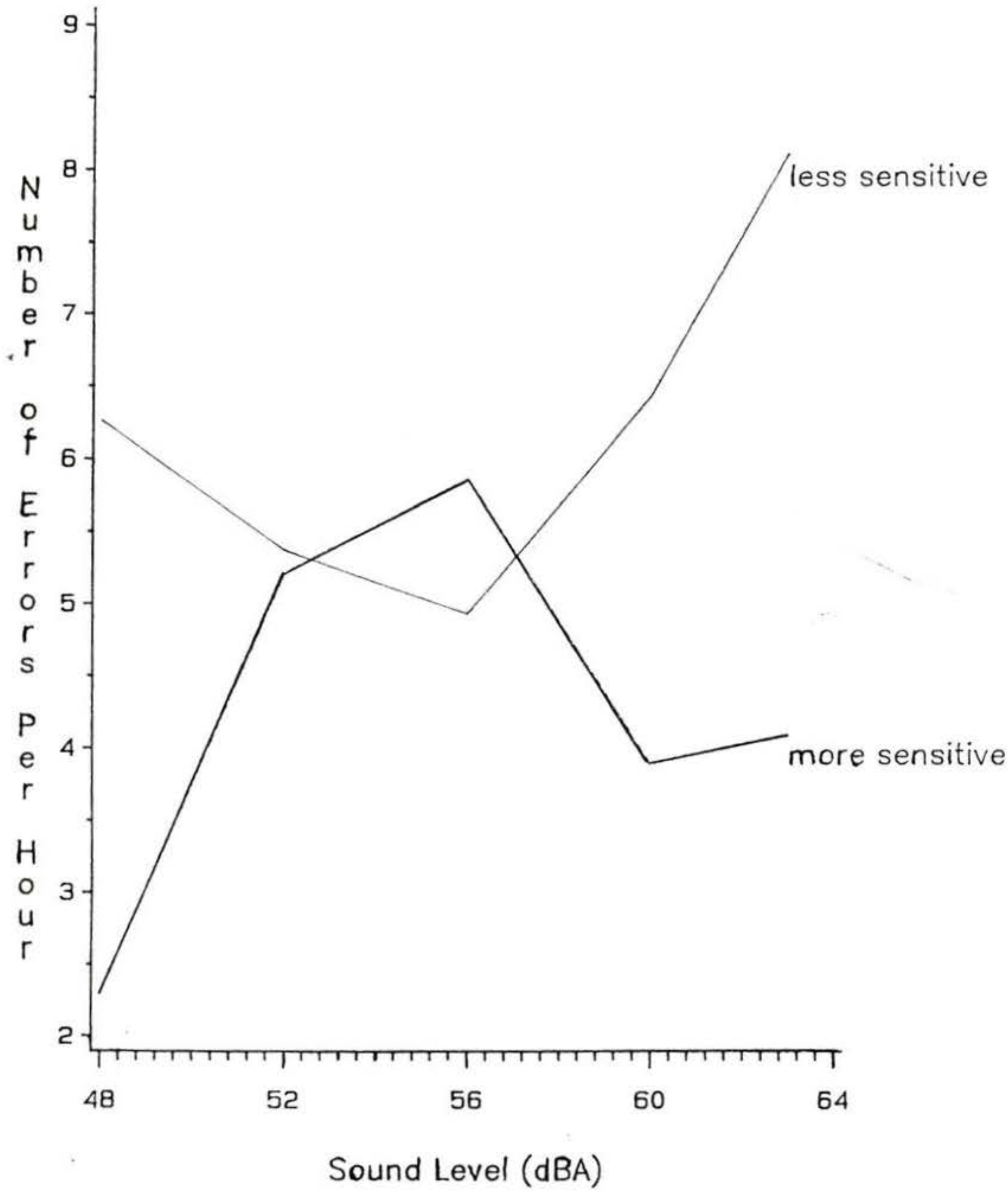


Figure 15. Average Accuracy as a Function of Sound Level Condition for More and for Less Noise-sensitive Subjects



GENERAL DISCUSSION

Overall, the results of the three studies have lent limited support to some of the hypotheses, but not the others.

Subjective Effects of Noise

The results of the subjective effects of noise in the three studies are consistent with the findings of previous surveys. The majority of office workers, particularly those in open-plan offices, feel that their offices are too noisy or far too noisy. Distractions from work, difficulty in hearing others, and irritation are the primary reasons given for noise annoyance. For the survey respondents and the subjects in Experiment 2, noises made by office machines and telephones, and co-workers' conversations are the major sources of distraction. The subjects in Experiment 1 report that the background conversation has made their work less enjoyable and is fairly distracting. About half the survey respondents also feel that they do not have enough privacy, particularly conversational privacy.

Although the questionnaire survey data do not fit the proposed causal model as well as desired, the direct effects between job level, office openness, aural distraction, conversational privacy, overall privacy, and satisfaction with the acoustical environment are clear. Obviously, other external variables such as noise source, perceived control, activity, and visual privacy may be added to the model. Such a model will become very complex and difficult to handle.

Individual characteristics, age and sex, seem to affect employees' responses to the environment. The female survey respondents report greater aural distraction. Similarly, the female operators in Experiment 2 prefer lower sound levels than did the male college students in Geen's (1984) study.

Self-reported Effects on Speech Communication

As the questionnaire survey shows, office workers spend on average 20% of their time talking. Office noise can interfere with speech communication in the office. Many survey respondents, particularly those working in open-plan and semi-open offiecs, find it difficult to hear others (35% of the respondents) and to be heard (21%) in a noisy office. Some respondents indicate that it is particularly problematic when on the phone.

Behavioral Effects on Non-auditory Tasks

As for behavioral effects of noise on non-auditory tasks, Experiment 1 has failed to show that moderate level, audible background conversation (noise that has meaning) lowers the accuracy or the speed of completion of a series of simulated office tasks (filing, telephone number search, calculation, spelling, comprehension, and proofreading). Only spelling speed is lowered by irrelevant conversations more than by relevant conversations.

Individual Differences

Nevertheless, the results of the experiments suggest that office noise and background conversation affect individuals with different sound sensitivity, introversion-extraversion, or stimulus screening ability differently.

Experiment 1 provides some evidence that screeners generally perform better than non-screeners when irrelevant information is present. Non-screeners work faster overall and on spelling, when relevant information is present than when irrelevant information is present. It appears that screeners can block out irrelevant information and as a result, can work faster or are at least unaffected by the information. When relevant information is present, non-screeners can take in the information that may help them work better.

As Experiment 2 shows, noise-sensitive data-entry operators are more accurate than less noise-sensitive ones.

Performance at the Most Preferred Sound Level

As predicted, some individuals in Experiment 2 perform best at the sound level they prefer the most. For those with more extreme scores on the introversion-extraversion scale and perhaps for those on the noise sensitivity scale as well, work speed is affected by sound level preference in the predicted manner. They produce most at the sound level that they prefer.

As for data-entry accuracy, it is apparent that noise-sensitive operators display a different pattern than less noise-sensitive operators. So do introverts and extraverts. Although these differences in patterns are not supported by statistical test evidence, it is worthwhile to investigate whether these results can be replicated with larger sample sizes.

Relationships between Performance Measures

Interestingly enough, the two measures of performance (speed and accuracy) for most tasks (filing, telephone number search, calculation, spelling, comprehension in Experiment 1, and data-entry in Experiment 2) are not related. The only exception is proofreading; more accurate proofreading implies slower proofreading. Furthermore, accuracy is dependent on the task more than speed is: One may be accurate in calculations yet very inaccurate in comprehension; on the other hand, one who is fast in calculations tends to be fast in comprehension too.

Perceived and Behavioral Effects

The results of the behavioral measures of performance do not agree completely with the perceived effects of noise on performance. In Experiment 1, although subjects find background conversation distracting and believe it has an impact on their performance, their actual performance is not affected significantly. Non-screeners work significantly faster overall and on spelling when a relevant background conversation is present than when an irrelevant conversation is present, but no such differences in distracting ratings are found.

In Experiment 2, some workers perform best at the sound level they prefer the most, but others do not. Research work along the same lines, such as studies on the impact of music on industrial workers (e.g., Gladstones, 1969) suggest that factory workers have higher morale when music is played, but there is no increase in productivity.

One plausible explanation is that office workers work harder in noise; even though their performance is not affected, such performance is maintained at a higher cost.

Validity and Reliability of Rating Scales

It is apparent that individual characteristics play a role in the effects of noise on satisfaction with the work environment and also on task performance. Nevertheless, the three studies reported show that valid and reliable rating scales that measure these characteristics are lacking.

With regard to validity, does sound sensitivity mean having a low threshold of annoyance, as suggested by Moreira & Bryan, or having a good ability to detect low intensity sound? Is sound sensitivity related to stimulus screening, field dependency, and other personality traits? If so, how are they related?

As in Griffiths and Langdon (1977), and Moreira and Bryan (1972), the simple three-point self-rating of noise sensitivity used in the questionnaire survey may not be sensitive enough to discriminate varying degree of sound sensitivity. Even Weinstein's 21-item noise sensitivity scale used in Experiment 2 has low internal consistency.

Another issue is whether sound sensitivity is a relatively stable trait? The test-retest reliability of a three-point self-rating of sound sensitivity was low (r = .35) in Griffiths et al.'s study, but was quite high (r = .85) in Moreira et al.' study. Weinstein (1979) also reported good test-retest reliability (r = .72).

Strengths

In comparison with many laboratory experiments on noise effects in which meaningless sounds, unfamiliar tasks, and unrealistically high noise levels are used, the two experiments reported have greater external validity. Office workers and data-entry operators took part in the studies. The stimuli were office sounds that were recorded in an actual office and were deliberately played at typical office sound levels. In addition, the performance of typical office tasks was measured.

Problems and Limitations

There are a few general problems with the studies. First, difficulty in recruiting office workers as subjects has resulted in the sample sizes being smaller than desired. Therefore, the conclusions should be considered tentative until successful replications with larger sample size are made.

Second, the validity and reliability of the noise sensitivity measure and the stimulus screening measure have yet to be established.

Future Research

The results of the present studies suggest a number of areas which are worthy of pursuing in the future.

First, the studies have demonstrated that individual differences can modify noise effects, and yet good, valid and reliable rating scales that measure individual characteristics are not available. The studies have also indicated some problems in defining cognitive variables as information rate. Future research should focus on valid operationalization of psychological variables, and on the development or refinement of individual characteristics measurements.

Second, the arousal hypothesis suggests that noise at a given level affects the performance of complex tasks more adversely than the performance of simple tasks. Although

Experiment 1 has examined task performance of office tasks that vary in complexity, the tasks are generally simple tasks. The performance effects of complex tasks that are performed by managers and professionals require future investigation.

Third, as in many laboratory studies of noise on performance, subjects in the two experiments were exposed to noise for a short period of time. Long-term influences of environmental stresses have not been studied as much. The adaptation theory proposes that long-term influences on performance depend on adaptation, but they are not well understood. Researchers should attempt to examine how prolonged exposure affects task performance, satisfaction and sound level preferences.

Conclusions

Within the typical office noise range and for a limited time noise exposure, no detrimental effect of either office noise or background conversation has been displayed across individuals.

Nevertheless, there are some, although not dramatic, individual differences in effects. As Mehrabian and Russell proposed, screeners may actually be able to block out irrelevant information more readily than non-screeners, and therefore are not affected by irrelevant information. There is also weak evidence that some individuals do in fact work best at their most preferred sound level. It follows that we should recognize and respect such individual differences.

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Appendix A

University of Victoria Survey of Offices

Robert Gifford and Cheuk Fan Ng
Department of Psychology

The purpose of this survey is to develop a better understanding of office employees' attitudes toward their work environment. Please be as honest and open as you can when completing this questionnaire. If possible, please complete it in your office. Confidentiality is assured: do not write your name on the survey. Address to Dr. Gifford, Psychology Dept., and put it directly into the campus mail.

Your cooperation is important to the success of this survey. Thank you for your participation.

Please answer every question. If a question does not apply to you, write NA (Not Applicable) next to it, so we know that you considered it.

Important Note. For the purpose of this survey, 'your office' refers to all the floor space enclosed by the nearest solid, floor-to-ceiling walls. (These walls may have windows.)

1. Do you work in: (Circle one letter only.)

   A a private office, i.e., with walls up to the ceiling and door that closes, in which you are the only occupant
   B a semi-open office, with partitions between all work stations
   C a semi-open office, with partitions between some work stations
   D an open office with no partitions between workspaces
   E other: please describe ______________________

2. How many other employees are there in your office?

   ____

3. If you share an office (i.e., your answer to Question 2 was not zero), what is the distance (approximately) to where your nearest neighbor usually sits?

   ____

4. What is the approximate distance from your work station to the nearest place, such as a hallway or aisle, where numerous others pass by on their way to other offices, an exit, washrooms, water fountains, etc.?

____

5. Approximately what percentage of your work time is spent: (The three answers should sum to 100%)

_______ % in your office (as defined earlier)
_______ % moving around from office to office in the same building
_______ % not in your office building

6. How do you find the sound level of your office, in general? (Circle one letter only.)

A far too quiet
B too quiet
C just right
D too noisy
E far too noisy

7. If you answered 'far too quiet' or 'too quiet' to Question 6, what about the quietness bothers you?

Please specify ______________________________

8. If you answered 'far too noisy' or 'too noisy', what bothers you about the noise? (Circle the letter next to any item that bothers you. Circle none, or as many of the items as you wish.)

A it distracts me from my work
B it is difficult to hear others
C it is difficult to make other people hear me
D it simply makes me feel irritable
E other: please specify ______________________

9. What sounds distract you <u>most</u> and <u>least</u>?
(Circle the letters of any sound sources that distract you. Then rank the circled items, placing a '1' in the space next to the most distracting sound, a '2' next to the next most distracting one, etc.)

_____ A office machines (especially ____________)
_____ B telephones
_____ C co-workers' conversation
_____ D mechanical noises, e.g., air conditioning, lighting, etc. (especially _____________)
_____ E others: please specify _________________

10. If your co-workers' conversations distract you, what <u>kind</u> of conversation do you find distracting?
(Circle the letters of as many items as you find distracting.)

A work-oriented talk, relevant to your job
B work-oriented talk, irrelevant to your job
C gossip
D non-gossip social conversations
E distant partially intelligible conversation
F other: please specify ______________________

11. Which sounds in the office do you <u>like</u>, if any?
List as many as you wish.

____

12. How would you rate the overall amount of <u>privacy</u> in your office? (Circle one letter only.)

A very satisfactory
B satisfactory
C neutral
D unsatisfactory
E very unsatisfactory

13. Do you feel that you can carry on a personal conversation at your desk without being overheard?
(Circle one letter only.)

A always
B usually
C sometimes
D never

14. Overall, how would you rate the acoustical environment of your office?

    A very satisfactory
    B satisfactory
    C neutral
    D unsatisfactory
    E very unsatisfactory

The following information will help us to understand how different groups of people feel about their offices. Therefore, we hope you will answer these questions. However, if you feel any question compromises your anonymity, don't answer it.

1. Age
    A under 30
    B 31-40
    C 41-50
    D over 50

2. Sex
    A male
    B female

3. Do you consider yourself sensitive to noise?

    A yes
    B about average
    C no

4. Which skill do you consider to be most central to your job? (Circle one letter only.)

    A teaching/research
    B managerial/administrative
    C technical
    D clerical/secretarial
    E other: please specify ______________________

5. How would you describe your job? (Circle more than one letter if you wish.)

   A repetitive, routine
   B requires deep thought and concentration
   C requires creativity
   D deals with many confidential matters
   E involves considerable verbal interaction with others
   F other: please specify ______________________

6. Please give an approximate breakdown of your daily activities on the job. (The total should sum to 100%.)

   ______ % reading, writing
   ______ % office machine operation (except for writing original material)
   ______ % using the telephone
   ______ % face-to-face conversation
   ______ % other: please specify ________________

7. Are there any piped-in music or artificial 'humming' sound systems in your office?

   ____

   If yes, what kind? ____________________
   and approximately what percent of the time is it on?

   ____

8. Have we omitted to ask about any important aspects of the sound or noise levels in your office?
   If we have, please describe them.

Thank you again.

Appendix B

An Overview of Path Analysis

Path analysis is a method for studying the patterns of causation among a set of variables. It allows one to determine how close a hypothesized causal model formulated on the basis of theory and empirical knowledge comes to accounting for a set of observed data. In the words of Sewell Wright (the "father" of path analysis):

> "(It is) a method of measuring the direct influence along each separate path in such a system and thus of finding the degree to which variation of a given effect is determined by each particular cause." (Wright, 1921, p. 557, cited in Land, 1969).

It is, however, not a method for discovering causes. In other words, it is used for testing theories rather than for generating theories (Pedhazur, 1982). Again, in the words of Wright:

> "...The method of path coefficients is not intended to accomplish the impossible task of deducing causal relations from the values of the correlation coefficients." (Wright, 1934, p. 193) The purpose of path analysis is to determine whether a proposed set of interpretations is consistent throughout." (Wright, 1960, p. 444, cited in Land, 1969).

When a researcher is interested in the underlying causes of a phenomenon, the researcher can use a true experimental design by manipulating the independent variables (taken as the causes) and then measuring any changes in the dependent variables (taken as the effects), while maintaining control over other variables not of interest to the researcher. Significant experimental effects can be given a causal interpretation.

In many studies in psychology, researchers can neither, for ethical or other reasons, manipulate the variables of interest nor randomly assign subjects to various experimental conditions. Under such circumstances, researchers must resort to non-experimental research methods. Unfortunately, the statistical tools that are commonly used today in analyzing correlational data in psychology, such as simple bivariate correlation and multiple regression analysis, do not allow researchers to draw any conclusions beyond the degree of association between variables or the percentage of variance of one variable accounted for by the other variables. But the researcher may be interested in making causal interpretations of the data.

What researchers need then is a method of analysis that allows them to identify how much of the change in a variable is contributed directly by another variable, indirectly through a mediating (or intervening) variable, or is merely spurious. The technique of path analysis may be one solution to solving the problem of causal inference in non-experimental research. It allows researchers to see how plausible a particular model accounts for the data.

The purpose of this overview is to outline the assumptions, and some of the basic principles and applications of path analysis.

History

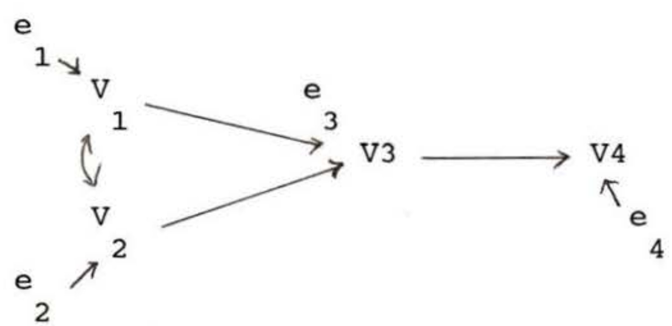
Path analysis was first developed by geneticist Sewell Wright as early as 1918 in the area of quantitative development of genetics (Wright, cited in Land, 1969). The scope of its application was later demonstrated in such diverse fields as population genetics (association mating), econometrics (corn versus hog prices), and finally psychology (heritability in the determination of intelligence) (Wright, cited in Li, 1975). Wright's ideas were eventually expressed in a theoretical paper in 1934.

In 1954, Herbert Simon brought path analysis to the attention of economists and sociologists in a paper on the causal interpretation of spurious correlation (Simon, 1954, cited in McPherson, 1976). Simon and Blalock then developed a technique for testing causal models (to be described later in this overview) in the early 1960s. In sociology, Duncan (1966) and Heise (1969) were responsible for modifying, extending, and popularizing Simon and

Blalock's technique in the mid- to late 1960's (McPherson, 1976).

<u>The path diagram</u>

Before doing a path analysis, it is useful for the researcher to draw a path diagram. The path diagram is a device for displaying graphically the pattern of causal relations among a set of variables. In drawing the path diagram, the researcher is forced to make clear statements about the proposed theory and its implications. Below is an example of a path diagram.



A distinction is made between exogenous and endogenous variables. An exogenous variable is one the variability of which is determined by factors outside the hypothesized causal model. An endogenous variable, on the other hand, is a variable the variability of which can be explained by the variables within the model, either by exogenous variables, endogenous variable, or some combinations of both. In this example, V_1 and V_2 are exogenous variables, and V_3 and V_4 are endogenous variables.

The arrows in the path diagram indicate the directions of the proposed cause-effect relationships in a causal model. The two-directional arrow between V_1 and V_2 indicates that the two variables are related in some way, but their relation is not analyzed in this particular model. If no arrows are shown, then the two variables are assumed to be independent of each other. In this example, V_4 is assumed to be caused by V_1, V_2, and V_3 directly, and by V_1 and V_2 indirectly through intervening variable V_3.

Each variable also has an error term (or residual), that is, variance unaccounted for. In this example, the error terms are e_1, e_2, e_3, and e_4. For the purpose of brevity, these error terms are usually not included in the path diagram.

Assumptions

As do other statistical techniques, path analysis makes several assumptions. The central assumption is that the residuals of endogenous variables are not correlated with one another or with other endogenous variables. A second assumption is that the causal direction of the model must be one-way: a variable cannot both affect and be affected by the same endogenous variable, and no variable can feed back upon itself through other variables. Reciprocal causation between variables is ruled out (Duncan, 1975). One-way causal ordering, however, need not hold for exogenous variables (e.g., as in V_1 and V_2). Any correlations among exogenous variables remain unanalyzed. According to Kerlinger and Pedhazur (1973), such one-way systems are called recursive models.

Because path analysis makes use of ordinary least squares regression, those assumptions necessary for regression also apply to path analysis. First, the relations among variables are assumed to be linear and additive. Consequently, curvilinear, multiplicative, or interactive relationships are excluded. Each endogenous variable is conceived of as a linear combination of the residual, and the exogenous or the endogenous variables in the model or both. For example, $V_4 = b_1 V_1 + b_2 V_3 + e_4$ where b_1 and b_2 are constants. Unrecognized nonlinearity may result in incorrect causal inference. If A is related to B curvilinearly, the path coefficient between A and B may be zero, which leads to the incorrect conclusion of no effect. When nonlinearity is found, it may be possible to represent the relationship by either treating the predictor as a categorical variable, or by using exponential terms in the path analysis (Kerlinger & Pedhazur, 1973).

The assumption of additivity means that there are no significant interaction effects. If interaction is plausible, then path analysis models developed specifically for interaction terms (e.g., Nygreen, 1971) can be applied (Billings & Wroton, 1978).

In addition, the variables should be measured in interval scales. Fortunately, it appears that the consequences of having unequal intervals are not severe. Carefully constructed measures with a reasonable number of values and multiple items will yield data with sufficient interval properties. Techniques for ordinal data may also be used to alleviate the problem (e.g., Boyle, 1970, cited in Billings et al., 1978). Other assumptions include zero error of measurement, independence of samples, and homoscedascity (Pedhazur, 1982).

The first two assumptions, uncorrelated residuals and one-way causal flow, must be met through theory. To have uncorrelated residuals, it is necessary for the researcher to include all relevant variables and to omit any irrelevant ones (Kenny, 1979). In other words, no plausible unmeasured variables may have been responsible for the observed relations between two endogenous variables in the model. Failure in considering that third variables may have been responsible for the observed relation between two variables often stems from inadequate theorizing. If such a third variable is controlled at one level, then it presents little problem except limiting the generalizability of findings. Alternatively, the third variable may be measured and be brought into the model.

Measurement errors should be minimized through careful construction of items, the use of multiple items or indicators, and an adequate pretesting of measures. If significant measurement errors exist, several techniques that adjust the estimate of the path coefficient for the degree of error present are available (Duncan, 1975, chap. 9).

Obviously, the violation of any assumptions can lead to incorrect causal inferences. Multicollinearity (i.e., when two variables become highly correlated) can create problems, because it is difficult to separate the effects of the two variables. When multicollinearity is extreme, it is difficult to reject the null hypothesis that the regression weight is zero. Moreover, the actual size of the regression weight may vary greatly from sample to sample (Billings et al., 1978).

Path analysis can be considered to be an extension of multiple regression analysis. However, it has advantages over multiple regression analysis. The intercorrelations between exogenous variables in multiple regression analysis make it impossible to sort out indirect or spurious effects from direct effects on the endogenous variables. For example, an exogenous variable may have a very low beta weight and thus be omitted from the model as unimportant, when in fact it has a substantial indirect effect on the endogenous variables. In contrast, path analysis can separate direct effects from indirect effects.

Identification

Path analysis is concerned with plausible interpretations or the erection of a causal structure among variables. Specifying the causal order (i.e., the direction of cause-effect) must come from theory because there are at least N! possible causal orders for any system of variables, where N is the number of variables (Duncan, 1975).

Causal models may be either under-identified, just-identified, or over-identified. In a system of three variables with no constraining assumptions, where x and y are predictors (exogenous or cause variables), z is the criterion (endogenous or effect variable), u is the residual term, and all scores are in standardized form, there are three known correlations between the observed variables, r_{xy}, r_{yz} and r_{xz}. The number of known correlations equals $1/2\ \{n(n - 1)\}$, where n equals the number of variables. There are three parameters to be estimated in this system: p_{xz}, p_{yz}, and r_{xy}. The number of parameters equals the sum of the number of path coefficients, the number of correlations between purely exogenous variables, and the number of correlations between residuals but excluding the path coefficients of the residuals (Kenny, 1979).

Where there is an equal number of parameters and known correlations, the system may be just-identified. Because the number of equations equals the number of parameters to be estimated, there is a unique solution for each of the parameters (Pedhazur, 1982).

The system is under-identified where there are more parameters than known correlations. In this case, the values of the parameters cannot be estimated. Obviously, the number of parameters can be reduced by making assumptions of a theoretical nature (Heise, 1975). This is a necessary but not a sufficient condition, because in some systems, one parameter may be over-identified and yet another parameter may be under-identified (Kenny, 1979).

Where the number of known correlations exceeds the number of parameters, the system is overidentified. It consists of more equations than are necessary for the purpose of parameter estimation. Over-identification results from constraints imposed on the causal model by the researcher.

A just-identified model can be converted into an over-identified model. One of the most common method is restricting certain path coefficients to zero. In other words, a variable is hypothesized to have no direct effect on a given endogenous variable, although it may have an indirect effect (Pedhazur, 1982).

The validity of a causal model is essentially assessed in its ability to reproduce or closely approximate the correlations among the variables. As long as the causal model is just-identified, the correlation matrix R can be reproduced regardless of how untenable and unreasonable the model is on logical or theoretical grounds, or both. In short, a just-identified model may always be shown to fit the data perfectly. Only models that are over-identified can be tested for their goodness of fit to the data.

Recursivity

A recursive model is one that has one-way causal ordering, that is, the direction of causality can plausibly flow in one direction only. A fully recursive model is one in which all the variables are interconnected; such a model is just-identified (Pedhazur, 1982).

Causal models that allow for feedback loops, reciprocal paths, or correlated disturbance variables can be devised, but they require additional restrictions. Such models are called non-recursive models (Fox, 1980).

Path coefficients

Given that a hypothesized causal model is recursive and overidentified, its path coefficients can be computed.

The path coefficient represents the magnitude of the direct effect of one variable on another. Wright (1934) formally defined path coefficients as:

> "The fraction of the dependent variables (with the appropriate sign) for which the designated factor is directly responsible, in the sense of the fraction which would be found if this factor varies to the same extent as in the observed data which all others (including the residual factor ...) are constant." (p. 162)

A path coefficient is represented by the symbol p_{yx}. The first subscript (y) indicates the effect (or the dependent variable), and the second subscript indicates the cause (or the independent variable). Path coefficients are equivalent to standardized beta weights in multiple regression analysis in that both refer to standardized scores and are calculated on the basis of ordinary least squares methods. The order of the subscripts, x and y, denotes the causal direction of the proposed effect. For example, p_{yx}, refers to the path coefficient for the relationship "x causes y", whereas p_{xy} indicates the effect of y on x. In general, p_{yx} is not equal to p_{xy}. The only exception is when x and y are the only variables in that particular regression equation and all other path arrows in the model remain the same. Path coefficients can take on values of less than zero up to greater than one. When negative, greater than unity values occur, they must necessarily occur together (Li, 1975).

<u>Calculation of path coefficients</u>

For each endogenous variable, a weighted function of the variables prior to the variable and the residual is constructed. The set of weighted functions created are formally called structural equations.

To represent the causal model described earlier in which the variables are expressed in standardized scores, one can construct the following equations.

1. $Z_1 = e_1$

   Variable 1, which is an exogenous variable, is equal to the residual only.

2. $Z_2 = P_{21} Z_1 + e_2$

   Variable 2 is expressed in terms of Variable 1 and the error unique to itself. The path coefficient p_{21} indicates the amount of expected change in Variable 2 as a result of a unit change in Variable 1.

3. $Z_3 = P_{31} Z_1 + P_{32} Z_2 + e_3$

   Variable 3 has two arrows pointing to it. So it is expressed in both Variable 1 and Variable 2; and

4. $Z_4 = p_{41} Z_1 + p_{42} Z_2 + p_{43} Z_3 + e_4$

Variable 4 is considered to be caused by three variables: Variables 1, 2, and 3.

The intercorrelations of the variables are used to solve a set of simultaneous equations. In simple models, these values can be solved algebraically. For example, the path coefficient is equal to a zero-order correlation whenever a variable is conceived to be dependent on a single cause and a residual, or when a variable is conceived to be dependent on more than one cause provided the causes are independent. In which case, $r_{12} = p_{21}$.

As an example, the path coefficients of the model described earlier are computed below.

$$r_{13} = 1/N\ (\sum Z_1 Z_3). \qquad \text{(Equation 1)}$$

On substitution,

$$= 1/N\ \{Z_1 \sum(p_{31} Z_1 + p_{32} Z_2) + e_3\}$$

$$= p_{31}\ (\sum Z_1 Z_1)/N + p_{32}\ (\sum Z_1 Z_2)/N + (\sum Z_1 e_3)/N$$

$$= p_{31} + p_{32} r_{12} + 0$$

(Note that the variance of a standardized variable = 1, and the correlation between variables and residuals = 0.)

$$r_{23} = p_{31} r_{12} + p_{32} \qquad \text{(Equation 2)}$$

On solving Equations 1 and 2 simultaneously, one can determine the values of p_{31} and p_{32}.

In more complex models, one can compute the path coefficients by doing a series of multiple regressions. At each stage, all variables taken as causes are treated as predictors, and the variable taken as the effect is treated as the criterion. The standardized beta weights that result are the path coefficients for the paths leading from the particular set of independent variables to the dependent variables under consideration (Pedhazur, 1982).

Thus, in the previous example, Variable 4 is treated as the criterion and Variables 1, 2 and 3 as predictors. Each path coefficient indicates the extent to which that predictor accounts for changes in Variable 4. In the second multiple regression analysis, Variable 3 is used as the criterion, and Variable 1 and Variable 2 as the predictors. The path coefficients represent the extent to which Variable 1 and Variable 2 contribute separately to any changes in Variable 3.

Decomposition of correlation coefficients

Decomposition of the correlations among variables represents the major task of path analysis. The first method, the tracing method, involves finding all the coordinating pathways between one variable and another. The correlation represents the sum of the coordinating pathways.

There are three types of pathways by which two variables may be coordinated (Heise, 1975): through a common cause, through commonly correlated causes, or through an indirect or direct pathway. One can trace the pathways by starting with the endogenous variable and proceeding backwards, either directly to the exogenous variable, or to another point of origin from which the path can be traced backward to the exogenous variable. Each variable can be traced only once, and only one correlation can be traced in any individual pathway (Li, 1975).

Correlations can also be decomposed by a mathematical method. A correlation can be expressed by an equation: $r_{yz} = p_{yxi} * r_{xiz}$, where y is the endogenous variable, and x_is are all of the variables that coordinate y and z. In the above example, $r_{32} = p_{31} r_{12} + p_{32} r_{22}$.

Calculation of effects

As has been shown, a correlation may be broken down into terms that compose of path coefficients and correlation coefficients. Each term indicates either a direct effect, an indirect effect, a spurious effect, or an unanalyzable effect.

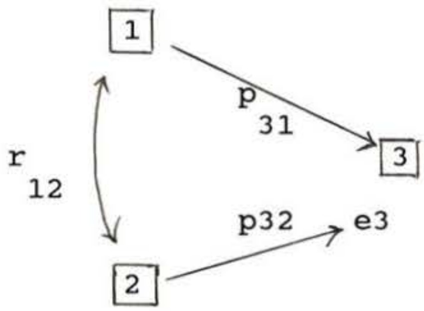


Figure 1

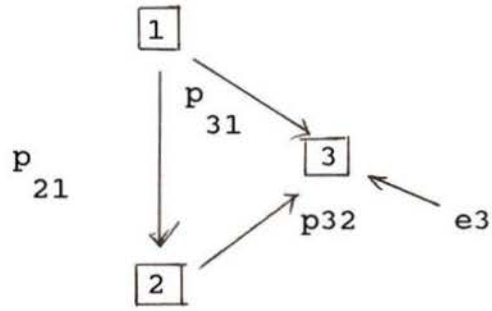


Figure 2

A direct effect is represented by a term that consists of a path coefficient only (e.g., from Variable 1 to 3 in Figure 2 above). An indirect effect occurs where one variable leads to another through an intervening variable (e.g., from Variable 1 to Variable 2, and then to Variable 3 in Figure 2 above). Note that the effect is actually a spurious one because the correlation between the two variables is due to a common cause (e.g., as between Variables 2 and 3 in Figure 2 above). An unanalyzable effect is one in which two exogenous variables share correlated causes (e.g., as between Variable 1 and Variable 2 in Figure 1 above).

The sum of direct effects and indirect effects is the total effect, or the effect coefficient. The total effect represents the overall influence of a cause on an effect, holding other causes constant. Some authors (e.g., Fox, 1980) refer the sum of unanalyzed correlations and spurious effects as the non-causal part of the correlation coefficient. Not all correlations consist of the four components indicated above. Spurious components may be identified only for correlations among endogenous variables. Unanalyzed components, on the other hand, may be identified only when the model has correlated exogenous variables (Pedhazur, 1982).

The ability to sort out indirect effects and spurious effects from direct effects represents the major strength of path analysis over multiple regression analysis (Pedhazur, 1982). In some cases, two variables can be highly correlated and yet have zero path coefficients, because the exogenous variable may have no direct effect on the endogenous variable. On the other hand, two variables that are uncorrelated may still have a large direct effect (Kenny, 1979). The total effect is affected by the theoretical strength of the model. Only when there are no unspecified causal relations can unanalyzable effects be eliminated. In such cases, the total effect consists of the direct effect(s) and the separate indirect effect(s).

<u>The residual term computation</u>

Once the path coefficients have been estimated, the residual term can be computed. Since each exogenous variable x_i in a regression equation contributes $p_{yxi} * r_{yxi}$ to the overall R squared, adding these contributions for each exogenous variable and then subtracting from one leaves the residual term (Li, 1975).

For example, in Figure 2 above, $e_3 = 1 - (p_{31} r_{13} + p_{32} r_{23})$.

Testing causal models

Path analysis is an important tool for testing causal models. Through its application, it is possible to test whether a causal model is consistent with the observed pattern of intercorrelations among variables. The closer the model is able to reproduce the observed correlation matrix, the better the model. Although it cannot prove the uniqueness of a model, it can identify which model has a better goodness of fit than others.

It should be noted that just-identified models are inherently untestable with respect to their overall goodness of fit. For any of the correlations, when the different effects are calculated and added together, the result is the original correlation. Therefore, the data will support any just-identified causal models no matter how implausible or absurd they may be (Pedhazur, 1982).

By setting certain partial correlations to zero *a priori* (according to theory), the observed correlations can be tested against the null hypotheses that they are zero. This is the technique proposed by Blalock and Simon, who made the first attempt in 1964 to test causal models (McPherson, 1976). The correlation between x and y is computed as $1/n\ (Z_x Z_y)$. The values of Z_x and Z_y in the structional equations are then replaced with known path coefficients. Blalock and Simon's technique emphasizes the elimination of unsupported alternatives rather than the acceptance of null hypotheses.

Duncan (1966) postulated, and Heise (1969) named the "theory trimming" approach. This approch involves deleting path coefficients post hoc; after the path coefficients for a just-identified model have been computed, the paths for which their path coefficients turn out to be both non-significant and negligible in magnitude are deleted from the model. Only those paths that have statistically significant path coefficients are retained. The resultant "trimmed model" is accepted as the true version of the model (Duncan, 1966).

The theory trimming approach has been criticized by McPherson (1976) for its "data dredging" nature. It produces information about empirical regularities, but no theory is tested. The technique is more concerned with accepting models rather than with rejecting models. McPherson (1976) has argued that path coefficients cannot be validly estimated unless the model is perfectly specified, in which case no trimming is necessary. The omission of any relevant variable must bias the estimate of the other path coefficients. The second problem is that testing each path coefficient for significance leads to the problem of multiple comparisons. For hypothesis testing, the test for each regression equation in the model must meet a more stringent criterion than the overall test meets because each equation contributes to the probability of an errorous conclusion. In practical terms, for a null hypothesis to be rejected, the alpha level for each equation should be larger than the alpha level for the model as a whole (McPherson & Huang, 1974, cited in Specht, 1975). Large samples present difficulties in finding non-significant path coefficients (Pedhazur, 1982). In addition, the use of meaningfulness as a criterion for deletion of paths suffers from being subjective. All in all, the most important problem it presents as a technique for evaluating causal models lies with its post hoc nature.

The third approach to testing causal models was proposed by Kerlinger and Pedhazur (1973). They have suggested a rule of thumb that the observed correlation and the recomputed correlation must differ by no more than 0.05. If they do, the causal relationship should not be accepted.

Specht (1975) has devised a new *a priori* test that is more powerful than the Simon-Blalock technique (Pedhazur, 1982). Alternative causal models are formulated on the basis of theory. Each model must be over-identified, that is, has at least one path deleted. Each model can be evaluated when its goodness of fit is compared with that of the just-identified version of the model. R_m^2, defined as a generalized squared multiple correlation, is the ratio of the generalized variance explained by the causal model to the generalized variance to be explained by the model (Specht, 1975, p. 120). For a fully recursive model,

$$R_m^2 = 1 - (1 - R_1^2)(1 - R_2^2) \ldots\ldots (1 - R_p^2)$$

where R_i^2 is the ordinary squared multiple correlation coefficient of the i^{th} equation (p. 121). For an over-identified model,

$$M = 1 - (1 - R_1^2)(1 - R_2^2) \ldots\ldots (1 - R_p^2).$$

M is calculated in the same way as R_m^2, except that some or all of the R^2's are based on a model with some of the paths deleted. M can take on values between zero and R_m^2. M equals R_m^2 when the fit of an over-identified model is perfect. The smaller the value of M, the poorer the fit. The Q statistic, $Q = (1 - R_m^2)/(1 - M)$, is a measure of goodness of fit. Its value ranges from 0 (no fit) to 1 (perfect fit). For large samples, Q can be tested for significance.

The statistic used is W; it equals $-(N - d) \log_e Q$, where N = sample size, and d = number of over-identifying restrictions (i.e., the number of path coefficients hypothesized to be equal to zero). The W statistics has a Chi-squared distribution, with the degree of freedom equalling to the number of deleted paths. Those models with statistically significant Ws are rejected, and those with non-significant Ws represent failure to reject. Thus, Specht's test is concerned with rejection of models that do not fit the data rather than with acceptance of models.

Unfortunately, there will always be more than one possible model that can survive the inferential test. To further eliminate one or more of these alternative models, a stronger test of inference based on theory is then needed.

The major shortcoming of Specht's (1975) test is its dependence on sample size. For large samples, models may be rejected even if they fit the data reasonably well. But if the sample size is too small, it is very difficult to reject models that do not fit the data. In such cases, it is perhaps best to use the statistic Q, which is sample-independent, and to set a subjective critical value (e.g., reject models if $Q < .95$) (Pedhazur, 1982).

The difference between two over-identified models can be tested for significance as well. In such cases,

$$W = -(N - d) \log_e \{(1 - M_1)/(1 - M_2)\}$$ where

N = sample size, and d = the difference between the number of overidentifying restrictions of the two models. M_1 is the measure of goodness of fit for the model with the larger number of estimated parameters, and M_2 is the measure of goodness of fit for the competing model (Specht, 1975, pg. 125). However, this test is applicable only when one of the models is nested within the other, that is, if one model can be obtained by constraining some of the parameters of the latter.

Conclusion

Path analysis can be a useful tool for analyzing non-experimental data in psychology. In particular, its advantages are that it enables one to test a hypothesized causal model, to identify the goodness of fit of models, and to distinguish the direct effect of one variable on another from the indirect effects and the spurious effects. Another advantage is that it forces the researcher to be explicit about the causal relationships among variables in the hypothesized model.

The major limitation is that it cannot establish the uniqueness of a model that fits the observed data, although it can identify which model has a better goodness of fit than others.

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Appendix C

<u>Computation of Correlation Coefficients based on the Proposed Model</u>

$r_{12} = 1/n \sum Z_1 Z_2$

$= 1/n \sum e_1 e_2$

$= 0$

$r_{13} = -.321$

$r_{14} = .629$

$r_{15} = p_{51}$

$= 0.507$

$r_{16} = 1/n \sum Z_1 Z_6$

$= 1/n \sum Z1 \; (p65Z5 + p62Z2 + p63Z3 + p64Z4 + e6)$

$= r_{15} p_{65} + r_{12} p_{62} + r_{13} p_{63} + r_{14} p_{64}$

$= (0.507)(0.082) + (-.321)(-.022) + (.639)(-.293)$

$= -.135$

$r_{17} = 1/n \sum Z_1 Z_7$

$= 1/n \sum Z_1 \; (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$

$= r_{15} p_{75} + r_{12} p_{72} + r_{13} p_{73} + r_{14} p_{74}$

$= (.507)(.151) + (-.321)(-.212) + (.639)(.477)$

$= .445$

$$r_{18} = 1/n \sum Z_1 Z_8$$

$$= 1/n \sum Z_1 (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{16} p_{86} + r_{17} p_{87}$$

$$= (-.135)(-.224) + (.445)(.704)$$

$$= 0.343$$

$$r_{19} = 1/n \sum Z_1 Z_9$$

$$= 1/n \sum Z_1 (p_{98} Z_8 + e_9)$$

$$= r_{18} p_{98}$$

$$= (.343)(.707)$$

$$= .243$$

$$r_{21} = 1/n \sum Z_1 Z_2$$

$$= 1/n \sum e_1 e_2$$

$$= 0$$

$$r_{23} = 1/n \sum Z_2 Z_3$$

$$= 1/n \sum e_2 e_3$$

$$= 0$$

$$r_{24} = 1/n \sum Z_2 Z_4$$

$$= 1/n \sum e_2 e_4$$

$$= 0$$

$$r_{25} = 1/n \sum Z_2 (p_{51} Z_1 + e_5)$$

$$= r_{12} p_{51}$$

$$= 0$$

$$r_{26} = 1/n \sum Z_2 Z_6$$

$$= 1/n \sum Z_2 \; (p_{65} Z_5 + p_{62} Z_2 + p_{63} Z_3 + p_{64} Z_4 + e_6)$$

$$= r_{25} p_{65} + p_{62} + r_{23} p_{63} + r_{24} p_{64}$$

$$= 0.071$$

$$r_{27} = 1/n \sum Z_2 Z_7$$

$$= 1/n \sum Z_2 \; (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$$

$$= r_{25} p_{75} + p_{72} + r_{23} Z_{73} + r_{24} p_{74}$$

$$= .096$$

$$r_{28} = 1/n \sum Z_2 Z_8$$

$$= 1/n \sum Z_2 \; (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{26} p_{86} + r_{27} p_{87}$$

$$= (.071)(-.224) + (.096)(.704)$$

$$= 0.052$$

$$r_{29} = 1/n \sum Z_2 Z_9$$

$$= 1/n \sum Z_2 \; (p_{98} Z_8 + e_9)$$

$$= r_{28} p_{98}$$

$$= (.052)(.707)$$

$$= .037$$

$$r_{35} = 1/n \sum Z_3 Z_5$$

$$= 1/n \sum Z_3 (p_{51} Z_1 + e_5)$$

$$= r_{13} p_{51}$$

$$= (-.321)(.507)$$

$$= -.163$$

$$r_{36} = 1/n \sum Z_3 Z_6$$

$$= 1/n \sum Z_3 (p_{65} Z_5 + p_{62} Z_2 + p_{63} Z_3 + p_{64} Z_4 + e_6)$$

$$= r_{35} p_{65} + r_{23} p_{62} + p_{63} + r_{34} p_{64}$$

$$= (-.163)(.082) + (-.022) + (-.309)(-.293)$$

$$= .056$$

$$r_{37} = 1/n \sum Z_3 Z_7$$

$$= 1/n \sum Z_3 (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$$

$$= r_{35} p_{75} + r_{23} p_{72} + p_{73} + r_{34} p_{74}$$

$$= (-.163)(.151) + (-.212) + (-.309)(.477)$$

$$= -.384$$

$$r_{38} = 1/n \sum Z_3 Z_8$$

$$= 1/n \sum Z_3 (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{36} p_{86} + r_{37} p_{87}$$

$$= (.056)(-.224) + (-.384)(.704) \qquad = -.283$$

$$r_{39} = 1/n \sum Z_3 Z_9$$

$$= 1/n \sum Z_3 (p_{98} Z_8 + e_9)$$

$$= r_{38} p_{98}$$

$$= (-.283)(.707)$$

$$= -.200$$

$$r_{45} = 1/n \sum Z_4 Z_5$$

$$= 1/n \sum Z_4 (p_{51} Z_1 + e_5)$$

$$= r_{14} p_{51}$$

$$= (.629)(.507)$$

$$= .319$$

$$r_{46} = 1/n \sum Z_4 Z_6$$

$$= 1/n \sum Z_4 (p_{65} Z_5 + p_{62} Z_2 + p_{63} Z_3 + p_{64} Z_4 + e_6)$$

$$= r_{45} p_{65} + r_{42} p_{62} + r_{43} p_{63} + p_{64}$$

$$= (.319)(.082) + (-.309)(-.022) + (-.293)$$

$$= -.260$$

$$r_{47} = 1/n \sum Z_4 Z_7$$

$$= 1/n \sum Z_4 (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$$

$$= r_{45} p_{75} + r_{42} p_{72} + r_{43} p_{73} + p_{74}$$

$$= (.319)(.151) + (-.309)(-.212) + (.477) \quad = .591$$

$$r_{48} = 1/n \sum Z_4 Z_8$$

$$= 1/n \sum Z_4 (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{46} p_{86} + r_{47} p_{87}$$

$$= (-.260)(-.224) + (.591)(.704)$$

$$= .474$$

$$r_{49} = 1/n \sum Z_4 Z_9$$

$$= 1/n \sum Z_4 (p_{98} Z_8 + e_9)$$

$$= r_{48} p_{98}$$

$$= (.474)(.707)$$

$$= .335$$

$$r_{56} = 1/n \sum Z_5 Z_6$$

$$= 1/n \sum Z_5 (p_{65} Z_5 + p_{62} Z_2 + p_{63} Z_3 + p_{64} Z_4 + e_6)$$

$$= p_{65} + r_{25} p_{62} + r_{35} p_{63} + r_{45} p_{64}$$

$$= (.082) + (-.163)(-.022) + (.319)(-.293)$$

$$= -.007$$

$$r_{57} = 1/n \sum Z_5 Z_7$$

$$= 1/n \sum Z_5 (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$$

$$= p_{75} + r_{25} p_{72} + r_{35} p_{73} + r_{45} p_{74}$$

$$= (.151) + (-.163)(-.212) + (.319)(.477)$$

$$= .338$$

$$r_{58} = 1/n \sum Z_5 Z_8$$

$$= 1/n \sum Z_5 (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{56} p_{86} + r_{57} p_{87}$$

$$= (-.007)(-.224) + (.338)(.704)$$

$$= .240$$

$$r_{59} = 1/n \sum Z_5 Z_9$$

$$= 1/n \sum Z_5 (p_{98} Z_8 + e_9)$$

$$= r_{58} p_{98}$$

$$= (.240)(.707)$$

$$= .170$$

$$r_{67} = 1/n \sum Z_6 Z_7$$

$$= 1/n \sum Z_6 (p_{75} Z_5 + p_{72} Z_2 + p_{73} Z_3 + p_{74} Z_4 + e_7)$$

$$= r_{56} p_{75} + r_{26} p_{72} + r_{36} p_{73} + r_{46} p_{74}$$

$$= (-.007)(.151) + (.071)(.096) + (.056)(-.212) + (-.260)(.477)$$

$$= -.128$$

$$r_{68} = 1/n \sum Z_6 Z_8$$

$$= 1/n \sum Z_6 \; (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= p_{86} + r_{67} p_{87}$$

$$= (-.224) + (-.128)(.704)$$

$$= -.314$$

$$r_{69} = 1/n \sum Z_6 Z_9$$

$$= 1/n \sum Z_6 \; (p_{98} Z_8 + e_9)$$

$$= r_{68} p_{98}$$

$$= (-.314)(.707)$$

$$= -.222$$

$$r_{78} = 1/n \sum Z_7 Z_8$$

$$= 1/n \sum Z_7 \; (p_{86} Z_6 + p_{87} Z_7 + e_8)$$

$$= r_{67} p_{86} + p_{87}$$

$$= (-.128)(-.224) + (.704)$$

$$= .733$$

$$r_{79} = 1/n \sum Z_7 Z_9$$

$$= 1/n \sum Z_7 \; (p_{98} Z_8 + e_9)$$

$$= r_{78} p_{98}$$

$$= (.733)(.707) \qquad = .518$$

$r_{89} = p_{98} = .707$

<u>Note</u>.
The structural equations and the path coefficients are displayed at Table 7 and Table 8.

Appendix D

A Transcribed Excerpt of the Irrelevant Stimulus Conversation

(A Social Conversation in the Office)

A: Hi, Judy.

B: Hi, Eileen. How was your weekend?

A: Really good, thanks. How was yours?

B: Oh, well, as weekends go. Considering that it was a holiday and it rained (pause) the whole time, wasn't bad.

A: That's good. Did you get out at all?

B: Yeh. Actually we got out yesterday -- for almost the whole day. We went to pick Henry up in the morning and went out with what seemed to be the rest of Victoria -- to have a look at the, the Goldstream Park salmon run which was quite nice except for the people. Oh God!

A: And the rain. Did it rained up there?

B: Yeh, and the rain. I got quite soaked, even as it was. Yeh, but it was pretty interesting.

A: Really?

B: There was just so much salmon in there. You can watch them fighting their way up the stream. Lots of dead ones lying around.

A: Really?

B: And the gulls. The gulls were hilarious. They were. It was as if they couldn't decide what they wanted. They go after one and then midway they would stop and then turn around and go for another one because they were attacking the salmon as the salmons were trying to go upstream.

A: Really, oh, really.

B: Because apparently. According to the warden, the gulls prefer to attack the live fat fish and eat them.

A: Dead ones?

B: Than go for the dead ones. He said by next week, the place would just be full of ravens. They will be eating all the dead fish. So that was, yeh.

A: Oh, I see. That's interesting.

B: It was very interesting. I have never seen that many salmon before in the Goldstream River. So we went. We walked along all the way down to the hut that they have inside by the fireplace.

A: Oh, they have a fireplace there?

B: Hm. Oh, yeh. Just at the end, down at the end of the trail along the river, there's a, a log cabin that was built. That has a fireplace, and (pause) oh, slide-shows and little displays, a lot for kids that they can pick up and look at things and touch and stuff. So it was pretty cute seeing all these little kids running round with big pine cones.

A: Oh really!

B: Shells, skulls of racoons and stuff.

A: Skulls of racoons?

B: There were skulls of little animals. They can pick up and handle it. There is a sign says "Please touch these things".

A: Oh really!

B: Yeh.

A: Isn't it great?

B: It's not too bad. It's good for kids.

A: Oh, yes.

B: That's what they like. So we sat there. I tended to dry out.

A: Oh, God. You must have been soaked.

B: And cold. I am always that way. I put on a heavy sweater and a scarf and had my umbrella in the car but didn't take my raincoat because it wasn't raining when we left. By the time I took my camera and binoculars and Monty got his bird book, that was his rush that I didn't take my raincoat. So then I was..... I got wet and then got quite cold. But, it was fun.

A: That's good.

B: So then we went up from there to Cowichan Bay.

....

A Transcribed Excerpt of the Relevant Stimulus Conversation

(A Office Conversation related to the Task at Hand)

A: I'd better get onto the typing. By the way, my typewriter needs to be cleaned. Who should I call, Mr. Smith or Miss Jones?

B: I can't remember. It's all in that memo.

A: Which memo?

B: The one from the Director of Supplies, L. MacDonald. He sent it out a few months age.

A: Let me take a look. I didn't even look at it. Let's see if I can find it. Who can keep track of all those memos? We get a million of them.

B: I think I filed it under office supplies, under O and I don't remember what drawer number that is.

A: Oh, ya, here it is. Oh, look. We're supposed to be getting our office supplies from Mr. Smith now. Did you know that?

B: No, I didn't. It seems they change every few months who you get supplies from.

A: Ya and what color order forms you're supposed to use. Is it yellow, blue or pink this month?

B: I'm not sure. I always double check. After I sent some on blue and got a nasty note and no supplies because they were supposed to be on pink, which lead to a lecture on ordering when Dr. Jones didn't get the pencils he likes.

A: Ya. Those people down in supplies are really picky. They think the whole company revolves around them.

B: Well, in a way it does because we get everything from them except of course batteries and calculators.

A: You're right. Oh, here's the number to call for my typewriter, 5678. I hope they can fix it soon. I've got to get this typing done.

B: Don't count on it. You know how fast they get things fixed around here. Sometimes I think it's better to try and fix it yourself. At least there's no harm in it.

A: Ya, except you get ink all over your clothes. Besides when I take something apart, I can never remember how to put it back together.

B: Well, when you call, ask them to bring you another one. I've done that before. You make it sound like it's in million pieces and they'll bring a replacement because they'll take yours to the shop.

A: Oh, that's a great idea. I hate trying to work while someone is taking apart my machine and getting ink everywhere.

B: Well. While you're waiting, let's get started on this proofreading. Now where's my dictionary?

....

Appendix E

OFFICE STUDY Participant's Name: ________________

Instructions:

Please use the following scale to indicate the degree of your agreement or disagreement with each of the statements on the following two pages. You may agree or disagree in different degrees with each statement. Highest agreement is +4; highest disagreement is -4; and when you cannot agree or disagree with a statement, simply answer with 0. Use the other numbers on the scale to show more moderate feelings in each direction. Tear this page off and record your answers in the spaces provided below.

+4 = very strong agreement
+3 = strong agreement
+2 = moderate agreement
+1 = slight agreement
0 = neither agreement nor disagreement
-1 = slight disagreement
-2 = moderate disagreement
-3 = strong disagreement
-4 = very strong disagreement

1. _____	11. _____	21. _____	31. _____
2. _____	12. _____	22. _____	32. _____
3. _____	13. _____	23. _____	33. _____
4. _____	14. _____	24. _____	34. _____
5. _____	15. _____	25. _____	35. _____
6. _____	16. _____	26. _____	36. _____

7. ______	17. ______	27. ______	37. ______
8. ______	18. ______	28. ______	38. ______
9. ______	19. ______	29. ______	39. ______
10. ______	20. ______	30. ______	40. ______

1. I am usually not much affected by the feeling of leather or upholstery on my bare skin. #
2. I don't startle easily. *
3. My strong emotions in a situation carry over for one or two hours after I leave it. #
4. I am not influenced as much as most people by the weather.
5. I am strongly moved when many things are happening at once. *
6. Sudden changes are not emotionally moving for me.
7. Having heard a sound, I often lay awake at night for some time. *
8. Compared to others, I don't get as "moved" by intense stimulation.
9. The mood of a physical setting affects me a lot. *
10. When I get stirred up my heart beats fast and keeps on beating for a while. *
11. I am generally less emotional, both in a positive and negative way, than others.
12. A sudden pungent odor can have a great influence on me. *
13. When I walk into a crowded room, it immediately has a big effect on me. *
14. Things usually don't get me stirred up. @
15. A long spell of bad weather affects me greatly. * @

16. A very emotional incident early in the day can change my mood for the whole day. *
17. I am not affected much by sudden or intense events. @
18. I am not affected much by the hardness or softness of the furniture I use. #
19. Strong foul odors can make me tense. *
20. Drastic changes in weather can affect my mood. * @
21. I am calm almost all the time.
22. I am not one to feel the changes in the mood of a situation.
23. I am tremendously affected by sudden loud noises. *
24. I get excited easily. * @
25. I am not bothered by the sight of an accident for a long time.
26. I sometimes tremble from excitement. *
27. Strong emotions don't have a lasting effect on me.
28. I am not one to be strongly moved by an unusual odor.
29. I quickly overcome being startled.
30. I am excited or moved long after a good movie. *
31. Sometimes if I have many things to do at once, I get rattled. * @
32. I am not affected much by the feel or textures of the clothes I wear. #
33. I am excitable in a crowded situation. *
34. It is easy to feel aroused when a lot is happening. *

35. Highly arousing stimulation affects me for a short time.

36. I don't react much to sudden loud sounds.

37. Sometimes I get emotionally moved over even simple things. *

38. My moods are not quickly affected when I enter new places. @

39. Sudden changes have an immediate and large effect on me. * @

40. Extremes in temperature don't affect me a great deal.

MANY THANKS

Please return this questionnaire to Cheuk Ng at the Department of Psychology.

Note:

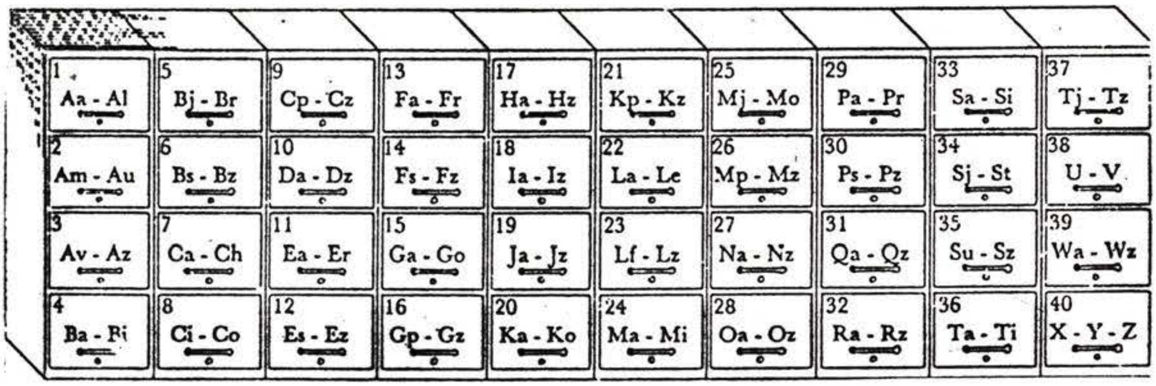
* The responses to these items are reversed before the scores are summed up.
@ The corrected item-total correlation of this item is greater than 0.60.
# The corrected item-total correlation of this item is less than 0.30.

This Note section does not appear in the rating scales that were administered to the subjects.

Appendix F

Part I: Filing

Instructions: After each name, write the number of the drawer in which that record should be filed. The first one is marked correctly.



Kuczma, H.G.	21		
Hilton, A.B.	_____	Beaton, E.C.	_____
Pakenham, N.B.	_____	Dickson, E.L.	_____
Harbicht, D.H.	_____	Armstrong, T.M.	_____
McTavish, S.	_____	Kerr, R.A.	_____
Englemark, A.B.	_____	Greenfield, W.J.	_____

Part II: Phone Numbers Search

Instructions: Please look up the phone number of each of the following users in the telephone directory provided (January 1984 issue) and write it down beside the name of the user. The first one has been done correctly.

User's Name	Phone Number
University of Victoria, Psychology Dept.	721-7525
S S Jones	________
Saba's Fabrics	________
Jas W Armatage	________
United Engineering Ltd.	________
B C Transit	________
John Hardy	________
Arthur Page	________
Giovanni Scigliano	________
H T Carlson	________
B C Government Motor Vehicle Licence Issuing Office	________

Part III: Calculations

Instructions: Use a calculator to solve the following problems. Write your answers in the spaces provided on the right. The first one has been done correctly.

	Answer
Sample: 6 + 5 =	11
(1) 64 - 37 =	(1) ________
(2) 2736 9 =	(2) ________
(3) 308 x 42 =	(3) ________
(4) 1304 x 0.4 =	(4) ________
(5) 40.6 + 6.2 + 347.0 + 622.9 =	(5) ________
(6) 63.4 - 7.9 =	(6) ________
(7) 25% of 536 =	(7) ________
(8) 162.9 x 1.9 =	(8) ________
(9) $275 less 20% =	(9) $________
(10) 841263 - 621142 =	(10) ________
(11) 4975.88 364 =	(11) ________
(12) 31 x 12 =	(12) ________
(13) (2 + 8) x 4 =	(13) ________
(14) 63.2 - 61.7 + 4.2 =	(14) ________
(15) 612 x 41 =	(15) ________

Part IV: Spelling

Instructions: Read each of the following phrases or sentences. Write down the correct spelling of any misspelled words in the spaces provided on the left. If there is no spelling mistake, put a tick beside it. The first two have been done correctly.

___two___ Sample: too apples

_________ Sample: in the past

_________ 1. It occured to me that ....

_________ 2. in excellent condition

_________ 3. Personel Department

_________ 4. I realize that ......

_________ 5. He usually gets up at 7 A.M.

_________ 6. pollution in our enviornment

_________ 7. What's your height?

_________ 8. on one occasion, ...

_________ 9. What's the attendence?

_________ 10. It is another repeatition.

_________ 11. an independant person

_________ 12. come to a decision

_________ 13. in particular

_________ 14. He acted immediately.

_________ 15. doing good business

_________ 16. in a familar surrounding

________________ 17. It was planed.

________________ 18. forty apples

________________ 19. Its great!

________________ 20. our school principle

Part V: Comprehension

Instructions: Read the following memorandum carefully and then complete the statements that follow.

MEMO

From: Director of Supplies

To: All departments

Date: September 1, 1984.

re: Requisition of Supplies and Services

Office supplies regularly stocked consist of such frequently used items as pencils, paper clips, rubber band, and typewriter ribbons, etc.

From now on, these items may be obtained by telephoning Mr. Smith of the Supplies Department (Tel. No.: local 4321) and requesting delivery of the desired quantity. Monthly statements of stock used by each department will be sent to Department Heads for record.

Pink order forms should be used for ordering printed material (bills, letterheads, etc.). These should be sent to Mr. Smith via campus mail.

If repair service is needed for office machines, call Miss Jones (Tel. No.: local 5678) and give her the details (type of machine, difficulty, etc.). When repairs have been made, inform her of this fact so that charges may be approved for payment.

When it is necessary to order special items not carried in stock, comparative estimates of cost must be obtained and item ordered from lowest bidder on blue order form, approved by both Department Head and Auditor.

L. MacDonald

Complete the following statements by circling the correct answer. You may refer back to the memo.

1. A written order is necessary to obtain:

   (a) all supplies

   (b) typewriter repairs

   (c) letterheads

   (d) pencils

2. Orders for typewriter repairs will be handled by:

   (a) Department Head

   (b) Mr. Smith

   (c) Miss Jones

   (d) stockroom

3. On which order is the Auditor's approval necessary?

   (a) pink

   (b) blue

   (c) repairs

   (d) stockroom

4. Printed forms are ordered from:

   (a) Miss Jones

   (b) Mr. Smith

   (c) Auditor

   (d) printer

5. Comparative bids should be obtained before entering of:

(a) special equipment

(b) repairs

(c) printed forms

(d) carbon paper

6. Charges for repairs are approved for payment by:

(a) Miss Jones

(b) Department Head

(c) Mr. Smith

(d) Auditor

7. Monthly statements will be sent covering:

(a) all supplies used

(b) supplies ordered from stock

(c) repair services

(d) supplies and repairs

Part VI: Proofreading

Instructions: Proofread the following typed material against the hand-written draft. Cross out any typing errors and correct them with the red pencil provided. The first error is marked correctly.

Since I am listing and sumarizing rather than developing or proving, it seems appropriate to present the sat of difficulties as follows:

1. Response-Class Problem

This involves the well-known difficulties of slicing up the raw behavioral flux into meaningful intervals identified by causally relevant attributes on the response side, a problem that exists already the Skinner box (Skinner, 1938. p. 70), worsens in study field by an ethnologist, and reaches almost unmanageble proportions in studying humane social behavior of the kind to which clinical, social, and personology psychologists must address themselves (see, e.g., MacCorquodale & Meehl, 1954, pp. 218-251, after a quarter century still considered by some as best statement of the problem; Hinde, 1979, pp. 10-13; Meehl, 1954, pp. 40-44 and chap. 6 passim; Skinner, 1938, pp. 33-43).

2. Situation-Taxonomy Problem

As is well-known, the importance of a adequate classification and sampling of environments and situations has received attention than Problem, above, despite emphasis by several major contributors such as Roger Barker (1968), Egon Brunswik (1955), and Saul B. Sells (1963). It seems likely the that problems of characterizing the stimulus side, even though often neglected by the profession or dealt with superficially, are about intractable as the characterization of the response class. It is even clear whether identification and measurement of the relevant stimulus dimensions (e.g., size) is the same task as concocting a taxonomy of "situations" and "environments," or whether the answer to this question would quickly generate rules for an adequate statistical ecoloty applicable to research design. So In am perhaps lumping under this "situation-taxonomy" rubric three distinguishable but related problems. I am inclined to think that most (not all of the current methodological controversy concerning traits versus situations is logically and mathematically reducible to this and the preceding category, since I think that traits are disposition, and dispositions always involve at least implicit references to the stimulus side; but this is not the place ot push that view.

3. Unit of Measurement

One sometimes hears this conflated with one or both of the preceding, but, of course, it is the same. There are questions in rating scales and in psychonetrics (as well as in certain branches of nondifferential psychology) in which disagreements persist about such fundamental matters an the necessity of a genuine interval nor ratio scale for the use of certain kinds of sampling statistical inference.

4. Individual Differences

Perhaps the shortest way to discuss this one is to point out the odd that what is one psychologist's subject matter is another psychologist's error term (Cronbach, 1975)! More genreally, the fact is that organisms differ not only with respect to the strengths of various dispositions, but, more common and more distressing for the researcher, they differ to as how their dispositions are shaped and organized. An a result, the individual differences involved in "mental chemistry" are tough to deal with then, say, the fact that different elements have different atomic numbers or that elements with the same atomic number vary in atomic weights (isotopes).

Since I am listing and summarizing rather than developing or proving, it seems appropriate to present the set of difficulties as follows:

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This involves the well-known difficulties of slicing up the raw ~~mat~~ behavioral flux into meaningful intervals identified by causally relevant attributes on the response side, a problem that exists already in the Skinner box (Skinner, 1938, p. 70), worsens in field study by an ethologist, and reaches almost unmanageable proportions in studying human social behavior of the kind to which clinical, social, and personology psychologists must address themselves (see, e.g., MacCorquodale & Meehl, 1954, pp. 218-231, after a quarter century still considered by some as best statement of the problem; Hinde, 1970, pp. 10-13; Meehl, 1954, pp. 40-44 and Chap. 6 passim; Skinner, 1938, pp. 33-43).

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5. Polygenic Heredity

It is generally conceded that the measurement and causal inference problems that arise in biometrical genetics are, with some exception, more difficult than those found in the kind of single factor dominant or recessive gene situation on which the science of genetics was originally founded. Except for Mendelizing ~~metal~~ mental deficiencies and perhaps some ~~psycholo~~ psychiatric disorders[3] that are transmitted in a Mendelizing fashion, most of the attributes studied by soft-field psychologists are influenced by polygenic systems. Usually we must assume that several totally different and unrelated polygenic systems influence a manifest trait like social introversion. Introversion may be based in part on a unitary (although polygenic) variable, as shown by Gottesman (1963) and others. However, as an acquired disposition of the adult-acculturated individual, it presumably results from a confluence of different polygenic contributors such as basic anxiety readiness, mesomorphic toughness, garden-variety social introversion, dominance, need for affiliation, and the like.

Appendix G

MEMORANDUM UNIVERSITY OF VICTORIA

TO ....

FROM Robert Gifford
Department of Psychology

I am now conducting a study of office employee performance under a variety of environmental conditions. To make the study realistic, I would like to employ real office workers (rather than students or some other substitute group). The study has been approved by the University's Human Subjects Committee. Participants will not find the study onerous; they will come to an office in our Human Social Interaction Laboratory in the Cornett building and engage in some routine clerical activities for about one half hour. We will offer them their choice of $5 or one ticket in a lottery as remuneration.

This letter is to ask your permission to approach clerical employees in your unit, requesting their participation in this study. If you would be kind enough to respond below and return this letter to me, I would be most appreciative. If you have any questions, call me at 7532.

_____ Yes, employees in my unit may participate any time their workload permits (total time: less than 45 minutes).

_____ Yes. We are very busy right now. Employees in my unit may participate any time their workload permits after/during (please indicate the period)

____

_____ Yes, employees may participate, but only on lunch breaks or during other non-work periods such as before or after work.

_____ No, --- please do not approach my employees.

_____ Other: ____

Appendix H

<u>From</u>: Cheuk Ng, PhD student,
Department of Psychology

<u>To</u>: UVic office employees

<u>Date</u>: February, 1985.

Dear employee,

<u>Office Study</u>

I am studying how different environmental conditions affect office activities. Your supervisor, , has indicated support for this project and will permit your participation as long as you participate during office hours when your workload permits. WE WOULD VERY MUCH APPRECIATE YOUR PARTICIPATION IN THIS STUDY.

To participate, you will
(1) complete a 10-minute questionnaire, and
(2) come to our office in the Cornett Building (Room A 150) and engage in some clerical activities for about half an hour.

As remuneration for your participation, we will offer you a choice of $5 or one ticket in a lottery. The prize in the lottery will depend on the number of participants who choose the lottery option, but will be no less than $50.

The study has been approved by the University's Human Subjects Committee. I assure you that your information will be kept strictly confidential.

To participate, please complete the attached form and mail it back to me. I shall then call to make an appointment with you to meet in our office.

Please participate. If you have any questions, please call me at 8646. Thank you.

Sincerely,

Cheuk Ng

Appendix I

Office Study

I wish to participate in your study.

Name: ______________________________ (Please print)

Administrative or Academic Unit: ________________________

Contact Phone No. or Address: ____________________________

Please fold here

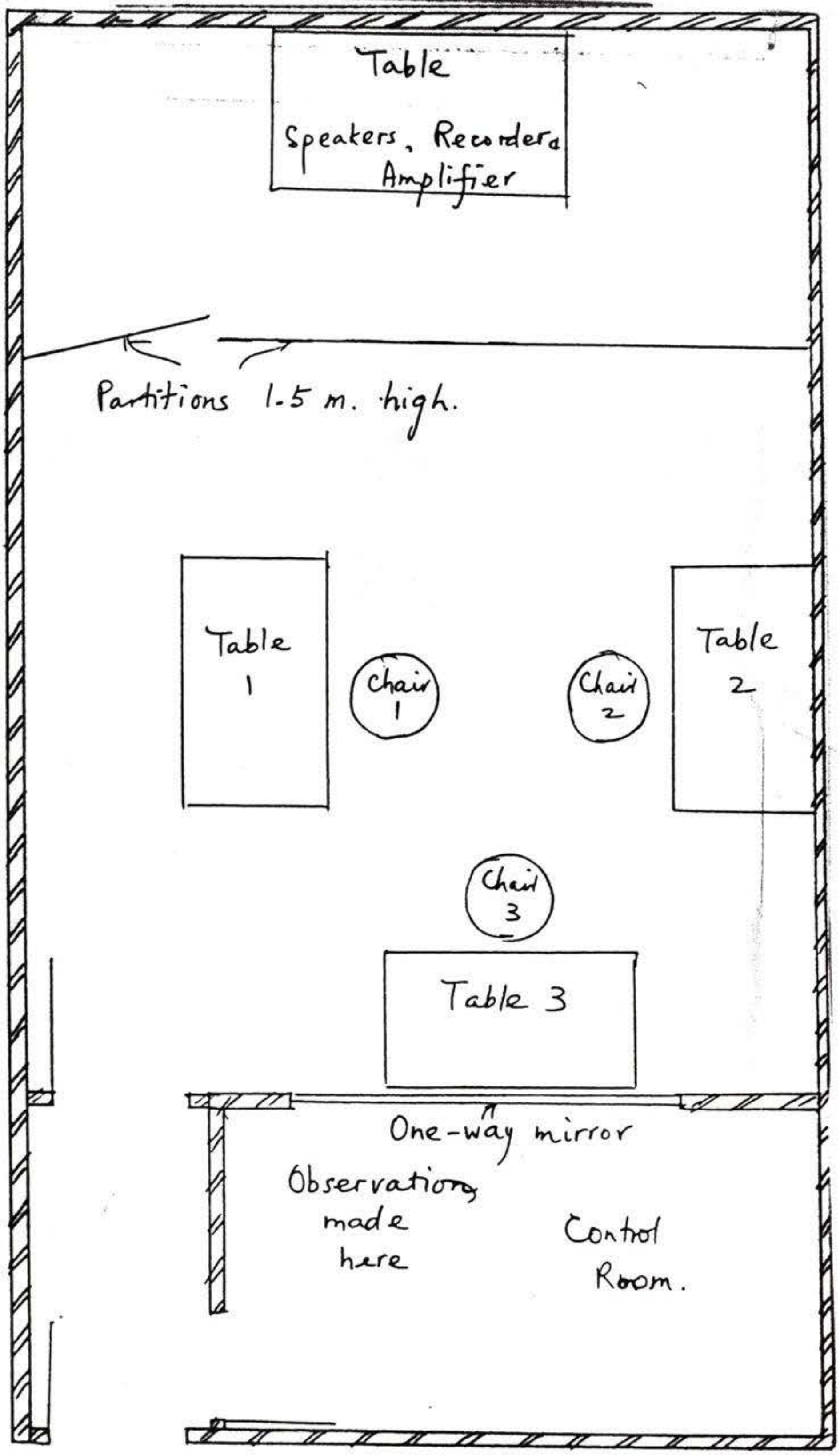
Please fold here

To: Cheuk Ng,

Psychology Dept.

Cornett Building

A Layout Plan of the Simulated Office



Appendix K

Photographs of the Simulated Office

Appendix L

OFFICE STUDY

There are seven tasks contained in separate envelopes (marked 1 to 7) in the "IN" tray. Please complete the tasks one by one in the following order:

(1) filing,

(2) phone number search,

(3) calculation,

(4) spelling,

(5) comprehension,

(6) proofreading, and

(7) a questionnaire.

Work as quickly as you can. When you have completed each task, put it back in the envelope and place it in the "OUT" tray immediately. When you have finished, please meet the research assistant in the next room.

Thank you for your participation.

Appendix M

Questionnaire

Instructions:

Please check the most appropriate responses to each of the following questions.

1. Did you hear a conversation in the background while you were working on the tasks?

1	2	3	4	5
All the time	Most of the time	Half the time	Some of the time	None of the time

If your answer is 'none of the time', go to Question 6 on the next page.

2. How relevant was the content of the conversation to the tasks you performed?

1	2	3	4	5
Very relevant				Very irrelevant

3. Did the conversation seem faster, slower or about the same as conversations you normally hear?

1	2	3	4	5
Much faster	Faster	About the same	Slower	Much slower

4. Did the conversation make your work more enjoyable than if the room was silent?

1	2	3	4	5
Much more enjoyable	More enjoyable	No effect	Less enjoyable	Much less enjoyable

5. How much did the conversation distract you from your work?

1	2	3	4	5
Very much				Not at all

6. Was the environment during the study noiser, quieter or about the same as the office in which you work everyday?

1	2	3	4	5
Very much noiser				Very much quieter

7. To what extent was your performance on the tasks in this study due to
(i) your own characteristics and abilities?

1	2	3	4	5
Very much				Not at all

(ii) the setting and/or the difficulty of the task?

1	2	3	4	5
Very much				Not at all

8. Think of a situation (at work or at home) in which you are faced with too many conflicting demands. Briefly, and in general terms, how would you deal with this situation?

THANK YOU FOR YOUR PARTICIPATION

Appendix N

Office Study

Consent Form

I, ____________________, hereby give my consent to Cheuk Ng to retain my data for analysis.

____________________ ____________________

Date Signature

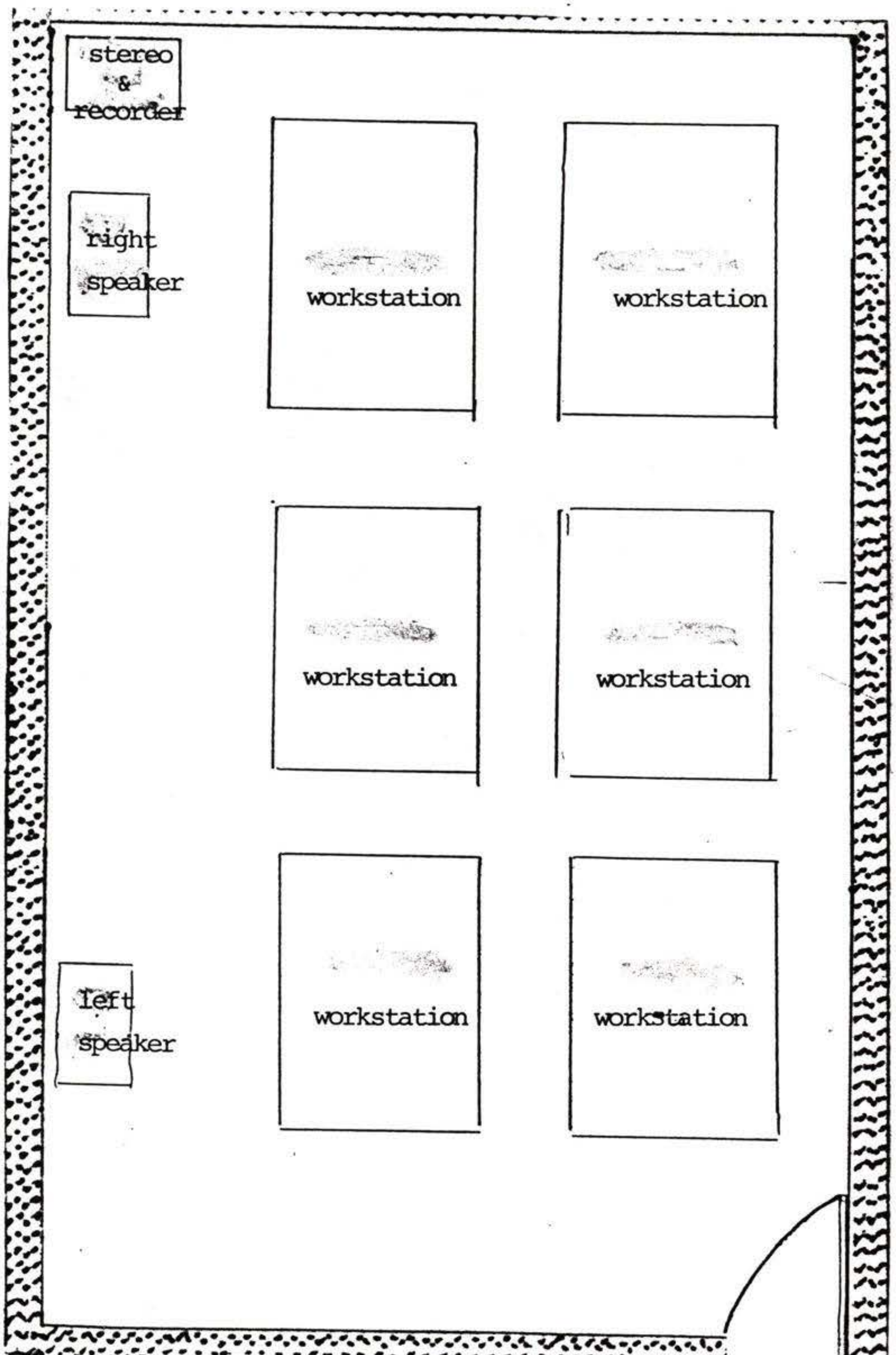
Appendix O

A Photograph of the Test Room

Appendix P

A Photograph of an Acoustic Cover

A Layout Plan of the Test Room



Appendix R

Participant No.: __________

Please indicate how much you agree or disagree with each of the following statements by putting the appropriate number in the blank beside each statement.

1 = strongly agree
2 = agree
3 = slightly agree
4 = slightly disagree
5 = disagree
6 = strongly disagree

Example:
I enjoy music.
(means you agree that you enjoy music) ___2___

1. I get annoyed when my neighbors are noisy. _____

2. When I want to be alone, it disturbs me to hear outside noises. _____

3. No one should mind much if someone turns up his stereo full blast once in a while. _____

* 4. It doesn't bother me to hear the sounds of everyday living from neighbors (footsteps, running water, etc.) _____

5. At movies, whispering and crinkling candy wrappings disturbs me. _____

* 6. In a library, I don't mind if people carry on a conversation if they do it quietly. _____

7. When it's noisy where I am working, I wish I could close the door or window or move somewhere else. _____

* 8. I wouldn't mind living on a noisy street if the apartment was nice. _____

* 9. There are often times when I want complete silence. _____

10. Sometimes noise gets on my nerves and gets me irritated. _____

1 = strongly agree
2 = agree
3 = slightly agree
4 = slightly disagree
5 = disagree
6 = strongly disagree

* 11. I wouldn't mind renting an apartment if it was located across from a fire station. _____

12. I get angry at people who make noise that keeps me from falling asleep or getting work done. _____

13. I am easily awakened by noise. _____

14. I like to drive with my radio on. _____

15. I wouldn't mind living in an apartment with thin walls. _____

16. I get used to most noises without much difficulty. _____

17. I am sensitive to noise. _____

* 18. I can always tell when it starts to rain or snow in the night. _____

19. I find it hard to relax in a place that's noisy. _____

20. Motorcycles ought to be required to have more effective mufflers. _____

* 21. I often hear sounds that others don't notice. _____

22. I'm good at concentrating no matter what is going on around me. _____

<u>Note</u>:
Items were scored on a six-point scale ranging from strongly agree (1) to strongly disagree (6).

The following items were scored in opposite direction before responses were summed: Items 1, 2, 5, 7, 9, 10, 12, 13, 17, 18, 19, 20 and 21.

* These items had low item-total correlations (less than 0.20) and were recarded from the final data analysis.

This Note section did not appear in subjects' rating forms.

Appendix S

Participant No.: __________

Please answer 'yes' or 'no' to each of the following questions by putting a check mark in the appropriate column.

		yes	no
	1. Do you often long for excitement?	_____	_____
	2. Are you usually carefree?	_____	_____
*	3. Do you stop and think things over before doing anything?	_____	_____
*	4. Would you do almost anything for a dare?	_____	_____
*	5. Do you often do things on the spur of the moment?	_____	_____
	6. Generally, do you prefer reading to meeting people?	_____	_____
*	7. Do you prefer to have few but special friends?	_____	_____
*	8. When people shout at you do you shout back?	_____	_____
	9. Do other people think of you as very lively?	_____	_____
	10. Are you mostly quiet when you are with people?	_____	_____
	11. If there is something you want to know about, would you rather look it up in a book than talk to someone about it?	_____	_____
*	12. Do you like the kind of work that you need to pay close attention to?	_____	_____
	13. Do you hate being with a crowd who play jokes on one another?	_____	_____
*	14. Do you like doing things in which you have to act quickly?	_____	_____

		yes	no
*	15. Are you slow and unhurried in the way you move?	_____	_____
*	16. Do you like talking to people so much that you never miss a chance of talking to a stranger?	_____	_____
*	17. Would you be unhappy if you could not see lots of people most of the time?	_____	_____
	18. Do you find it hard to enjoy yourself at a lively party?	_____	_____
	19. Would you say that you were fairly self-confident?	_____	_____
	20. Do you like playing pranks on others?	_____	_____

Note:
To score for extroversion, give 1 point for each "E" item answered "yes" and each "I" item answered "no". High scores then indicate extroversion and low scores introversion.

"I" items: Items 3, 6, 7, 10, 11, 12, 13, 15 and 18.
"E" items: Items 1, 2, 4, 5, 8, 9, 14, 16, 17, 19 and 20.

* These items had low item-total correlations (less than 0.20) and were discarded in the final analysis.

This Note section did not appear on subjects'rating forms.

Appendix T

Participant No.: ___________

Office Noise Study
Information for Participants

First of all, I wish to thank you for agreeing to take part in this study.

At ___________ on the dates indicated below, you will work at one of the machines in the newly built room. Please use Operator Number __________ when you work in that room.

date

____

____

____

____

____

____

While you are working, you will hear some office sounds in the background. The recording will be played through two speakers at levels typical of large offices.

To understand how individuals might differ in their reaction to office sounds, I would ask you to complete two rating scales as well. I assure you that the information you provide will be kept strictly confidential.

If you usually use the Walkman at work, please do not use it 15 minutes before or during the hours indicated above.

It is very important that you take part in all six hours of the study. Otherwise, I cannot use any of the information you provide. However, should you wish to drop out of the study for whatever reason, you are free to do so at any time.

Appendix U

Participant No.: ____________

1. Please circle the one sound level that you prefer (one that you like the best or with which you find most comfortable).

   LEVEL 1   LEVEL 2   LEVEL 3   LEVEL 4   LEVEL 5

2. Please circle any sound level or levels that bother(s) you.

   LEVEL 1   LEVEL 2   LEVEL 3   LEVEL 4   LEVEL 5

3. What do you usually listen to at work?

   music? __________ What kind? ____________
   radio talk shows? _______________
   soap operas? _______________
   TV game shows? _______________

4. On average, how many hours a day do you use your headphone at work?

   ___________ hours

Appendix V

Participant No.: __________

Day ________

1. Was the background noise: far too loud for YOU?

   slightly too loud

   just comfortable

   slightly too soft

   far too soft

   (Please circle one answer.)

2. Which sounds in the tape recording were pleasant to you? What about them was pleasant to you?

3. Which sounds were annoying to you? What about them did you find annoying?

4. Which sounds distracted you from your work, if any?

5. In general, did the background noise affect you in any way? If yes, how?

Appendix W

Participant No.: __________

Day ________

1. Was the background noise: far too loud for YOU?

   slightly too loud

   just comfortable

   slightly too soft

   far too soft

   (Please circle one answer.)

2. Which sounds in the tape recording were pleasant to you? What about them was pleasant to you?

3. Which sounds were annoying to you? What about them did you find annoying?

4. Which sounds distracted you from your work, if any?

5. In general, did the background noise affect you in any way? If yes, how?

6. In which session did you find most comfortable to work? (Please circle one answer.)

   Day 2 Day 3 Day 4 Day 5 Day 6

7. How long did it take you to get used to working inside the "box"?

Questionnaire Survey — Raw Data

```
title  uvic office workers' survey
file handle vic/name='office.dat'
data list  file=vic
  /1 subnum 1-3 office 5 employ 6-7 neigh 8-9 path 10-11
     time 12-18 level noise1 to noise5 dis1 to dis5
     disrank1 to disrank5 conver1 to conver6 privacy
     personal accusen 19-43 age sex sensi skill
     job1 to job6 45-54 acti1 to acti5 55-64
missing values all ()
variable labels  subnum 'respondent number'/
     office 'office type'/
     employ 'number of employees in the same office'/
     neigh 'closest distance to neighbor'/
     path 'closest distance to a common place'/
     time 'percent of time spent in the office,'/
          'in the building, outside the building'/
     level 'sound level rating'/
     noise1 'distract from work'/
     noise2 'difficulty in hearing others'/
     noise3 'difficulty in being heard'/
     noise4 'makes irritable'/
     noise5 'other effects'/
     dis1 'distracting sound office machines'/
     dis2 'distracting sound telephone rings'/
     dis3 'distracting sound coworkers conversations'/
     dis4 'distracting sound mechanical sounds'/
     dis5 'other distracting sounds'/
     disrank1 'rank order of distracting sound -'/
              'office machines'/
     disrank2 'rank order of distracting sound -'/
              'telephone'/
     disrank3 'rank order of distracting sound -'/
              'conversation'/
     disrank4 'rank order of distracting sound -'/
              'mechanical noise'/
     disrank5 'rank order of distracting sound - other'/
     conver1 'work relevant conversation'/
     conver2 'work irrelevant conversation'/
     conver3 'gossip'/
     conver4 'social non-gossip conversation'/
     conver5 'distant partially intelligible'/
             'conversations'/
     conver6 'other conversations'/
```

```
privacy 'overall privacy rating'/
personal 'conversational privacy rating'/
acousen 'satisfaction with acoustical environment'/
sensi 'sound sensitivity rating'/
skill 'central skill'/
job1 'repetitive routine work'/
job2 'work that requires deep thought and'/
     'concentration'/
job3 'work that requires creativity'/
job4 'work that involves confidentiality'/
job5 'work that involves verbal interaction'/
job6 'other types of work'/
acti1 'reading and writing in percent'/
acti2 'office machine operation in percent'/
acti3 'telephoning in percent'/
acti4 'face-to-face conversation in percent'/
acti5 'other activities in percent'/
```

```
value labels office 1 'private' 2 'semi-open all partitions'
             3 'semi-open some partitions' 4 'open-plan'
             5 'other'/
    level 1 'far too quiet' 2 'too quiet' 3 'just right'
          4 'too noisy' 5 'far too noisy'/
    noise1 to noise5 dis1 to dis5 conver1 to conver6
          1 'bother' 2 'not bother'/
    acousen privacy 1 'very satisfactory' 2 'satisfactory'
          3 'just right' 4 'unsatisfactory'
          5 'very unsatisfactory'/
   personal 1 'always' 2 'usually' 3 'sometimes' 4 'never'/
    age 1 'under 30' 2 '31-40' 3 '41-50' 4 'over 50'/
    sex  1 'male' 2 'female'/
    sensi  1 'yes' 2 'about average' 3 'no'/
  skill 1 'teaching research' 2 'managerial administrative'
       3 'technical' 4 'clerical secretarial' 5 'other'/
    job1 to job6 1 'yes' 2 'no'/
```

```
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002 100   05 78200230    1111031240001010332 22340100102525153500
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060 412100209010004111101111013240010000545 12141001102020202020
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067 4031006068300230    1101013020      343 22241000100550102015
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075 3030610080200030    1101031020001000333 22241000001540301500
076 30312201000004000011000010000       343 12241100101010206000
077 100    100900010410000111011340211110233 41221111105505152500
078 304030808010105111111110001     001110545 12141000101050202000
079 5011508090090130    1100132001           22141000000580050505
080 3051020100000030                    333 32240101103040151500
081 100    06060301041001011001130 02   324 22140101102020303000
082 4050402099000130    0001100021000100324 22241001002000202040
083 4040825075151030    1000110002      232 12341001110515206000
084 4050502095050030    1010110302100010444 22141101108010050500
085 100    30050203041000011000         333 22120011105000302000
086 4040704093050530    0011100123000011434 22140001010550151020
087 100    12075151030                  223 41220010104000203010
088 100    96090100030  0010000100001100122 32240101100070201000
089 4030603080200020    0100001000      343 1214010000
090 40306010653005411000110002100 0      544  2220011101530152515
```

```
091 100  35060390130     1001010020      222 12240000103000202030
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100 3070915080200041010011100231000010000434 32340001000050005000
101 4100310075250051001001001020010001100445 12241000100030007000
102 20410201000000020     0100001000010000222 12241000000080200000
103 4200902100000041001011010210 30      342 22141000002075050000
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108 100  15100000030     0001000010011000112 42120101108000101000
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110 100  30075052030     0100102001      122 41320001105000102020
111 40108050603010 30    0000100001      245 12241000000050202010
112 10012150940105 30    1010010200      112 31120101105508151507
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115 3271205098020041001001100021000100000432 42341100101040203000
116 3180602100000041001011111231450100000534 12241000008505050500
117 41805061000000 40    0100001000      243 22340101102525252500
118 10000100502030 30    1111032140000010122 31221111104000154000
119 4040706          30  1111031240010000443 32240101102525252500
120 100  0004010504010100111001320111111224 32120010101000152500
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122 100  35070201030     1111012340      212 41220000103000304000
123 40212071000000 30    0010000100010010342 32241000000095050000
124 100  25080190130     1111014230001110121 32140111105025052000
125 500  0810000005110111110012300001100544     1201001010004 04010
126 1000805080051551111011110213400010 00224     120110002000
127 4010804095050040100011100      000001232 32240100102020303000
128 4011207097030030000001000010000000000445  24000010107010 0505
```

```
title 'the effects of background conversation on performance'
file handle   perform/name='converse.dat'
data list  file=perform  records=2
     /1 subnum 1-2 con 4 rel 6 rate 8 screen 10-13 a1 15-16
         a2 18-19 a3 21-22 a4 24-25 a5 27 a6 29-30
         s1 to s6 32-61
     /2 contime 1 relchek 3 ratechek 5 enjoy 7 distract 9
         noise 11 abil 13 sett 15
missing values  all()
variable labels  subnum 'subject number'/
    con 'condition'/
    rel 'relevance of conversation level'/
    rate 'information rate level'/
    screen 'stimulus screening score'/
    a1 'accuracy on filing task'/
    a2 'accuracy on telephone search task'/
    a3 'accuracy on calculation task'/
    a4 'accuracy on spelling task'/
    a5 'accuracy on comprehension task'/
    a6 'accuracy on proofreading task'/
    s1 'speed for filing task'/
    s2 'cumulative speed for telephone task'/
    s3 'cumulative speed for calculation task'/
    s4 'cumulative speed for spelling task'/
    s5 'cumulative speed for comprehension task'/
    s6 'cumulative speed for proofreading task'/
    contime 'amount of time subject heard conversation'/
    relchek 'relevance of conversation manipulation check'/
    ratechek 'how fast did conversation seem'/
    enjoy 'did conversation make task more enjoyable'/
    distract 'how much did conversation distract subject'/
    noise 'noise level in comparison to own office'/
          'environment'/
    abil 'performance perceived as due to own ability'/
    sett 'performance perceived as due to setting'/
value labels
    rel 1 'relevant' 2 'irrelevant' 3 'no conversation'/
    rate 1 'high information rate' 2 'low information rate'
         3 'no conversation'/
    contime 1 'all the time' 5' none of the time'/
    relchek 1 'very relevant' 5 'very irrelevant'/
    ratechek 1 'much faster' 5 'much slower'/
    enjoy 1 'much more enjoyable' 5 'much less enjoyable'/
    distract 1 'very much' 5 'not at all'/
    noise 1 'very much noisier' 5 'very much quieter'/
    abil 1 'very much' 5 'not at all'/
    sett 1 'very much' 5 'not at all'/
```

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1	3	3	4	3	2	2	3									
3	1	1	1	- 55	9	10	15	18	7	26	136	707	1206	1521	1812	2805
1	1	2	4	3	2	2	3									
14	1	1	1	- 44	10	10	13	18	7	18	129	545	925	1142	1613	2447
1	2	2	4	2	2	2	3									
16	1	1	1	- 32	10	10	13	19	7	26	110	744	1150	1353	1655	2725
2	2	2	5	2	1	2	4									
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2	3	1	5	2	2	2	2									
48	1	1	1	- 71	10	9	15	20	5	27	116	614	814	1025	1450	2233
4	2	2	5	4	2	2	3									
50	2	1	1	- 1	10	10	15	20	6	26	138	742	2040	2329	2830	3836
4	1	3	5	4	1	1	4									
53	2	1	1	50	10	9	14	20	5	24	131	742	1143	1411	1857	2741
2	5	2	5	1	6	2	2									
28	2	1	1	41	10	10	14	18	7	25	245	945	1444	1754	2124	3127
3	3	3	4	3	4	2	4									
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1	1	3	2	4	5	4	4									
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3	2	4	5	2	3	1	1									
47	2	1	1	8	10	10	13	20	5	22	107	627	1140	1346	1901	2859
4	5	2	3	4	3	1										
7	3	1	2	- 39	10	10	14	20	7	24	135	638	1234	1445	1936	2933
1	1	5	5	1	1	2	4									
8	3	1	2	- 53	10	10	14	18	6	18	130	622	1221	1418	1812	2624
1	1	4	5	1	1	3	3									
17	3	1	2	-116	10	9	13	18	6	8	132	842	1432	1640	2016	2841
1	3	5	5	3	3	3	3									
29	3	1	2	- 63	9	10	15	20	5	28	159	904	1714	1925	2952	4542
1	1	5	5	1	3	1	1									
6	3	1	2	- 65	10	10	14	16	6	22	130	810	1221	1348	1742	2747
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34	4	1	2	37	10	9	15	18	7	25	104	553	932	1130	1502	2338
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35	4	1	2	33	9	8	14	19	6	20	149	749	1226	1505	2030	3330
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1	3	5	4	4	2	2	3									
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2	2	4	5	1	2	3	3									

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3 5 3 3 3 2 3 2
 5 5 2 1 - 53 10  9 15 19 7 26  120  915 1314 1607 1935 3556
2 5 2 4 2 2 3 4
13 5 2 1 - 68 10 10 14 19 7 18  143 1225 2058 2315 2710 3602
3 4 2 5 4 3 2 3
39 5 2 1 - 39 10  9 14 20 7 21  158  702 1144 1426 1923 2942
2 5 3 5 3 1 1 1
12 5 2 1 - 31  9  9 12 19 7 24  132  842 1806 2110 2450 3424
1 3 3 3 4 2 2 2


18 5 2 1 - 28 10 10 15 20 7 21  119  542 1040 1242 1647 2502
2 4 2 4 2 2 2 4
26 6 2 1   87 10  9 15 20 7 26  101  457  854 1029 1347 2943
4 5 3 3 4 3 1 5
27 6 2 1   21 10  8 14 18 6 26  120  821 1258 1519 1835 2406
1 5 2 4 2 3 3 2
42 6 2 1   41 10  9 14 20 4 27  119  548 1000 1252 1745 3017
4 5 4 5 5 5 4 4
44 6 2 1 - 18 10 10 13 19 7 18  147  716 1414 1709 2405 3400
1 5 3 3 2 3 4 4
10 7 2 2 - 75 10 10 15 16 7 24  103  538 1004 1317 1637 3225
1 5 5 4 3 2 2 3
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3 5 5 4 3 2 1 2
22 7 2 2 - 63 10 10 14 20 6 22  131  656 1256 1616 2009 3025
2 5 5 5 4 5 1 4
43 7 2 2 - 50 10  9 15 15 7 26  125  608 1207 1504 2012 3043
1 5 3 4 2 3 2 3
51 7 2 2 - 68 10  9 13 17 6 23  226  932 1627 2344 2858 4025
2 5 4 4 3 3 4 4
 9 8 2 2 - 27 10  9 14 19 6 19  106  552 1107 1442 2018 2844
1 5 4 5 3 2 3 3
11 8 2 2   19 10 10 15 20 6 24  110  605 1033 1307 1707 2859
1 5 3 5 4 1 1 1
15 8 2 2   20 10 10 15 19 7 24  119  704 1427 1649 2116 3010
3 5 3 5 4 2 2 4
23 8 2 2 - 25 10  8 14 18 6 21  155  822 1336 1558 2325 3448
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40 8 2 2   30 10 10 15 18 7 17  205  745 1209 1522 1932 2833
2 4 3 5 2 3 3 4
45 8 2 2 -  8 10 10 15 19 7 28  121  620 1150 1607 2112 3310
2 5 4 5 3 2 2 3
32 9 3 3 - 32 10 10 15 16 4 23  121  633 1109 1502 1915 3020
4         5 3 3
54 9 3 3 - 32 10 10 15 19 7 27  222  936 1538 1923 2625 3752
2         5 1 2
55 9 3 3 - 82 10 10 15 20 7 28  100  414  833 1131 1521 3115
5         5 2 3
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```
31 9 3 3 - 56 10  9 14 19 7 28  121  635 1107 1421 1800 3101
5           4 1 5
33 9 3 3 - 55 10 10 15 18 7 26  147  923 1529 1756 2300 3242
5           5 4
19 9 3 3 - 14 10  9 15 16 5 23  145  829 1548 1908 2408 3728
5           4 3 3
20 9 3 3 - 24 10 10 15 20 7 24  142  945 1430 1908 2425 3701
5           5 1 5
21 9 3 3   19 10 10 15 19 6 21  123  918 1725 2016 2445 3533
5           2 1
24 9 3 3 -  4 10 10 15 20 7 26  101  434  732  926 1221 2513
5           5 1 3
25 9 3 3 - 10 10  9 13 18 7 25  113  618  859 1120 1519 2530
5           5 1 5
```

```
title  reliability of mehrabian's stimulus screening scale
data list  records=2
        /1 subnum 1-2 item1 to item20 4-63
           /2 item21 to item40 4-63
begin data
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    3 -2  2 -1  2  1 -2  1  0  2  3 -3  1  2  1  1  2  0  2 -2
02 -4  1  4 -2  1 -1  1 -1  3  1 -3  3 -2  1 -1  1 -1 -4  3  2
    2 -1 -1 -2 -1 -3  3 -3  4  2 -1 -2 -1  3  3 -2  1  1 -2 -4
06 -1 -1  3 -1  3 -2  3 -1  2  2 -2  2  3 -2  1  3 -2 -2  0  1
    1 -1  3  2 -2  1 -3 -1 -1  1  3 -2  2  2  2 -2  1 -1  1 -2
12 -2 -3  2  2 -2  2  2 -2  2 -2 -3  1 -3 -2 -2 -2 -2 -2  3 -2
    2 -2  4  3 -2 -2 -3 -1  2  3 -1 -2  1  2  2 -4  2 -2 -2 -2
17  3 -4  2 -4  4 -4  4  0  4  4 -4  4  4 -4  4  4 -4 -4  1  4
   -1 -3  4  4  0  2 -4 -4  3  4  4 -4  4  0  0 -4  2 -4  3 -4
23 -2 -1  1 -1  0  0 -3  0  2  2 -2  2 -3  0  0  3 -2 -3  3  1
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28 -1 -2  1 -1 -2  2 -3  2  1 -1  1 -3 -3  1  1  1  1 -1 -3  1
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35 -3  2  2  4 -1 -1 -3  3  1  1  2  0  0  2 -2 -3  1 -1  1 -2
    3 -2 -2 -3 -1 -3  1  3  3  1  1 -3 -3  1  2  1 -3  0 -2 -2
41  4  4 -1  2 -3  3  4  0  3  2  3  1  1  3  1  2  0  2  0  0
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	0	0	1	0	1	-1	-3	-2	3	3	3	-2	1	1	1	0	3	0	-1	-3
33	-1	2	2	0	2	-3	-1	2	4	-1	2	4	-1	1	1	3	-4	-2	4	1
	-2	-4	4	1	-3	-3	-4	-3	1	3	-2	-4	-4	4	3	-4	3	-1	3	-4
36	2	3	4	-1	1	1	-3	3	-3	3	0	3	-4	4	1	1	-2	3	3	-4
	4	-4	2	-4	2	-4	3	-3	4	1	1	-2	-3	3	3	-2	-3	0	0	4
37	-2	2	1	3	-3	2	0	0	-2	0	-2	1	-3	1	1	1	2	-2	2	1
	2	-2	2	-2	-1	1	2	-3	3	-3	-3	-3	-4	-3	0	-2	-3	-2	-2	3

38	2	1	2	4	2	2	-4	1	3	2	2	1	3	3	-4	-3	-1	3	-2	-4
	3	-4	-3	3	3	-3	-3	3	3	3	2	-2	3	3	-1	3	3	3	-3	4
39	3	1	1	0	2	0	2	0	2	3	0	2	0	-1	1	3	-2	-1	4	1
	3	-1	1	1	-4	-3	0	-4	-3	-3	3	1	0	2	0	-1	2	-1	1	-4
40	3	2	4	3	2	2	-3	-2	2	3	2	-3	-3	1	-2	1	1	-2	-3	-3
	2	-3	1	2	2	3	-2	3	2	2	-3	2	-3	-2	2	2	1	2	-2	2
42	-4	3	2	4	-3	2	2	2	2	-3	3	-3	3	4	-2	3	2	-4	-3	-3
	4	-3	-3	-4	-2	-4	-1	3	4	-2	-4	-3	2	-3	4	1	2	3	-2	-4
43	-1	-1	2	-1	1	-1	1	-1	2	2	-1	3	2	-2	1	1	-2	-1	3	1
	-1	-2	-1	2	-2	-2	-2	-3	2	2	1	-1	2	2	1	-1	2	-2	-1	-2
44	-2	1	-1	-1	-2	-2	2	1	2	2	1	-2	3	2	-1	1	-2	-2	1	2
	2	-2	-1	1	1	-2	-2	2	2	1	1	-2	0	0	0	-2	2	-2	1	-1
45	-2	-2	3	4	2	1	3	2	1	2	3	-3	2	-2	-2	2	1	-3	0	-2
	-1	-3	-1	-3	0	-4	0	3	3	1	3	-2	1	0	2	-1	3	-3	-2	-2
48	4	-3	-4	-2	3	-3	-3	-3	4	3	-4	3	2	-3	2	4	-4	4	4	3
	-3	3	4	2	-4	1	-4	-3	-2	1	3	4	2	3	-4	-4	2	-3	2	4
50	-3	0	-2	2	1	0	2	-2	2	2	-2	0	-3	2	-2	2	-3	-2	-1	-1
	2	-3	-2	1	-4	-3	2	-4	3	-2	-3	-3	-3	-3	2	-2	2	2	-2	-3
51	4	-3	-4	-2	3	-3	3	-3	2	0	-4	1	1	-2	2	3	-2	3	1	2
	1	-3	3	3	-4	0	-4	-1	-4	3	3	4	1	3	-3	-3	3	-2	2	-2
52	-1	-2	2	3	3	-2	-2	-2	3	3	-2	3	-2	-2	-2	4	-2	-2	3	-1
	2	-3	4	2	-3	4	-4	-2	3	4	1	-4	2	2	-3	-4	4	-3	3	3
54	-2	-2	2	1	-3	-3	3	2	3	-2	2	0	-1	-1	-3	4	-3	-2	0	2
	-3	-3	1	-3	0	-3	-3	0	-2	-1	3	-3	-3	1	-1	-2	4	2	3	-2
55	0	-4	4	-2	2	-2	0	-2	3	3	-4	2	1	-3	2	4	-3	-1	0	3
	-4	-3	3	3	-2	2	-4	0	-3	2	3	-3	2	-2	3	-3	3	-3	3	4
56	1	2	-3	3	0	1	-1	0	2	0	1	1	0	3	-4	1	1	1	1	0
	3	-3	1	-3	-2	-4	-1	-1	2	1	1	2	-2	1	0	2	1	0	1	1

Experiment 2 -- Raw Data

```
title 'productivity of data-entry operators at various'
      'sound levels'
file handle noise/name='prefer.dat'
data list file=noise records=6
    /1 subnum 1-2 order 4 product1 6-10 error1 12-15(2)
       product2 17-21 error2 23-26(2) product3 28-32
       error3 34-37(2) product4 39-43 error4 45-48(2)
       product5 50-54 error5 56-59(2) prelevel 61
    /2 proprati 1-5 errprati 7-10(2) prousual 12-16
       errusual 18 annoy1 20 annoy2 22 music 24 radio 26
       scap 28 game 30 phone 32-33(1) relia 35 proannoy 37-41
       errannoy 43-46(2) pronoan 48-52 errnoan 54-57(2)
       errecord 59-61(2) errcent 63
    /3 wein1 to wein22 1-44 rat1 to rat5 45-54
    /4 eysen1 to eysen20 1-40
    /5 index 1 repro 3-7 reerr 9-12(2) norepro 14-18
       noreerr 20-23(2) undrepro 25-29 undreerr 31-34(2)
       ovrepro 36-40 ovreerr 42-45(2)
missing values   all()
variable labels  subnum 'subject number'/
   order 'order of presentation of sound levels'/
   product1 'productivity in number of keystrokes per hour' +
            'in sound level 1 condition'/
   error1 'number of errors per hour in sound level 1'/
   product2 'productivity in number of keystrokes per hour' +
            'in sound level 2 condition'/
   error2 'number of errors per hour in sound level 2'/
   product3 'productivity in number of keystrokes per hour' +
            'in sound level 3 condition'/
   error3 'number of errors per hour in sound level 3'/
   product4 'productivity in number of keystrokes per hour' +
            'in sound level 4 condition'/
   error4 'number of errors per hour in sound level 4'/
   product5 'productivity in number of keystrokes per hour' +
            'in sound level 5 condition'/
   error5 'number of errors per hour in sound level 5'/
   prelevel 'preferred sound level'/
   proprati 'productivity in number of keystrokes per hour' +
            'during practice session'/
   errprati 'number of errors per hour during practice' +
            'session'/
   prousual 'normal productivity in number of keystrokes' +
            'per hour'/
   errusual 'normal accuracy rating'/
   annoy1 'sound level condition that was annoying'/
   annoy2 'sound level condition that was annoying'/
```

```
music 'listen to music at work'/
radio 'listen to the radio at work'/
soap 'listen to soap operas at work'/
game 'listen to tv game shows at work'/
phone 'number of hours a day use headphone'/
relia 'rating of noise at preferred sound level' +
      'condition'/
proannoy 'mean number of keystrokes per hour at' +
         'unannoyed conditions'/
errannoy 'mean number of errors per hour at annoyed' +
         'conditions'/
pronoan 'mean number of keystrokes per hour at' +
        'annoyed conditions'/
errnoan 'mean number of errors per hour at unannoyed' +
        'conditions'/
errecord 'percent of errors made per record'/
errcent 'accuracy rating during experiment based on' +
        'number of errors per record'/
wein1 'response to Item 1 of Weinstein scale'/
wein2 'response to Item 2 Weinstein scale'/
wein3 'response to Item 3 Weinstein scale'/
wein4 'response to Item 4 Weinstein scale'/
wein5 'response to Item 5 Weinstein scale'/
wein6 'response to Item 6 Weinstein scale'/
wein7 'response to Item 7 Weinstein scale'/
wein8 'response to Item 8 Weinstein scale'/
wein9 'response to Item 9 Weinstein scale'/
wein10 'response to Item 10 Weinstein scale'/
wein11 'response to Item 11 Weinstein scale'/
wein12 'response to Item 12 Weinstein scale'/
wein13 'response to Item 13 Weinstein scale'/
wein14 'response to Item 14 Weinstein scale'/
wein15 'response to Item 15 Weinstein scale'/
wein16 'response to Item 16 Weinstein scale'/
wein17 'response to Item 17 Weinstein scale'/
wein18 'response to Item 18 Weinstein scale'/
wein19 'response to Item 19 Weinstein scale'/
wein20 'response to Item 20 Weinstein scale'/
wein21 'response to Item 21 Weinstein scale'/
wein22 'response to Item 22 Weinstein scale'/
rat1 'subjective rating of sound level 1'/
rat2 'subjective rating of sound level 2'/
rat3 'subjective rating of sound level 3'/
rat4 'subjective rating of sound level 4'/
rat5 'subjective rating of sound level 5'/
```

```
   eysen1 'response to Item 1 of Eysenck scale'/
   eysen2 'response to Item 2 Eysenck scale'/
   eysen3 'response to Item 3 Eysenck scale'/
   eysen4 'response to Item 4 Eysenck scale'/
   eysen5 'response to Item 5 Eysenck scale'/
   eysen6 'response to Item 6 Eysenck scale'/
   eysen7 'response to Item 7 Eysenck scale'/
   eysen8 'response to Item 8 Eysenck scale'/
   eysen9 'response to Item 9 Eysenck scale'/
   eysen10 'response to Item 10 Eysenck scale'/
   eysen11 'response to Item 11 Eysenck scale'/
   eysen12 'response to Item 12 Eysenck scale'/
   eysen13 'response to Item 13 Eysenck scale'/
   eysen14 'response to Item 14 Eysenck scale'/
   eysen15 'response to Item 15 Eysenck scale'/
   eysen16 'response to Item 16 Eysenck scale'/
   eysen17 'response to Item 17 Eysenck scale'/
   eysen18 'response to Item 18 Eysenck scale'/
   eysen19 'response to Item 19 Eysenck scale'/
   eysen20 'response to Item 20 Eysenck scale'/
   index 'most preferred sound level'
   repro 'number of keystrokes at most preferred sound'+
         'level'/
   reerr 'number of errors at most preferred sound level'/
   norepro 'number of keystrokes at not preferred sound'+
           'levels'/
   noreerr 'number of errors made at not preferred sound'+
           'levels'/
   undrepro 'number of keystrokes at below most preferred'+

             'sound level'/
   undreerr 'number of errors at below most preferred'+
             'sound level'/
   ovrepro 'number of keystrokes at above most preferred'+
           'sound level'/
   ovreerr 'number of errors at above most preferred sound'+
           'level'/
value labels
   errusual errcent 1 'excellent' 2 'good plus' 3 'good'
         4 'satisfactory plus' 5 'satisfactory' 8 'poor'/
   wein1 to wein22 1 'agree strongly' 2 'agree'
         3 'slightly agree' 4 'slightly disagree'
         5 'disagree' 6 'disagree strongly'/
   eysen1 to eysen20 1 'yes' 2 'no'/
   music radio soap game 1 'yes' 0 'no'/
   relia rat1 to rat5 1 'far too loud' 2 'slightly too loud'
           3 'just comfortable'
           4 'slightly too soft' 5 'far too soft'/
```

04 1 16641 366 15610 444 15922 000 17600 109 16973 632 2
16210 811 16167 1 5 1 1 0 0 70 2 16973 632 16443 230 079 2
4 3 6 2 4 2 5 6 4 5 6 5 2 4 6 2 4 4 2 2 5 2 3 4 5 5 5
2 1 1 2 2 1 1 2 2 1 1 1 1 1 1 2 2 2 1 2
1 16641 366 16526 296 16526 296
06 1 15091 690 15794 333 15348 1236 15578 549 15821 444 1
10065 1500 12052 4 4 5 0 1 0 0 30 3 15700 497 15411 753 188 5
2 4 5 2 2 2 3 6 2 1 6 3 5 2 6 4 2 5 3 1 2 4 3 3 5 5 5
2 2 1 2 2 2 1 1 2 2 2 1 2 1 1 2 2 2 1 2
1 15091 690 15635 641 15635 641
07 1 13609 1111 12535 217 11525 286 11023 1284 10755 1134 1
10037 500 10864 3 4 5 1 1 1 1 55 3 10889 1209 12550 538 288 8
3 2 5 2 6 3 5 5 2 5 5 5 4 5 5 3 5 3 5 2 1 5 3 3 5 5 5
2 2 1 2 2 2 1 2 1 2 1 2 1 2 2 2 1 2 1 2
1 13609 1111 11460 730 11460 730
16 1, 15219 260 15907 978 15183 805 14407 938 16015 337 1
12106 645 13521 3 4 5 1 1 0 0 30 3 15211 638 15436 681 195 5
2 5 5 2 2 2 5 5 2 2 2 5 2 2 2 2 3 4 4 2 4 2 3 4 5 5 5
2 2 1 1 2 2 1 2 1 2 1 1 2 1 2 2 2 2 2 2
1 15219 260 15378 764 15378 765
18 1 16148 000 16656 316 16299 1319 16477 404 16151 1443 2
14158 1184 15478 4 3 5 0 0 0 0 00 3 16309 1055 16402 158 178 5
5 1 2 1 6 2 5 4 1 2 2 1 3 2 5 3 2 6 2 4 5 2 1 3 4 5 5
1 1 2 1 2 2 1 2 2 1 2 1 2 2 2 2 1 2
2 16656 316 16269 792 16148 000 16309 1055
21 1 15707 119 17276 330 15680 316 16418 659 14828 213 1
15425 290 15381 1 1 1 1 0 30 4 084 2
3 2 2 5 4 2 2 4 2 2 4 2 2 3 5 2 5 2 2 2 5 5 2 4 5 5 5
1 1 1 2 2 2 2 2 2 1 1 1 1 1 1 2 1 1 1 2
1 15707 119 16051 380 16051 380
08 2 13566 556 2
14186 750 14079 4 5 1 0 0 60 189 5
5 4 1 2 5 2 2 5 3 2 5 4 2 2 6 2 5 5 3 1 1 2
2 1 2 2 1 1 1 2 2 2 1 1 1 2 1 2 2 1 2 2

09 2 17177 1078 19550 500 18555 600 19686 538 17755 412 2
17701 1014 16023 5 5 1 1 0 1 40 3 17755 412 18742 679 152 4
4 3 2 2 2 4 2 4 2 2 5 2 5 3 6 3 5 2 3 2 4 3 3 3 3 4 5
2 1 2 2 1 1 1 2 2 1 1 1 1 1 2 2 2 2 1 2
2 19550 500 18293 657 17177 1078 18665 517
12 2 19013 1509 19772 505 19788 313 19888 667 3
16993 2 4 5 1 0 0 0 40 3 19888 667 19524 776 145 4
5 2 2 2 2 2 2 5 2 2 6 1 3 2 2 2 4 6 3 2 1 2 1 3 4 4 4
1 1 1 2 1 2 1 1 1 2 2 1 2 1 2 2 2 2 1 2
2 19772 505 19563 830 19013 1509 19838 490

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10 2 17250   100 18682   206 18931   303              16991  154 1
16458   357 14963 1 4 5 0 1 0 0 10 2 16991   154 18288   203 039 1
 3 2 5 2 2 2 1 5 1 1 6 2 3 2 5 2 3 2 2 2 3 2 3 4 4   5
 1 2 1 2 2 1 1 1 2 2 2 1 1 2 2 2 2 2 1 2
1 17250   100 18201   221                  18201   221
13 2 14780   619 17291   000 18041   104 15415   000 16166   000 3
16909   127 14000 1 1 5 1 1 0 0 40 3 15473   310 16916   035 041 1
 3 3 1 2 5 2 1 6 2 2 4 1 1 1 6 5 4 2 4 2 5 3 3 3 4 5 5
 1 1 1 2 1 2 1 2 2 2 2 1 2 2 2 2 2 2 2 2
1 14780   619 16728   026                  16728   026
14 3 14101   814 18138   690 15565   370 17653   169 18286   575 3
16558   139 13000 2       0 0 0 0 00 2                           148 4
 3 3 2 4 6 2 3 3 2 2 6 5 5 2 5 2 5 3 5 3 3 2 2 3 4 4 5
 2 2 2 2 1 1 1 1 2 1 1 2 1 2 1 2 2 2 1 2
2 18138   690 16401   482 14101   814 17168   371
20 3 12243   879 11867   225 11706   244 11512   723 11054   562 2
10906 1169 12610 4 4 5 0 1 0 0 45 3 11283   643 11939   449 210 6
 4 2 5 3 1 2 3 3 3 2 2 3 5 2 3 2 4 5 2 3 4 3 2 3 4 5 4
 2 1 2 2 2 2 1 1 2 1 2 2 2 2 1 2 2 2 1 2
2 11867   225 11629   602 12243   879 11424   510
15 3  9306   000  7304   482  8191   353  9201   476 10817   349 2
10241   685  8120 3 4 5 1 1 0 0 25 3 10009   413  8267   278 156 4
 4 2 5 5 3 2 2 5 2 3 5 5 2 2 4 3 3 3 2 2 3 2 2 3 4 5 5
 2 1 1 2 2 2 2 2 2 1 2 1 2 1 2 2 2 1 1 2
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17 3 12578   112 13744 1183 14022   417 13653   465 13076   385 3
14379   286 13883 2 5   0 1 0 1 60 2 13076   385 13499   544 164 4
 3 4 6 2 5 2 4 6 2 2 3 2 2 3 6 3 2 2 4 2 2 3 2 3 4 5 4
 2 1 1 2 2 2 1 1 2 2 2 2 1 2 1 2 1 2 1 2
2 13744 1183 13332   345 12578   112 13584   422
11 3 12274   000 12409   989 17164   482 16105   676 11925   000 1
14758   625 11000 2 4 5 1 1 1 1 30 2 14015   338 13949   490 138 4
 3 3 6 2 3 2 3 6 2 2 6 2 2 3 6 3 2 4 2 4 4 3 2 4 4 4 5
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1 12274   000 14401   537                  14401   537
05 3 13973   723             14253   405 14944   897 13239   390 2
                        4 5 0 1 0 0 60   14092   644 14113   564
 2 5 6 3 2 2 2 3 5 2 5 2 1 1 6 5 2 5 3 1 5 6 3   4 4 5
 1 1 1 2 1 2 2 2 2 1 2 1 2 1 1 2 2 2 1 1
1 13973   723 14145   564                  14145   564
24 4 10334   388 10816   198 11309   449 12108   408 12787   241 3
 9627   625 10000 4 5   1 1 0 0 60 2 12787   241 11142   361 129 3
 2 4 4 2 1 4 1 2 6 2 6 3 3 3 6 3 3 6 3 6 6 3 2 3 4 5 5
 1 1 1 2 1 1 1 1 2 1 1 1 1 2 1 1 1 1 2 2
2 10816   198 11635   372 10334   388 10816   198
25 4 13859   000 13246   729 14123   109 13786   130 14289 1364 3
10817   943 12200 3 4 5 1 1 0 0 20 3 14038   747 13743   279 156 4
 2 2 6 2 3 2 3 4 2 1 6 2 2 5 6 5 2 2 2 1 5 3 3 3 3 4 5
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3 14123   109 13795   556 13553   365 14038   747
```

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26 4 14130   417 13781   200 14971   690 12701   125 14085   500 2
10446   370 11000 5 4 5 1 1 0 0 35 4 13393   313 14294   426 115 3
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 1 1 1 1 1 2 1 2 1 2 2 1 1 1 2 1 2 2 1 2
3 14971   690 13674   311 13956   309 13393   313
27 4 11881   645 12338   326 13716   110 13237   349              1
 9338 1000 11633 3 5   1 1 0 0 30 5               12793   358 380 8
 3 4 5 2 2 2 4 5 3 4 4 2 2 2 5 3 5 5 3 2 5 3 1 3 4 4 5
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2 12338   326 12945   368 11881   645 13447   230
28 4 14219   500 14190   923 15233   323 14146   978 15662 1395 2
12618   179 13300 2 1 5 1 1 0 0 35 2 14941   948 14523   741 230 6
 3 3 3 4 3 3 4 4 2 2 5 4 4 2 6 4 4 5 3 3 4 3 3 4 4 5 5
 2 1 2 2 1 2 1 2 2 1 2 1 1 1 1 2 2 2 1 2
1 14219   500 14808   905               14808   905
29 4 15305   408 18540   952 19441   396 18808   515 20833   396 2
17117   476 13600 4 5   1 1 0 0 50 3 20833   396 18024   568 133 4
 2 5 5 2 2 2 3 5 3 2 5 2 3 2 5 2 3 5 3 2 5 2 1 3 3 4 5
 1 1 1 2 1 2 1 1 1 2 2 2 2 2 2 2 2 2 1 2
3 19441   396 18372   568 16923   680 19821   456
19 5 16843   000 16614   000 16889   920 16673   106              2
17311   000 15381 1 5   0 1 0 0 50 2                           066 2
 2 3 6 2 3 2 5 6 1 3 2 2 2 1 5 2 3 2 3 2 3 2 3 4 4 5 4
 2 2 2 2 2 1 1 2 1 2 1 2 1 1 1 1 1 1 1 2
1 16843   000 16725   342               16725   342


02 5 18411   900 18817 1735               19257 1400              1
17235   750 14000 2     1 1 0 0 20 2                           312 8
 3 6 4 2 5 2 5 4 2 5 5 5 5 3 5 2 5 3 5 2 2 2 2 3   4
 1 1 1 2 2 2 1 2 1 2 2 1 2 1 2 2 2 2 1 2
2 18817 1735 18834 1150 18411   900 19257 1400
22 5 12408   449 12359   309 10614   235 13065   988              2
12766 1264 11907 5 4 5 1 1 0 0 70 2 13065   988 11794   331 178 5
 2 1 6 1 2 1 1 6 2 2 6 2 1 1 6 2 4 3 5 2 2 1 1 4 4 5
 2 1 2 2 1 1 1 2 1 1 2 1 2 1 2 2 2 2 1 1
2 12359   309 12029   557 12408   449 11840   612
01    17809   111 18363   206 17778   990 17549   098 17316   123 1
15904   123 11000 1 4 5 0 0 0 0 00   17433   111 17983   436 078 2
 1 1 6 4 2 4 1 2 1 1 4 1 2 6 6 4 1 5 1 1 5 6
 2 2 1 2 1 1 1 2 2 1 1 2 1 2 1 2 1 1 2 2
1 17809   111 17752   354               17752   354
23
                    4 5 0 1 0 1 60
 2 5 5 2 5 2 5 5 2 2   5 2 2 5 2 2 2 5 2 2 2
 1 1 1 2 1 2 1 2 1 2 1 1 2 1 1 1 2 2 1 2
```

VITA

Surname: NG Given Names: CHEUK FAN

Place of Birth: Hong Kong Date of Birth: Oct. 22, 1952

Educational Institutions Attended, with Dates of Entering and Leaving:

UNIVERSITY OF MANITOBA, WINNIPEG 1978 to 1981

UNIVERSITY OF VICTORIA, B.C. 1981 to 1989

Degrees, Diplomas, Etc., Awarded, with Dates and Names of Institutions:

B.A. (Honors) 1981 University of Manitoa, Winnipeg

M.A. 1983 University of Victoria, B.C.

Honors and Awards:

Sara Spencer Research Award, 1983

University of Victoria Graduate Fellowship, 1983/84 to 1985/86

Publications:

Gale, C., Ng, C.F., & Rosenblood, L. (1988). Neighborhood attitudes toward group homes for persons with mental handicaps. The Mental Retardation and Learning Disability Bulletin, 1988, 16, 7-26.

Gifford, R., Ng, C.F., & Wilkinson, M.W. (1985). Nonverbal cues in employment interviews: Links between applicant qualities and interviewer judgments. Journal of Applied Psychology, 70, 729-736.

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Office Worker Performance and Satisfaction: The Effects of Office Noise and Individual Characteristics

Author [redacted]

CHEUK FAN NG

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(Date)