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Environmental Load and the Allocation of Attention

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INTRODUCTION

The modern day urban dweller is bombarded with a wide range of environmental stimulation. Unlike rural or small town counterparts, the city resident continuously encounters complex, intense, surprising, and threatening stimuli. Random bursts of noise, hot and crowded mass transport, and air polluted with ash and carbon monoxide are among the many inputs impinging on daily activities. These conditions have long been recognized by social critics as well as the urbanites themselves and are often alleged to produce behavioral and physical consequences inimical to man. Only recently, however, have specific stressing¹ elements within the urban environment been subject to systematic investigation.

What are the effects of environmental stress on human behavior? A growing body of literature offers some interesting findings that, curiously enough, are often nonintuitive. Of the existing evidence, three substantive and replicable findings stand out as being central to understanding the problem. First, the effects of environmental stress vary according to the task being performed. Thus in some situations it is detrimental, at other times beneficial; but often moderate (i.e., not physiologically damaging) levels of environmental stress have little if any effect on observable behavior (e.g., Broadbent, 1971; Freedman, 1973). Second, environmental stressors that occur unpredictably or are uncontrollable (i.e., cannot be escaped or avoided) have a greater impact on behavior than those that occur predictably and can be controlled (e.g., Averill, 1973; Glass & Singer, 1972;

¹The term "stressor" is used in this paper to refer to stimulation that represents an adaptive threat or potential adaptive threat to the organism.

Pervin, 1963). Finally, prolonged exposure to unpredictable and uncontrollable environmental stress, although often having little if any effect on tasks performed during exposure, does affect poststimulation behavior (e.g., Glass & Singer, 1972; Sherrod, 1974).

Although the above findings have elicited various theoretical interpretations, no one analysis is capable of explaining them all. The present paper attempts to interpret all of these findings within one theoretical framework. The proposed interpretation is based on a capacity model of attention. An individual is regarded as having a limited amount of attention that can be allocated at any one time. Information overload is said to occur when this capacity is exceeded, i.e., when there are too many inputs with which the system must cope or when successive inputs come too fast. Unable to process all the incoming stimuli, the organism develops techniques or strategies to deal with overload. Although maladaptive strategies, such as random omitting of inputs, are sometimes employed (e.g., Miller, 1964), the present analysis focuses on the more adaptive and presumably more usual strategy of using available attention on inputs that are most relevant to the task at hand and thus ignoring inputs that are less relevant or irrelevant to task performance.

This analysis is similar to the one suggested by Milgram (1970) in his paper on the social consequences of the urban environment. Like Milgram, we argue that the city's myriad stimuli often overload processing capacity and that strategies adopted to deal with overload often have considerable impact on interpersonal behavior. However, whereas Milgram's analysis focused on the evolution of urban norms as adaptations to overload, the present analysis is concerned with *individual response* to both short- and long-term attentional overloads. In addition, Milgram's model is primarily concerned with overloads resulting from the urban dweller's contact with vast numbers of people, and it limits its focus to the consequences of overload for social behavior. The intent of the proposed analysis is to extend the use of a capacity model of attention in the study of the effects of urban and environmental stress, demonstrating that physical and social stimulation have similar effects on the attentional processes and that behavioral manifestations of these effects are similarly apparent in perceptual, motor, and social behaviors.

The proposed model is similar in some basic ways and borrows much of its terminology from Kahneman's (1973) analysis of attention. Like Kahneman, we propose that it is limits on available capacity that determine how many activities are carried out. Likewise, we use the terms "capacity," "attention," and "effort" interchangeably. Effort is mobilized in response to the changing demand of the task in which one engages; accordingly, a rise in the demands of ongoing activities causes an increase in the level of effort and attention. Moreover, a standard allocation of effort can be determined for any task, and investment of less than this standard effort causes a deterioration of performance. Unlike previous atten-

tional models, the proposed theory attempts to deal with both the allocation of attention at any one point in time and the effects of prolonged demands on the allocation process. There are four basic assumptions involved:

1. *Humans have limited attentional capacities.* Capacity, however, is not seen as a spatial or temporal concept but is instead viewed as being synonymous with effort. Thus, a person can invest only a limited amount of effort in the attention process at any one time.
2. When the demands of the environment exceed capacity, a set of priorities is developed. The usual strategy is to focus available effort on inputs most relevant to the task at hand at the cost of those that are less relevant or irrelevant to task performance.
3. *The occurrence, or anticipated occurrence, of an environmental stimulus possibly requiring an adaptive response will activate a monitoring process that evaluates the significance of the stimulus and/or decides on appropriate coping responses.* The amount of effort required to monitor an environmental stimulus is an increasing function of the uncertainty it arouses concerning its adaptive significance.² For example, inputs that are predictable, and thus can be incorporated into a plan of a sequence of events to occur, demand less attention than similar inputs that occur unpredictably. Likewise, mild inputs, which are less likely to be viewed as an adaptive threat, often demand less attention than do intense ones. It follows that a person who is exposed to intense, unpredictable environmental stimulation has less attentional capacity available for task performance than he or she would under normal environmental conditions.
4. *Prolonged demands for effort cause a temporary depletion in capacity.* The rate of capacity depletion increases with both the momentary effort required by an ongoing activity (including that required by extraneous inputs) and the duration of the activity. Thus, an individual can attend to fewer inputs after enduring prolonged demands than he or she can in a rested state. It follows that attentional overload can occur in low-demand situations following prolonged periods of substantial demands on capacity. Recovery of capacity occurs with rest.

The proposed model suggests conditions under which overload occurs but makes no direct predictions about its effects on behavior. There is, however, a

²The present paper is concerned primarily with environmental stimuli that are monitored because they are potentially threatening. However the term "adaptive" is used here in its broadest sense, encompassing those stimuli that may provide an opportunity for positive pursuits as well as those posing a potential threat. A discussion of "salient" stimuli that, because of biases that have been built in the organism, demand attention is provided by Kaplan (1977).

direct link between the model's assumption and certain modes of behavior occurring under conditions of attentional overload. As stated in the second assumption, it is presumed that the adaptive strategy most often employed under conditions of overload is the focusing of available attention on those cues that are perceived by the individual as being most relevant to the task at hand and neglecting less relevant cues. Thus, a person *does not perceive* (i.e., is not aware of) many environmental inputs, both physical and social, that are perceived under less demanding conditions. The effects of this "focusing" of attention vary depending on the ongoing activity; task performance can be hurt if a portion of the neglected inputs are task-relevant and improved if the processing of neglected inputs would have distracted from task performance. Similarly, interpersonal behavior can be adversely affected when another's subtle (and sometimes gross) social cues are not processed but positively affected if these neglected cues are disturbing or disrupting.

Before discussing the specific implications of the model, it is appropriate to consider the evidence on which it is based. Factors involved in the allocation of attention are considered first and the fatigue effect, second. Although it is tempting to suggest that the proposed model can predict the effects of any environmental stressor, for the present the discussion is limited primarily to noise and crowding, two pervasive urban stressors. The great majority of research cited in this paper has been conducted in a performance setting. Moreover, studies of noise far outnumber those of crowding.

OVERLOAD AND THE ALLOCATION OF ATTENTION

Information overload is said to occur when there are too many inputs with which the system must cope or when successive inputs come too fast (Milgram, 1970). Further, when overload does occur (i.e., when the demands on attention exceed available capacity), the organism sets priorities, allocating attention to relevant cues at the cost of subsidiary ones. A number of studies on the effects of stimulus overload on task performance indicate that such a reallocation of attention does occur. For example, it has long been known that a subject's attention capacity can be overloaded by requiring the performance of two tasks at the same time.³ Studies on the performance of simultaneous tasks suggest that rather than equally dividing available attention between the two tasks, subjects tend to maintain performance on one task and to allow the other to suffer (literature reviewed by

³It is important to note that dual tasks create overloads even when one task is auditory and the other visual (e.g., Mowbray, 1952, 1953, 1954). Thus, one's limitation on performing dual tasks does not seem to be sensory but rather the results of overloading of some central mechanism.

Welford, 1968). In cases where the subject is instructed as to which task is more important, attention is focused on that task.

This tendency to maintain priority-task performance allows the dual-task procedure to serve as a means of assessing the load imposed by the primary task under differing conditions, because increases in primary-task demand appear as degradations in secondary-task performance (cf. review by Kerr, 1973). The dual-task procedure has been used, for example, to assess the effects of differing primary loads on subsidiary short-term memory tasks. In a study reported by Brown and Poulton (1961), subjects driving a car through either a residential or shopping area listened to eight-digit numbers presented aurally every 4 seconds. One digit changed between each group and the next, and the subject indicated which had changed. Errors on the secondary task were greater in shopping areas, where there were presumably more competing inputs, than in residential areas. Similarly, Murdock (1965) studied the effects of maintaining performance on card-sorting tasks of varying difficulty on the immediate recall of 20-word lists. Recall of the lists was worse when the sorting was based on two or more dimensions than when it was based on one. Poulton (1958) likewise reports greater deterioration of short-term memory when the priority task involves monitoring six dials as opposed to two.

Whereas the above studies induced overload by increasing the number of inputs, similar effects on the reallocation of attention are obtained when subjects are forced to increase their processing speed, either because they are given less time to complete a task or because of a higher rate of stimulus input. For example, Kalsbeek (1965) required subjects to press right and left pedals in response to 2000 cps. and 250 cps. tones respectively. The signals were presented at fixed rates of from 10 to 120 per 2-minute interval. Performance on a subsidiary spontaneous-writing task deteriorated with increased speed of the primary task. Increased demands on capacity associated with increasing signal rates are also reported by Brown (1962, 1965) and Gould and Schaffer (1967).

Also of interest is the work assessing the effects of signal predictability on primary-task load. Several studies report that the capacity demanded by tasks requiring response to unpredictable signals is greater than that needed for equivalent performance with predictable signals. For example, Dimond (1966) required subjects to press a key in response to a light appearing at intervals of from 4 to 10 seconds. A subsidiary six-choice key-pressing task was performed simultaneously. After practice (required to learn predictable nature of the signals), secondary-task performance was better when the signals in the primary task were predictable than when they were unpredictable. Likewise, in a study reported by Bahrick, Noble, and Fitts (1954), subjects performed a five-choice reaction-time task with either repetitive or random patterns of signals and, at the same time, gave answers to simple arithmetic problems read aloud by the experimenter. Again, after practice, the arithmetic task was performed better when

primary-task signals were predictable than when they were random. Similar effects of predictability are reported by Bahrick and Shelley (1958).

A closer examination of the allocation of attention under overload suggests that focusing occurs not only at the *macrolevel* of performing one task at the cost of the subsidiary one but also in the selection of cues on a single task (the subsidiary task in the dual-task paradigm), where there is some but not enough available attention. The typical strategy is to focus on centrally located signals at the cost of peripheral ones. Thus, in a study reported by Webster and Hasterud (1964), both an auditory (counting clicks) and visual (counting flashes) primary task had equally detrimental effects on both the number of responses and reaction time to peripheral lights in a subsidiary visual-detection task. Similar results are reported by Leibowitz and Appelle (1969), who found that luminance thresholds to peripheral lights increased with the difficulty of a primary foveal-fixation task.

Rate of processing has a similar effect on secondary-task focusing. Youngling (1967), using a central tracking task with a multiposition peripheral-light detection task, found that as the tracking target rate increased, there was a funneling or systematic loss of response to peripheral signals that was greater the more peripheral the light position. Furthermore, he found no difference between time-on-target scores at the different tracking rates. Thus, the extra attention that was needed to maintain primary-task performance was preempted from the secondary task. Moreover, the attention deficit on the detection task resulted in a reallocation of available attention to central cues at the cost of peripheral detections.

Although we are arguing that there is a focusing of attention on *relevant cues* when there is insufficient capacity to maintain normal task performance, the evidence cited up to this point demonstrates focusing based on spatial (i.e., central versus peripheral) cues and not on a relevance or importance criterion. Focusing on central cues can, of course, be interpreted as the best strategy in a detection or tracking task in which central and peripheral signals are equiprobable. They can also be considered the most important cues if their probability of occurrence is greater than the probability of peripheral occurrences. In fact, Hockey (1970b) suggests that central cues in tasks of this sort often have a higher subjective probability than peripheral ones. These interpretations, of course, are only speculative. However, a study varying both task load and cue value (Kanarick & Petersen, 1969) provides concrete evidence that attentional focusing is based on "relevance" rather than "spatial" criteria. Rather than using a dual-task procedure, Kanarick and Petersen required subjects to track several visual inputs simultaneously under differing signal rates. They report that high-input-rate subjects pay proportionately more attention to high-value information sources at the expense of monitoring low-value sources, where high value refers to those signals earning more points. Because spatial position of high-payoff channels was counterbalanced, the results suggest focusing based on cue relevance rather than position.

Several conclusions are supported by the studies reviewed thus far:

1. A task's demand on capacity increases with (a) rate of signal input (whether varying time or number of inputs), and (b) unpredictability of the signal sequence.
2. When performing simultaneous tasks whose combined demands exceed total available capacity, attention is focused on the task deemed more important at the expense of the subsidiary task.
3. When there is not enough capacity to maintain normal performance on a task, whether a subsidiary task or a single task with high-capacity demands, available attention is focused on relevant task cues at the cost of less relevant cues.

EVALUATING THE SIGNIFICANCE OF ENVIRONMENTAL STIMULI

The research cited in the previous section suggests that demands on attentional capacity increase with the sequential rate of task-relevant signals. It is clear that subjects performing these tasks according to instructions, and thus attempting to attend to many inputs simultaneously, experience attentional overload. The urban experience, however, differs in an important way from these experimental situations. Many of the additional stimuli in the urban environment are *not* task-relevant. They are "background" stimulation. Is capacity also expended on competing stimuli not relevant to the task at hand?

The effects of task-irrelevant stimuli are more easily understood if examined in the context of mechanisms involved in the allocation of attention. It is possible to view the allocation of attention as being determined by two sets of factors: the momentary task intentions of voluntary attention, and the more enduring dispositions that control involuntary attention (Kahneman, 1973). These enduring dispositions cause us to pay more attention to some stimuli than to others. Thus, stimuli that are novel, intense, surprising, complex, conflicting, or having some special learned significance elicit an apparently automatic response (Berlyne, 1960). The characteristic response made to these classes of stimuli has been called the "orienting response" (Sokolov, 1963). The orienting response (OR) occurs because the organism is uncertain about the adaptive significance of a stimulus and thus responds with attention and alertness (Glass & Singer, 1972). The response is characterized by an increase in sensitivity to the stimulus source on both the physiological and cognitive levels. The individual focuses attention on novel stimuli and readies him- or herself to act.

Individuals are, however, capable of attenuating even complex, intense, and novel stimuli. Evidence concerning the OR suggests that such a filtering mechanism is operative. After repeated presentation of a particular stimulus, the OR habituates. The stimulus is no longer novel and thus no longer elicits response. For example, when a subject is instructed to "listen to tones," the first and

perhaps the second tones elicit very substantial ORs, but after several presentations, the response is no longer elicited (Uno & Grings, 1965). The habituation of the OR does not, however, imply that the stimulus is no longer analyzed (Kahneman, 1973); rather, it implies that the stimulus is expected to occur predictably. When the expectation is violated, an OR is elicited. A demonstration of this effect is provided by Sokolov (1969). When a single flash of light is omitted from a regular series, an OR occurs soon after the omitted light was due. Similar results are reported by Badia and Defran (1970).

An input evaluation process similar to that suggested by research on the OR is proposed by Lazarus (1966) in regard to evaluating the potential harmfulness of stimuli. Lazarus introduces the concept of threat appraisal as the process intervening between stimulus presentation and stress reaction. In order for a situation to be deemed threatening, the stimulus must be evaluated as harmful. This process is presumed to depend on two classes of antecedent conditions: the psychological structure of the individual, and the cognitive features of the stimulus situation (e.g., predictability). When a stimulus is evaluated as threatening, an appropriate coping response is chosen by means of a second process. Thus, potentially dangerous inputs are monitored in order to evaluate their adaptive significance and to decide on appropriate coping responses when necessary.

These approaches suggest that attention level and responsiveness to a stimulus depend on the degree of uncertainty elicited by its occurrence or nonoccurrence. It follows that competing (i.e., task-irrelevant) stimuli that are intense and unpredictable, and thus arouse uncertainty concerning their adaptive significance, often demand a greater allocation of attention than do milder and more predictable inputs. Stressors such as noise and crowding can thus be most profitably viewed in terms of the uncertainty they arouse, i.e., their information value. Those that occur in a predictable sequence, eliciting little uncertainty, can be monitored at an attenuated level (e.g., Sokolov, 1969) with a small but not substantial demand on capacity. However, those that occur unpredictably, (i.e., eliciting high levels of uncertainty) demand a continual monitoring and evaluation process even after repeated presentation. Thus, even when voluntary attention is task directed, some capacity is required in the low-level processing of environmental stressors.

STRESS, OVERLOAD, AND THE ALLOCATION OF ATTENTION

If effort is expended in the monitoring of irrelevant inputs, we would expect that a person exposed to intense and/or unpredictable environmental stimulation could process fewer task-relevant inputs than he or she could in a less distracting environment. Research using the dual-task procedure to assess attentional demand imposed by exposure to environmental stress suggest that this, in fact, is the

case. As described earlier, this procedure allows us to assess increases in priority task load by monitoring performance on the subsidiary task. Thus, any effect of a stressor sufficient to require the use of excess capacity to maintain primary task performance is evidenced as a secondary task decrement.

In a study reported by Evans (1975), subjects performed simultaneous tasks while in a crowded or uncrowded room. (Density was manipulated by varying spatial parameters with both large and small rooms containing 10 people.) The primary task was a figure-matching task requiring subjects to choose matching pairs of figures from stimulus sheets containing 80 figure pairs. Simultaneously, subjects listened to a story read aloud on which they were to be tested later. Whereas the primary task was unaffected by crowding, the subsidiary task — recognition memory for the story — was poorer in the crowded group than in the uncrowded group. Thus, it appears that the additional attention required to maintain primary-task performance under crowded conditions was preempted from the subsidiary task.

Similar effects of subsidiary-task performance occur under noise. In an experiment by Boggs and Simon (1968), subjects performed two tasks simultaneously under quiet conditions and also while exposed to unpredictable, 92-decibel noise. The primary task was a visual reaction-time (RT) task, the secondary one an auditory monitoring task. Although exposure to noise did not affect performance on the RT task, there was task degradation on the auditory-monitoring task in noise, as compared with quiet, and this degradation was greater when the primary task was complex rather than simple. (Because secondary task stimuli were presented during intervals between noise bursts, degradation in auditory monitoring cannot be attributed to masking.) Thus, it appears that the additional effort required to perform under noise consumed enough attentional capacity to impair task performance on the secondary task.

Research on the maintenance of items in immediate memory similarly suggests that effort is expended in the monitoring of noise. If extraneous environmental stimulation is capacity consuming, we would expect that the addition of noise during item presentation or during performance of a task intervening between presentation and reproduction would, by preempting capacity allocated to item rehearsal, cause memory decay (cf. Posner & Rossman, 1965). Evidence reported by Rabbitt (1968) suggests that this is the case. Results of a first study indicate that lists of digits are less likely to be correctly recalled when they are presented through noise than when presented in quiet. (The noise had no effect on performance when lists of digits were to be recognized or transcribed, and thus the effect cannot be attributed to masking.) Therefore, it can be argued that the process of recognizing digits through noise preempted the processing capacity necessary for their efficient retention. In a second experiment, subjects presented with two consecutive groups of digits recalled the first group of digits better if the second group was presented in quiet than if it was presented in noise. There was no evidence that presentation of the first group through noise affected

recognition of the second group. This is consistent with the assumption that the rehearsal of the first group of digits is inhibited, because the needed capacity was preempted by the task of recognizing a second group through noise. Similar results were obtained in a replication of these two experiments using lists of nouns instead of digits and measuring recognition instead of recall (Rabbitt, 1966).

Studies on recall of peripheral stimuli also find performance degradation under environmental stress. It is difficult to determine whether this effect can be attributed to a lack of attention paid to task-irrelevant stimuli or to the subject's inability to retain these items in memory. In either case, however, the performance deficit can be attributed to a focusing of attention on task-relevant cues under noise. O'Malley and Poplawsky (1971) presented subjects with a series of slides each containing a four-letter word printed in the center in heavy black capitals and a three-letter word in small, light print located in the periphery. Subjects were given standard serial anticipation instructions with no mention of the periphery words. The slides were presented in 75-, 85-, and 100-decibel noise, or quiet. A free-recall test indicated that subjects in the 85- and 100-decibel noise conditions learned fewer of the peripheral words than did subjects in the 75-decibel noise and quiet conditions.

An exploratory study (Saegert, 1973) found a similar lack of memory for peripheral cues under conditions of high density. Subjects were brought to the shoe department of a New York department store at a time chosen to assure either high or low density. Their task was to write short descriptions of 12 shoes in the area. After the task was completed, the subject was taken to a secluded part of the store where she was asked to describe the same shoes she had previously described, in the same order, and to draw a map of the shoe section in as much detail as she could remember. High-density subjects drew maps that had a less detailed and less correct picture of the area in which they were working. (Scoring was based on memory for large objects that would be visible under high-density conditions.) Thus, subjects in the high-density condition either did not originally attend to, or could not remember, peripheral cues irrelevant to their ongoing task.

The capacity-consuming nature of irrelevant stressing stimuli has also been reported in the clinical literature. Research and clinical observation on the applied use of noise stress (Licklider, 1961) suggests that noise is an effective suppressor of pain. Thus, dental patients who previously required a conventional anesthetic or analgesic agent to undergo dental operations undergo audio analgesia without serious pain or unpleasantness. The patient wears earphones and controls the acoustic stimulation through a control box held in his or her lap. There are two control knobs, one for music and a second for white noise. When the patient feels any discomfort, the volume on the music control is increased; at the first sign of any pain, he or she turns up the noise knob. The noise level can be set as high as 116 decibels. Audio analgesia seems to be effective in 65% of the cases.

Predictability, Controllability, and Demands on Capacity

Of special interest is the effect of increasing the randomness or unpredictability of unwanted stimuli on attentional capacity and allocation. It was suggested earlier that unwanted inputs that are unpredictable require greater expenditures of capacity than similar inputs that occur predictably. In line with this is a study reported by Finkelman and Glass (1970). Subjects working on simultaneous tracking-and digit-recall tasks showed performance degradation on the secondary task under unpredictable noise but not under predictable noise. Performance on the primary task was unaffected by either type of stimulation. Thus, although primary task performance under unpredictable noise demanded enough additional capacity to cause a reallocation of available attention, equivalent performance under predictable noise had no significant effect on the distribution of attention. Several additional studies similarly suggest that performance under unpredictable noise requires greater processing capacity than equivalent performance under predictable stimulation. The effects of unpredictable noise include increasing the variability of performance across subjects in paper and pencil tasks (Sanders, 1961), degrading tracking-task performance (Plutchik, 1959), and producing a reduction in complex psychomotor performance (Eschenbrenner, 1971). Similarly, research on audio analgesia (Licklider, 1961) suggests that random noise is more effective in suppressing pain than predictable sounds.

The stressing effects of unpredictably occurring events have received considerable attention and suggest a conceptual framework in which to view the allocation of attention under stress. For example, Mandler and Watson (1966) suggest that inputs that can be incorporated into a plan of the sequence of events to occur are less anxiety provoking than those that cannot be incorporated into a plan. Thus a predictable input, because it can be planned for, elicits less anxiety than an unpredictable input. Likewise, an input whose onset or offset can be controlled, and thus incorporated into a plan, is less aversive than an uncontrollable input. This analysis leads us to expect that the ability to control the onset and/or offset of an aversive stimulus may have similar effects on attentional capacity and allocation as the ability to predict its occurrence. Although there are no noise or crowding studies relevant to this suggestion, a study by Wachtel (1968) using threat of electric shock as a stressor does suggest support. A tracking task and a subsidiary peripheral-light detection task were performed simultaneously. Subjects threatened with uncontrollable electric shock performed no differently than an unthreatened group on the primary task but had significantly longer RTs to lights in the subsidiary detection task. Subjects who were told that they could avoid the shock with good performance on the tracking task showed no such increase in RT. Thus, the anticipation of uncontrollable shock preempted attention from the subsidiary task, whereas the anticipation of controllable shock required little, if any, attention.

Predictability and Crowding

In the context of noise research, unpredictability refers to stimulation occurring when it is not expected. For example, noise is considered predictable when bursts occur at fixed intervals and unpredictable when bursts occur at random intervals. It is less obvious, however, how the concept of predictability fits into the crowding literature. Some clarification of this point is provided in a recent theoretical paper by Rapoport (1975). Rapoport suggests that a condition of high density is unpredictable when there are no social-cultural norms, physical barriers or markers to structure behavior. Thus, when expectancies of how others will behave are vague, nonexistent, or nonoperative, the situation is unpredictable. On the other hand, under similar conditions of spatial limitation, when social-cultural norms and physical markers and barriers effectively structure behavior (i.e., expectancies are accurate), the situation is considered predictable. Rapoport further suggests that unpredictable density demands a substantial allocation of attention and that this allocation decreases with increased predictability. As a consequence, "crowding" effects are more likely to occur under unpredictable than predictable density. The foregoing analysis is consistent with the model developed earlier. That is, the stimuli that occur in dense conditions are demanding (i.e., capacity consuming) only to the extent that uncertainty is aroused concerning their adaptive significance.

Conclusions. It is clear that noise and crowding have similar effects on attentional capacity and allocation, as do overloads induced by increasing number and rate of inputs. In line with the conclusions made earlier, research on the effects of noise and crowding on attentional capacity and allocation indicate the following:

1. Environmental stress creates demands on attentional capacity, and these demands increase when the stressor is (a) intense, (b) unpredictable, and (c) uncontrollable.
2. When simultaneous tasks are performed under conditions of environmental stress, attentional load increases, resulting in a decrement in subsidiary-task performance.
3. When simultaneous tasks are performed under environmental stress, there is a focusing of attention on relevant cues to the neglect of less relevant ones on the subsidiary task.

These results provide strong support for points (1), (2), and (3) of the attentional model presented earlier. Most important, overloads induced by the occurrence of moderate physical stressors (e.g., noise) have the same effects as those induced by more conventional means.

COGNITIVE FATIGUE EFFECT

The term "fatigue" is usually employed to describe the "detrimental effects of work upon work, whatever the nature of those effects" (Broadbent, 1953a, p. 173). However, deeper probing reveals that there are many aspects of the problem, many different mechanisms that may result in lower work output. The term "cognitive (or mental) fatigue" is used in this context to delineate one such mechanism, a decrease in total available attentional capacity. This depletion of capacity is reflected both in the amount of information that can be handled at any one instant and in the amount that can be handled in a given period, and hence in slowness of perception, choice, and so on (Welford, 1968, p. 247). Although it is similar to neuromuscular fatigue in that it disappears with rest, cognitive fatigue is viewed as a change in the state of a central process, whereas neuromuscular fatigue is usually seen as a peripheral process.

The proposed model assumes that the rate of cognitive fatigue — of depletion of attentional capacity — increases with both the amount of attention required by a task and the duration of the task. Thus, subjects performing complex tasks, more than one task at a time, or performing under environmental stress, show signs of capacity depletion earlier than those performing on less demanding tasks. These decrements in attentional capacity are manifest in an inability to provide the attention demanded by many situations and thus in a reduction in performance and in the focusing of attention associated with attentional overloads.

There is considerable evidence in the performance literature indicating that task performance becomes worse over prolonged working periods. A difficulty arises, however, in distinguishing the effects of monotony (or boredom) from those of cognitive fatigue, because tasks that are fatiguing are often repetitious as well. One factor that aids in delineating the effects of monotony and fatigue is a tendency for a subject, when given the opportunity, to distribute efforts over a working period so as to minimize fatigue (Forrest, 1958; Katz, 1949; Saulley & Bilodeau, 1963). Thus, a subject will adjust pace to the expected length of the working period right from the beginning (Welford, 1968). This means that fatigue effects are more likely if subjects work on paced tasks or under pressure for speed for an unknown period than if they work at their own pace for a time known in advance. It is difficult to attribute these differences between paced and unpaced tasks to associated fluctuations in boredom. It is likely that self-paced subjects who are bored would rush through a task as quickly as possible rather than slow down. Second, we expect that fatigue, and consequently the rate of performance degradation, will accelerate when tasks are complex as opposed to simple and when they are performed under intense environmental stimulation as opposed to normal environmental conditions. Monotony, however, would likely be lessened under these conditions and thus performance improved. Finally, tasks impaired by cognitive fatigue should show significant improvement

after short periods of rest; boring tasks would be less likely to show such reversals. The evidence that follows can be attributed, by at least one of the foregoing criteria, to cognitive fatigue. Although interpretation of some of these results is somewhat ambiguous, the overall picture lends strong support to the fatigue hypothesis.

It has generally been found that performance on serial reaction-time tasks becomes progressively worse over time. Thus, Broadbent (1953b) reports that subjects performing a self-paced, serial reaction-time task show a decrease in the rate of work and an increase in the variability of the rate. However, this degradation in performance did not appear until the last 10 minutes of the 1-hour task. When the task was paced, on the other hand, subjects showed an increase in errors after only 10 minutes. Similar indications of task performance declining uniformly as a function of time are reported for vigilance tasks wherein subjects must remain alert for relatively long periods during which they must note small changes on one of a complex of dials, lights, or clocks (Poulton, 1970).⁴ Performance on these tasks can be restored, however, by a short rest period (Mackworth, 1970). Thus, Mackworth (1950) reports that performance on the Jump Clock test declines over the first half-hour and declines further over the second half-hour. A half-hour rest, however, restored performance to the original level.

A direct relationship between time on task and decline in performance on a variety of tasks is suggested in a paper by Mackworth (1964). In her review of performance decrement in vigilance, threshold detection, and high-speed perceptual motor tasks, Mackworth concludes that decrements in performance found on these tasks appear to be a linear function of the square root of time on task. She argues that "continuous attention to a simple decision-making task leads to a decrement in performance over a wide range of stimuli and responses [p. 221]." Moreover, this decrement is due to a *decreased ability to perceive the stimulus*. The results from a number of the studies reviewed by Mackworth are shown in Fig. 1.1. The figure shows the results of five different studies. Thus, in a study on auditory thresholds, Solandt and Partridge (1946) report an increased range of pitch discrimination as the test proceeded. Likewise, Bakan (1955) reports

⁴Decreases in vigilance performance over time are especially difficult to interpret. Some vigilance tasks seem to require little attention and thus are unlikely candidates for cognitive fatigue. Moreover, decrements on those that are attention demanding (e.g., Jump Clock Test) are attributable to shifts in decision criterion (Sweets, 1973). Thus, a progressively more conservative decision criterion (less hits but also proportionally fewer false alarms) comes about over time. It is, however, possible to interpret conservative criterion shifts in terms of the reallocation of attention under overload. As time elapses, capacity decreases, and available attention is allocated to only the most relevant (i.e., "sure hit" signals).

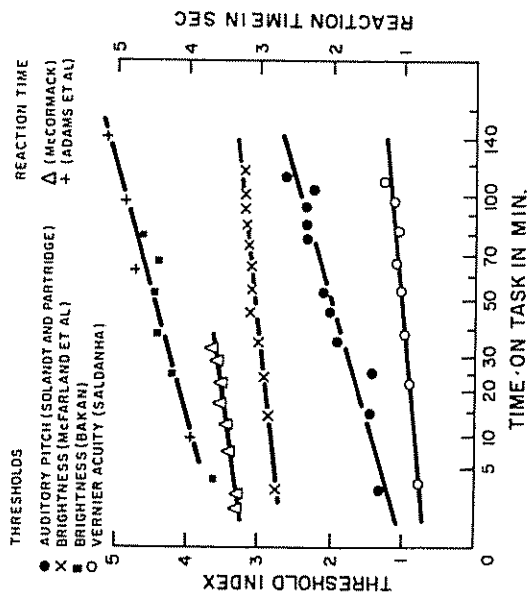


FIG. 1.1. Changes in thresholds and reaction time as a function of the square root of time on watch. (From Mackworth, 1964, fig. 2, p. 214.)

that thresholds for a flash of light increased with time on task. Similar effects on visual threshold are reported by McFarland, Holway, and Hurvich (1942) and Saldanha (1957). Reaction-time studies by Adams, Stenson, and Humes (1961) and McCormack (1960) also show performance decrement as a function of time on task.

Mackworth (1964) also points out that declines in performance on these tasks can be prevented by rest pauses. For example, Bergum and Lehr (1962) report that rest pauses of 10 minutes every half-hour were sufficient to maintain performance in a vigilance task. McFarland et al. (1942) found marked recovery on a visual threshold task following 10 minutes of exercise, and McCormack (1958) showed that a rest pause of 5 minutes after 30 minutes of testing improved RTs but did not restore performance to its original level, whereas a pause of 10 minutes was sufficient to do so.

Declines in performance over time occur because a point is reached at which available attentional reserves are inadequate. As discussed earlier, such a state of overload requires a reallocation or focusing of attention. Thus, prolonged task duration should be reflected in a focusing of attention on relevant task cues as well as the more gross measure of overload — performance decrements. In fact, attentional focusing after prolonged performance is reported in a series of experiments by Drew (reported in Davis, 1948). Drew tested subjects for 2-hour spells in a simulated aircraft cockpit under blind flying conditions. He reports

that most subjects tended to pay less and less attention to the more peripheral parts of the task as time on task increased, giving their main attention increasingly to the controls in constant use. For example, the fuel indicator had to be reset every 10 minutes but came to be more often neglected.

It was suggested earlier that environmental stress, by increasing demands on capacity, should increase the rate of cognitive fatigue. Evidence consistent with this assumption is reported under a variety of conditions. Several studies (e.g., Broadbent, 1954; Jerison, 1959) find that performance degradation on a serial RT is accelerated in time under noise as opposed to quiet. Thus Broadbent (1953b) reports that 100-decibel "white" noise as opposed to quiet reduces the accuracy of repetitive serial responding, but only during the last 30 minutes of the test. Similar results are reported by Corcoran (1962) and Wilkinson (1963). Sanders (1961) found an increase in variability of performance on a serial responding task performed under 75-decibel noise, appearing in the last half of a 30-minute session. Likewise, Hartley (1973) found that the number of errors produced by noise on a serial reaction-time task depends on the duration of noise exposure. Subjects who worked on tasks for 40 minutes, but were exposed to noise for only the last 20 minutes, showed less impairment of performance than those exposed for the entire session.

The relationship between length of the working period and whether or not a stressor impairs performance is discussed by Wilkinson (1969) in a review of the effects of environmental stress on performance. After reviewing the research on the effects of noise, heat, cold, sleep deprivation, hypoxia, vibration, and acceleration, Wilkinson (1969) concludes that "duration of work is an important factor to be considered in any attempt to predict or simulate their impact on performance. In almost all cases, furthermore, this influence is in the direction of increasing the adverse effect of the stress as time wears on [p. 262]." He suggests that this tendency is so common that it is tempting to conclude that it reflects some factor common to most stresses that increases with exposure to the associated task. Thus, it appears that prolonged task performance under environmental stress results in increasing task degradation — an effect attributable to a depletion of available attention.

Task duration under experimental conditions is usually limited to between 20 minutes and 1 hour. Although this may be sufficient to cause a significant decay in available capacity, it may not affect performance on the primary task, which by that point is well practiced and requires little effort. However, subsequent tasks demanding considerable attention on the part of the subject, would be sensitive to fluctuations in available processing capacity. Thus, we would expect depletions in attentional capacity resulting from prolonged task and environmental demands to be manifest in deficits on tasks administered immediately after termination of the principal task.

Aftereffects of demanding cognitive tasks have, in fact, been reported. Rey and Rey (1963) report that after 45 minutes of work at a cancellation task, RT

became larger, CFF lower, and rate of tapping more irregular. Takakuwa (cited by Welford, 1968) found that the accuracy of aiming at a target over a period of 1 minute deteriorated after a number of tasks regarded as mentally fatiguing. A direct test of the relationship between principle-task load and duration on the performance of aftereffects tasks has recently been completed in our own laboratory (Cohen & Spacapan, 1978). The principle task required subjects to respond to 12 colored lights (four each of red, green, and yellow) by pressing one of three corresponding colored response keys as quickly and accurately as possible. The lights occurred at either a high [200 millisecond interstimulus interval (ISI)] or low (800 millisecond ISI) rate, and the task lasted either 15 or 30 minutes. After completing the principle task, subjects were immediately ushered into a second room where a second experimenter administered the Feather tolerance-for-frustration task (cf. Glass & Singer, 1972). The subjects were led to believe that the task was part of a different experiment than the RT task. Results indicate that high-load subjects performed more poorly on the tolerance-for-frustration task than did low-load subjects. Moreover, subjects required to perform the principle task for 30 minutes performed more poorly than those required to work on the task for 15 minutes, although this latter effect was only marginally significant. These results do suggest that cognitive fatigue, and therefore performance on aftereffects tasks, is related to both the amount of attention required by and the duration of the principle task.

Similar evidence suggesting a decreased ability to perform attention-demanding tasks after prolonged demands on capacity is provided by the research on the aftereffects of environmental stress. Thus, in an experiment by Glass, Singer, and Friedman (1969), subjects worked for 25 minutes on a simple arithmetic task. During this period, they were exposed to predictable or unpredictable 110 or 56-decibel noise. A control group worked in quiet. Subjects working under unpredictable noise, in contrast to predictable noise and no noise, showed degradations in performance on attention-demanding tasks administered after stimulation was terminated. These effects were more pronounced when the unpredictable noise was delivered at 110 decibels as compared to 56 decibels. A second experiment reported in the same paper showed that the adverse poststress effects following loud, unpredictable noise were substantially reduced if the subjects believed they had control over the termination of the noise. Glass and Singer report similar results for the effects of electric shock (Glass & Singer, 1972; Glass, Singer, Leonard, Krantz, Cohen, & Cummings, 1973).

These results are consistent with the assumption that more capacity is expended in performance under unpredictable and uncontrollable stressors than under predictable and controllable ones. Because there is a greater expenditure of effort in these conditions, capacity depletion is accelerated and fatigue effects are more likely to occur after a relatively short period of time. Subjects exposed to unpredictable, uncontrollable noise show a degradation in task performance on a second task that is indicative of a depletion of total available capacity. Deg-

IMPLICATIONS FOR PERFORMANCE

Because the proposed model is presented in the language of the performance literature, many of the implications of the theory for performance are evident. It is, however, necessary to clarify an important point. Under what conditions is task performance adversely affected, and under what conditions is performance positively affected by attention overload?

As discussed earlier, the less available attention, the fewer the inputs that can be processed. The first inputs to be reduced (dropped out) are those that are irrelevant or only partially relevant to task performance. As available capacity decreases, task-relevant cues are also neglected. In some tasks, proficiency demands the use of a wide range of cues (e.g., dual-task performance or single tasks requiring the integration of information from many sources). Any reduction in available capacity is likely to adversely affect performance on such tasks, because remaining attention would likely be less than that required to process task-relevant cues. In other tasks, proficiency demands the use of only a restricted range of cues. Such tasks improve with moderate decreases in available attention (improvement in performance occurs only to the extent that reducing competing cues facilitates a particular task) but are detrimentally affected when available capacity falls below that required to process task-relevant cues. Thus, continued reduction in capacity will improve and then impair proficiency.

Recent analyses of the effects of noise on task performance (e.g., Hockey, 1970a) suggest support for this interpretation. Because noise is assumed to require capacity, there is less attention available for tasks performed in noise than in quiet. Thus, in reviewing the effects of acoustic noise on visual monitoring efficiency, Hockey finds that multisource tasks, requiring the integration of information from many sources, are generally impaired by noise, whereas single-source tasks, on which performance is improved by a focusing of attention, are generally performed better under noise than quiet. In fact, all the reviewed experiments using more than one source (e.g., Broadbent, 1951, 1954; Broadbent & Gregory, 1963) are impaired by noise. In contrast, those studies using single-source tasks (e.g., Davies & Hockey, 1966; Kirk & Hecht, 1963) characteristically result in increments in task performance or in no effect.

The negative effects of noise on performance in the dual-task studies cited earlier are consistent with the proposed effects of overload and with the findings of Hockey's review. To complete the picture, it is appropriate to examine a task in which performance is improved when competing stimuli are ignored. One such task is the Stroop Color-Word (CW) test (Jensen & Rohwer, 1966; Stroop, 1935). The task stimuli are the names of four colors (green, red, orange, and blue), each of which is printed in one of the other three colors. That is, the word "green" may be printed in either red, orange, or blue. The four color words are presented randomly over a series of trials, and the subject is asked to say aloud the color in which the word is printed. In order to be successful at the task, the sub-

radiation in performance on a second task as a function of duration of noise/work exposure on a first task is reported by Hartley (1973). Errors on a serial reaction-time task were made more often by subjects working under noise in a pretest period and quiet during the testing period than by those who spent the pretest period in quiet and the test period in noise. Thus, it appears that prior exposure to noise (task during pretesting period was either the same RT or reading) results in a depletion in total available capacity and a consequent inability to adequately perform a subsequent task.

In a study on the aftereffects of density by Sherrod (1974), a noncrowded group of subjects, a crowded group, and a crowded group who were told that they could leave the room if they felt too uncomfortable (perceived control over termination of stress) worked for 1 hour on either a simple or complex task. Immediately afterward, all subjects worked in a noncrowded situation on two additional tasks, one involving frustration tolerance and the other involving quality of proofreading performance (cf. Glass & Singer, 1972). Crowding had no effect on simple or complex task performance. In the postcrowding situation, however, crowding resulted in negative behavioral aftereffects on the frustration tolerance measure, although perceived control ameliorated these aftereffects. There were no significant aftereffects on the proofreading measure.

The work on audio analgesia in the suppression of pain also suggests the existence of aftereffects. Licklider (1961) reports that "stimulation of intense noise appears to have a more or less persistent aftereffect on pain. In some instances, after long or intense exposure, it has been possible for patients to undergo ordinarily painful operations without further presentation of noise [p. 52]."

Evidence reported in this section lends support to Assumption (4) of the proposed model. Available attention appears to be depleted by prolonged spells on demanding tasks. Moreover, performance under conditions of environmental stress accelerates this depletion.

SUMMARY OF THE MODEL

A short summary of the important points of the model is appropriate at this point. As suggested by earlier theorists, information overload occurs at any time that the demand for attention exceeds total available capacity. The present model diverges from previous theory in suggesting that total available capacity is not fixed and in fact "shrinks" when there are prolonged demands on attention. Thus, an individual can attend to fewer inputs after prolonged demands than he or she can in a rested state. The model further suggests that the presence of an environmental stressor, because it requires an allocation of capacity, is likely to create informational overload. Finally, the most usual strategy employed to deal with overload is the focusing of available attention on the aspects of the environment most relevant to task performance at the cost of less relevant inputs.

ject must ignore the word itself and attend only to the color in which it is printed. Thus, focusing attention on relevant cues (color) to the detriment of irrelevant cues (words) should improve task performance. In fact, the facilitative effect of noise on Stroop performance is reported by several investigators (Hartley & Adams, 1974; Houston, 1969; Houston & Jones, 1967; O'Malley & Poplawsky, 1971). In contrast, a similar task not requiring the subjects to ignore competitive stimuli (reading sets of colored asterisks) is not affected by noise (Hartley & Adams, 1974; Houston, 1969).

Evidence for the improvement and subsequent impairment of proficiency as available attention decreases is also provided by the research on the Stroop. Stroop performance is better when the test is administered under noise than when administered in quiet. Thus, attention that, under quiet, is allocated to competing cues is being consumed in the monitoring of noise. However, there is a decrement in Stroop performance when the test is given after prolonged exposure to noise (Glass & Singer, 1972; Hartley & Adams, 1974). Thus, there is not enough available attention after prolonged performance under noise (cognitive fatigue effect) to process relevant task cues.

IMPLICATIONS FOR SOCIAL BEHAVIOR

In order to understand the implications of the proposed model, some translation from performance jargon to the language of social behavior is necessary. The term "task-relevant" is interpreted as meaning relevant to fulfilling one's own personal needs and wants. Thus, attentional overload results in a focusing of attention on environmental inputs relevant to one's own goals, neglecting other cues, social and nonsocial alike.

Important social cues that are often neglected when attention is restricted include those that carry information concerning the moods and subtly expressed needs of others. The neglect of such cues results in a lowered probability of help-

ing another, expressing sympathy for another, or reacting appropriately to another's needs. The experience of attentional overload can affect the probability of such helping responses in three ways:

1. The cue that suggests that a helping response may be required is *not even perceived*. Thus, if a husband doesn't see the distressed look on his wife's face, he cannot know that she is in need of sympathy. Likewise, if a potential helper does not see a man lying on the sidewalk, he cannot give him aid.
2. The cue is perceived, but a lack of available attention makes the person *incapable of evaluating its significance*. Because distress cues are often ambiguous, an evaluation is usually required in order to determine whether a cue actually represents distress and whether intervention on the part of the potential helper is appropriate (cf. Latané & Darley, 1970). This evaluation requires a substantial allocation of attention. Thus, a husband may perceive an emotional expression on his wife's face but not interpret its meaning. Likewise, a man lying on the sidewalk may be seen but his plight not recognized.
3. The distress cue is perceived and evaluated, but aiding the person in need *requires effort that is not available* or that is being reserved for an ongoing activity judged more important. This analysis is not meant as an explanation for neglecting someone who is clearly in desperate need but rather suggests that many situations that may, under less demanding conditions, elicit token aid are ignored under conditions of attentional overload. Thus, a husband recognizes that his wife is distressed but finds it more important to use his available effort to go over the accounts. Likewise, even though it is clear that the man lying on the sidewalk has fainted, the bystander decides to use his remaining efforts to complete his work at the office.

An attentional interpretation of decreases in sensitivity to others under overload assumes that social cues are ignored in the same way as nonsocial cues. There is, however, at least one fundamental difference between social and nonsocial cues that suggests that they may be processed differently. It is likely that people are more interesting and/or more response-demanding than nonsocial objects. For example, social situations may induce sympathy, empathy, or pity — responses unlikely to be elicited by nonsocial stimuli.

In order to determine the effects of environmental stress on sensitivity to task-irrelevant (peripheral) social cues, we (Cohen & Lezak, 1977) have recently conducted a study of memory for incidental social cues presented under noise. Subjects were presented with six stimuli, each consisting of two slides presented side by side. One of the slides contained a nonsense syllable, and the other (the social cue slide) pictured a person or persons engaged in an interaction or task. Subjects were told that their task was to remember the nonsense syllables in the

⁵This "focusing-of-attention" effect is often attributed to fluctuations in arousal. Thus Easterbrook (1959) suggests that increases in arousal are associated with increased neglect of environmental cues. At first, irrelevant cues are dropped out, and as arousal increases, task-relevant cues are neglected. Hockey (1970a) suggests a similar analysis viewing the effect of arousal as a change in the information-selection strategy of the organism. Although the evidence seems to bear out that a focusing of attention does occur under conditions that are expected to cause arousal, autonomic indices often find no perceptible physiological changes (e.g., Houston, 1969). It is also possible to interpret conditions that are usually associated with arousal as increasing attentional load. Moreover, many situations that are not expected to induce physiological arousal but are designed to overload attentional capacity (e.g., Kanarick & Petersen, 1969) also result in attentional focusing.

order that they were presented and that any other visual or auditory stimulation occurring during the experiment was part of our effort to determine the effects of distraction on memory. After stimulus presentation, half of the subjects were given the expected recall test for nonsense syllables. The remaining subjects were told that although we and asked them to learn the nonsense syllables, we would like them to try and remember everything they could about the "distraction" pictures. They were then administered a memory recognition questionnaire that required them to choose out of several choices the "correct" descriptions of the social slides. Individual subjects viewed the stimuli either under 95-decibel random intermittent noise or in quiet. For all subjects, half of the social cue slides portrayed a person(s) in *distress*, and the other half pictured a *calm* person(s). Results indicated that although noise did not affect memory for the nonsense syllables — task-relevant cues, social cue slides — task-irrelevant cues, regardless of whether they depicted calm or distressed persons, were remembered less well under noise than under quiet. Thus, it appears that peripheral cues that are social in nature are ignored (or not deeply processed) under conditions of environmental stress and that the probability of these peripheral cues being processed is not affected by their meaning (distress/calm).

Does this apparent attenuation of peripheral social cues translate into decreased helping? Much of the research on the influence of information overloads on helping behavior is inferential, comparing behavior in urban settings, where many other factors besides information overload are acting, to behavior in less urban settings (cf. Milgram, 1970). However, direct evidence for decreased helping under conditions of attentional overload is provided by several recent experimental studies.

In a study conducted in Holland, Korte, Ypma, & Toppen (1975) used sound level, traffic count, pedestrian count, and a number of visible "public" buildings to specify areas that they characterize as either high or low on environmental inputs. They report that regardless of whether the area is in a city or town, people in low-input areas are more likely to assist a lost person and to grant a street interview than people in high-input areas. A similar lack of helping subjects in high-load environments is reported by Krupat and Epstein (1975) in a laboratory setting. They find that subjects assigned to very heavy work loads are less likely to grant a favor that required interruption on their assigned tasks (subject was to provide some information by writing a letter) than those assigned to light work loads.

Evidence that acoustic noise causes decreases in helping is reported by Matthews and Canon (1975). Subjects were less likely to aid a person who had dropped a pile of books when a loud lawnmower was running than when it was quiet. Moreover, a subtle cue suggesting the legitimacy and degree of need for assistance — a cast on the victim's arm — increased helping under ambient conditions but did not affect the level of helping under noise. This result can be interpreted as supporting an attentional focusing hypothesis. Under noise, subjects

did not act on a subtle cue (the arm cast), whereas under quiet, that cue was perceived, evaluated, and acted on.

Two field studies on the effect of density on helping report a similar lack of sensitivity to the needs of others (both studies are reported in Bickman, Teger, Gabriele, McLaughlin, Berger, & Sunaday, 1973). In the first study, students living in low-, medium-, and high-density dormitories were confronted with "lost" letters, apparently dropped by their senders and needing mailing. Results indicated that the greatest percentage of letters were returned by those living in low-density dorms, followed by medium-density dorms, with the least helping occurring in high-density dormitories. In the second study, the lost-letter finding was replicated, and an additional helping measure, whether dorm residents would save milk cartons for an art project that other students were conducting, similarly indicated that the least helping occurred in high-density housing and that medium- and low-density dorms (although not significantly different from each other) helped more. Both studies suggest that those living in high-density — high-load — environments are less responsive to others' needs than those living in lower density — lower load — environments.

An experiment by Sherrod and Downs (1974) investigated the social after-effects of overload. Subjects were required to proofread a prose passage, underline the errors as they read, and at the same time monitor an audio taped series of random numbers. In the nonoverload conditions, the random numbers were superimposed over a recording of a soothing simulated seashore. In the stimulus-overload condition, the random numbers were superimposed over a recording of Dixieland jazz plus a second male voice reading nonrelevant prose. In a final condition, subjects experienced the same treatment as the stimulus overload condition but were told that they could terminate the distracting stimulation if they found it necessary (perceived control). After the completion of the 20-minute experiment, subjects left the laboratory and were confronted by a second experimenter who asked for voluntary help in pretesting some experimental materials. Subjects in the nonoverload condition were most helpful, followed by subjects in the overload condition with perceived control treatment, and finally by the overload condition. These results are consistent with two earlier suggestions: first, that the experience of overload without perceived control demands a greater allocation of effort than overload with control; and second, that the amount of capacity available following an ongoing activity is inversely proportional to the total demands of the ongoing activity. It follows that the experience of overload without control results in less available effort for perceiving, interpreting, and acting on a distress cue.

Similar results were found in a study of the aftereffects of density and task load that we have recently conducted in a large shopping center (Cohen & Spacapan, 1978). Subjects were required to perform high- or low-information rate

shopping tasks during periods in which the shopping center was crowded or uncrowded. After completing their task, subjects (on their way to meet the experimenter) entered a deserted corridor where they encountered a woman who feigned dropping a contact lens. Those subjects who performed high-load tasks and/or were crowded helped less often and for less time than their low-task-load, uncrowded counterparts. The least help (0%) was offered by those who performed high-load tasks under crowded conditions, and the most help (80%) was offered by those who performed low-load tasks under uncrowded conditions. These results are consistent with those of Sherrod and Downs and suggest that cognitive fatigue (and the consequent focusing of attention) can result in insensitivity to the needs of others.

The research reviewed up to now supports the argument that a person is less likely to offer simple assistance under environmental stress than under ambient conditions. It is important to note, however, that none of these studies definitively establishes that decreased sensitivity to the needs of others is due to an attentional deficit. One strong alternative, for example, would attribute these decreases in helping to a negative affective state induced by overload. That is, "I feel bad, therefore I will not help" (cf. Moore, Underwood, & Rosenhan, 1973). Further research is necessary in order to clarify the roles of attentional and affective mechanisms in response to overload.

Another possible (not as yet researched) effect of attentional focusing is to oversimplify and distort perceptions of complex social relationships. Thus, it involves less effort to view the relationship between two groups as either clearly positive or clearly negative than it does to view the more subtle similarities and differences between groups. A similar distortion of information can likewise occur in the perception of individuals. Gross cues like group membership are likely to be overemphasized, because effort is not available to process and interpret a wider range of information. Evidence of stress-induced distortion in the perception of individuals is provided in a recent paper by Siegel and Steele (1976). In judging individuals on the basis of profiles, subjects making their judgments in noise were more likely to generalize from inadequate information and were more sure of their judgments than those working in a quiet environment.

A similar analysis can be applied to communication under conditions of overload. The focusing of attention on the major theme and consequent neglect of the more subtle nuances can result in a gross distortion of a communication, especially when it is complex or includes qualifications. Although the distortion of communications under overload poses a major problem in formal communications networks, interesting social implications include the effect of overload on the transmission of rumors and other informal intra- and intergroup messages.

It is clear from the foregoing analyses that the focusing of attention under conditions of overload has a wide variety of implications for both social and non-social behavior. It should be emphasized that the aforementioned effects are

likely to occur as aftereffects of stress (or of any high demand conditions) as well as during periods of attentional demand and that the source of inputs demanding attention include stress and nonstress conditions alike.

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