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Human Adaptation to Levels of Environmental Stimulation

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This paper examines the environment as a source of dimensions of stimulation that are directly related to the individual's affective response to his environment, and his behavioral adaptation to it. The concept of an optimal level of stimulation is introduced, along with a view of environmental stress as resulting from conditions of excessive deviation from such optimal levels, with particular reference to variations in intensity, diversity, and patterning of the stimulus input. This analysis provides the framework for a consideration of behavioral adaptation to the environment by reference to the concept of adaptation level. Levels of adaptation to particular environmental dimensions, established as a function of past exposure, are shown to act as potent determiners of the individual's evaluation of his environment, as well as representing a plausible basis for the optimal level of stimulation principle itself. The presentation proceeds to an examination of the process of adaptation to the environment as a multilayered process, and to a discussion of the concept of the cost of adaptation as it applies in the behavioral realm. Finally, adaptation is contrasted with an alternative mechanism, adjustment, involving active alteration of the environment by the individual, and the relative place to be accorded to these two processes in the individual's relation to the environment is considered.

INTRODUCTION

Ecologists are inclined to describe environments in terms of particular sites, locales, or regions, or qualitatively defined attributes. An alternative approach, grounded in the experimental study of perception and motivation, is to

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analyze environments into component dimensions of stimulation of different kinds, permitting one to specify particular environments in terms of characteristic *levels* of various stimulus dimensions. In particular, a consideration of effects of quantitatively defined levels of stimulation on the individual is of relevance to an understanding of certain aspects of the adaptation of behavior to its environment. Before exploring such adaptation, however, let us consider this stimulus-dimensional view of the environment in a more general sense.

LEVELS OF STIMULATION AND STRESS

Let us start with the assumption that the individual functions optimally within a certain range of environmental conditions and, more particularly, of values of stimulation contained within the environment. We are referring here not only to properties of the environment, such as temperature, air pressure, and acidity, which exert a direct effect on physiological processes, but also to dimensions of the stimulus environment to which the individual responds primarily through the excitation of sensory receptor mechanisms, transmitting information to the higher neural centers. For the moment, let us dwell on two important consequences of the assumption just enunciated.

The first is that it is possible to view environmental stressors at the behavioral level as acting in a manner similar to physiological stressors, i.e., as exceeding the limits of tolerance for that individual. Second, just as physiological equilibria may be disturbed by deviations in either direction (e.g., extreme hot or extreme cold), so psychological stressors may likewise involve departures from some mode in the direction of either over- or understimulation. This is an important point, since in the past psychologists have been prone to view the role of stimulation in the development and maintenance of behavior primarily from a "the-more-the-merrier" perspective. Both the animal research and the voluminous human literature on the effects of sensory deprivation have given dramatic evidence of the deleterious effects on behavior of marked reduction in the amount of stimulation present in an individual's environment. Very little attention, however, has been given to the effects of hyperstimulating conditions on behavior, and the possibility that such conditions may likewise exert adverse effects on behavior has not been seriously examined, except for certain intensive variables of stimulation such as noise level or shock.[2]

[2] This is puzzling, since behavior theorists (e.g., Fiske and Maedl, 1961) have increasingly invoked the concept of an *optimal level of stimulation* as essential to the maintenance of arousal, and thus to maximally effective performance or to maximization of positive affect. Yet the limited evidence we have in support of such an optimization notion is based entirely on research on preference responses, ratings of liking, and similar measures; extensions to possible impairment of performance or to deleterious effects on mental health have occasionally been suggested, but rarely if ever put to an empirical test. The proposi-

Main Varieties of Hypo- and Hyperstimulation

We may usefully distinguish three kinds of hypostimulation: deprivation of sensory stimulation, of social interaction, and of movement.

Deprivation of Sensory Stimulation

Deprivation of sensory stimulation is the condition on which most of the experimental research has concentrated, inspired in large measure by the emphasis which Hebb (1949) has placed on a constant influx of stimulation as essential to the maintenance of behavior and the dramatic effects of sensory deprivation which the pioneering work originating in the McGill laboratories under Hebb's auspices demonstrated (*cf.* Vernon, 1963). It typically involves the elimination of all potential sources of stimulus input, across some or all sensory modalities.

It is obviously impossible to review here the voluminous evidence on the behavioral effects of sensory deprivation (*cf.* Zubek, 1969), nor is it essential to do so for the particular purposes of this paper. Suffice it to note the relevance of the sensory deprivation work to an understanding of a person's responses to such environmental circumstances as those faced by individuals during extended stays in the Antarctic (e.g., Gunderson, 1968; Nelson, 1965) or by astronauts on prolonged space flights.

Isolation (Deprivation of Social Interaction)

The stimulation provided by interaction and communication with other human beings is clearly of a special sort, and deserves to be treated as separate from sensory deprivation. Most probably, the distinctive feature of social stimuli is the fact that they provide feedback to the individual's responses and, perhaps as a consequence, arouse affect of a sort which the world of inanimate stimuli would be incapable of providing. (The world of animals is presumably intermediate between these two categories.)

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tion that stress can result from either hyper- or hypostimulating conditions is consonant with the *sensoristasis* concept advanced by Schultz (1965). In explicating this concept, Schultz draws an analogy to Canon's homeostasis concept and explicitly considers increases of stimulation beyond the optimal level as disturbing the internal balance and disrupting behavior. Further, he cites Lindsley's (1961) analysis of the role of the reticular formation, postulating similar effects of sensory restriction and sensory overload. While the reference to Lindsley's model reinforces the plausibility of a comparable conception of hyper- and hypostimulation effects, it does not preclude the possibility—indeed, the strong likelihood—that the overt behavioral manifestations may be quite different in the two cases, just as bodily reactions to extreme heat and extreme cold take very different forms. It will therefore be essential to maintain the distinction between hyper- and hypostimulation, while searching for possible similarities in the individual's general mode of response and adaptation to them.

Social isolation may, of course, be found in combination with sensory deprivation, as in the case of the prison inmate in solitary confinement. But it is possible to differentiate its effects from those of sensory deprivation in the laboratory, and research devoted to this question is indeed available (see Haythorn, 1973, for a recent review). On the other hand, its role in a relatively pure state is brought out in accounts of adventurers and explorers and scientists who have had occasion to spend extended periods away from their fellow men (e.g., Van Lawick-Goodall, 1967).

Confinement (Deprivation or Restriction of Movement)

Confinement represents still a different form of hypostimulation; most likely, it owes its distinctiveness to the role of stimulation from the proprioceptors in maintaining posture and arousal. It, too, is typically found in conjunction with either sensory or social deprivation—or both, as in the case of the prison inmate in solitary confinement. Indeed, some of the experimental literature on the effects on behavioral development of impoverishment of stimulation during early experience is open to criticism on this ground: it is difficult to raise an organism under conditions of severe deprivation of sensory stimulation (e.g., by raising it in the dark) without at the same time substantially reducing the amount of movement the animal is likely to engage in. At the same time, it is not difficult to give at least one by no means rare example of a condition involving confinement to the point of immobilization, without either social isolation or sensory deprivation: the situation confronting a patient confined for an extended period to a hospital bed.

Sensory Overload

Turning now to the opposite end of the scale, that of hyperstimulation, we again find it useful to distinguish between an excess of stimulation and an excess of social interaction or contact. For reasons to be explained, there is no clear counterpart at this pole of the confinement condition cited above; that is, we are not dealing here with a bipolar dimension.

In sharp contrast to the topic of sensory deprivation, the effects of a hyperstimulating environment, that is, of very high levels of stimulation on the individual, have received virtually no attention on the part of psychologists, except within the very restricted realm of the effects of noise, which can hardly be considered to represent the counterpart at the hyperstimulation pole of the sensory deprivation condition. Precisely what "overstimulation" may mean will be more fully discussed below; we should recognize, in the meantime, that the use of the prefixes "hyper-" and "over-" may be begging the question if any-

thing more than a condition characterized by relatively large amounts of stimulus input is intended. Whether extreme amounts of stimulation will necessarily produce negative effects on behavior remains to be determined, of course. But the relevance of the problem for an understanding of the conditions of human existence in some of our urban environments, for instance, should be apparent.[3]

Crowding

Effects of crowding have, most recently, become the subject of active research, at both the animal and the human levels. Such research is extending our grasp of this problem considerably beyond that reflected in the pioneering work of Calhoun (1962) and calls into question some of the generalizations to the human condition which that work had inspired (e.g., Zlutnick and Altman, 1972). Yet it is undeniable that crowding is a commonly encountered aspect of urban existence and a potential source of psychological stress. The stress, however, may derive less from the stimulation generated by people *en masse* than from the likelihood that crowding results in goal blocking, and thus in a state of frustration for the individual.[4]

MAJOR DIMENSIONS OF SENSORY DEPRIVATION AND OVERSTIMULATION

While it is easy to define sensory deprivation in absolute terms, attempts to investigate its effects confront one with the problem of identifying the rele-

[3] One particular aspect of this question must be noted here, since it relates to an important semantic distinction, that between *sensory* and *information* overload. This distinction concerns the question of whether the stimuli impinging on the individual do so merely in the sense of passive exposure, or whether they contain information requiring him to respond in a certain way. Obviously, this distinction does not have a counterpart at the deprivation end, which is devoid of information by definition; yet there is reason to believe, as we shall point out, that sheer exposure to stimulation has much less marked effects on behavior, or at the very least rather different effects, than information overload. Therefore, it seems advisable to designate the upper end as "sensory overstimulation," given that the prefix "over-" is intended as merely descriptive, and to reserve the term "over*load*" to situations where the individual must process information carried by the stimuli impinging on him.

[4] It is possible to add a further category, namely, "hyperdynamic" conditions. If restriction of movement did have an opposite pole, it would have to be a condition marked by an inordinate amount of physical movement. While there are assuredly specific situations (e.g., in sports) that may be characterized by high levels of activity, and possibly of movement *per se,* it is difficult to envisage an environment which would enforce such high levels of movement. Conceivably, it might be rigged experimentally, as through the use of a treadmill, though that would elicit a very restricted form of movement. More to the point, environmental circumstances corresponding to this condition are not readily thought of.

vant components of the condition. For instance, does it mean an absolute zero of stimulation (complete darkness, a soundproof room) or simply an unvarying, homogeneous background of stimulation (e.g., diffuse, unpatterned light or, in the auditory domain, a background of white noise)?

The problem becomes even more acute at the overstimulation end: we may take it for granted that it is impossible to incorporate every type and mode of stimulation that might be invented for this purpose into our experiment. But just what dimensions of stimulation shall we include in creating such a condition? There appear to be at least three major aspects worth differentiating: intensity, diversity, and patterning. In order to appreciate their respective roles, let us refer briefly to the way in which they have been operationalized in the context of sensory deprivation research and proceed to examine their possible significance at the opposite end of the spectrum, i.e., that of overstimulation.

Intensity

The role of intensity of stimulation is clearly illustrated by the case of noise, or more precisely loudness, and other similar dimensions. Here the "optimal level" principle referred to above reveals itself in the aversive character of environments characterized by high levels of noise, i.e., around airports or along busy highways, though, as any frequenter of rock concerts knows, this matter is subject to considerable individual as well as situational variation. At the hypostimulation end, the effects are obviously different: silence is not painful in the biological sense in which high-intensity noise can be, nor does it interfere with ongoing activity or conversation; yet, at the level of psychological comfort or well-being, a certain level of background auditory stimulation is apt to be preferred over complete stillness as a condition for most normal activities.

Here then we have a case of a partially symmetrical, and, in other ways, functionally asymmetrical, continuum. An instance of a dimension of stimulation that is more clearly symmetrical in character in its effects, both physiologically and behaviorally, is that of temperature, but perhaps this should be considered as a qualitative rather than an intensive variable, much as sound *frequency*—i.e., pitch—as opposed to amplitude.

Diversity

The role of *variation* in stimulation, in both a simultaneous and a successive sense, in eliciting and maintaining behavioral arousal and interest has been receiving increasing emphasis in recent experimental psychological literature. It is reflected in studies of effects of stimulus complexity such as Berlyne's (e.g.,

1965), in which heterogeneity of the elements of a stimulus represents one among several ways in which complexity is operationalized. More fundamentally, it enters into the conceptualization of the role of stimulation in the arousal and maintenance of behavior; thus Fiske and Maddl (1961), among others, postulate a need for stimulus variation as a basic property of living organisms and invoke the concept of "variation seeking" in explaining particular forms of exploratory activity found to be a function of diversity of stimulation. The emphasis has, however, been almost exclusively on the role of diversity, complexity, or variation in *raising* affect, arousal, or exploratory behavior. Yet our physical environment may at times produce stress, or mental fatigue, through a surfeit of diversity, akin perhaps to the tedium produced by the lack of it—as witness the phenomenon of "visual pollution," i.e., the wearisome hodgepodge of highly diverse sights, represented by the succession of gaudy signs, gas stations, and hamburger stands greeting the motorist at the entrance of so many American cities.

There is, in any event, considerable evidence to indicate that diversity conforms to the optimization principle, i.e., that the perceived attractiveness of a stimulus configuration is maximal for intermediate values of this variable. Thus laboratory research on the relationship between stimulus variation and preference has quite consistently shown that stimuli falling somewhere between the two extremes of this continuum are most strongly preferred. This is true whether diversity is operationalized simply in terms of number of elements of random nonsense shapes (Day, 1967; Vitz, 1965), of amount of variation contained in random sequences of tones (Vitz, 1966), of number of *different* items (e.g., postage stamps) present in a constant-size matrix of such items (Wohlwill, 1971), or of pictures of the physical environment or of nonrepresentational modern art scaled in terms of amount of variation which they contain along certain specified stimulus dimensions (Wohlwill, 1968, 1971).

Patterning

Research in the area of sensory deprivation has shown conclusively that elimination of patterned visual information (achieved by exposing the subject's retinas to homogeneous fields of diffuse light) results in effects at least equally as potent as those obtained by keeping the subject in darkness. Yet, at the other extreme, a diversified stimulus field completely devoid of structure would seem to represent a condition of overstimulation, i.e., one potentially overtaxing the individual's capacity to encode and transmit information. Here we have, then, a dimension with a virtually built-in optimization feature: some modal combination of structure and uncertainty is probably maximally conducive to the main-

tenance of attention and interest—a principle, incidentally, recognized in the field of aesthetics (*cf.* Meyer, 1956).[5]

In the "real world," the problem becomes more complex, and *a priori* definitions of objective complexity based on informational content cease to be applicable. A particular problem relates to the necessity to specify the *units of perceptual analysis* into which the perceiver analyzes a complex stimulus field. One example may suffice: the view of an urban scene from the air may change from one of visual order and pattern to one approaching chaos as the plane descends from cruising altitude to a landing. Thus perceived complexity may differ from the potential complexity contained in a stimulus field in terms of the structuring of its objective elements—a point recognized by Heckhausen (1964) in his stress on *phenomenal* complexity, as well as by Rapoport and Hawkes (1970) in their emphasis on *usable* information in the environment.

This point is of more than academic interest, since it may well be that one possible source of stress in our environment results from the difficulty which an individual experiences in trying to impose a structure or pattern on the seemingly chaotic or random constellation of stimuli or events confronting him. Thus, as Lynch (1960) has argued on the basis of his work on urban imagery, where the urban environment contains clearly defined elements, landmarks, boundaries, etc., that aid the individual in structuring it, the satisfaction he is apt to derive from it is enhanced.

THE CONCEPT OF BEHAVIORAL ADAPTATION AND ITS APPLICATION TO ENVIRONMENTAL ASSESSMENT

Since the concept of adaptation has been used in many different ways, both across different disciplines (anthropology, biology, psychology) and within psychology proper, it is important to define it in fairly rigorous terms for the purposes of this paper. In this initial discussion of adaptation, at least, we will restrict ourselves to phenomena having direct reference to dimensions, qualities, or attributes of the stimulus environment, and we will define adaptation as a quantitative shift in the distribution of judgmental or affective responses along a stimulus continuum, as a function of continued exposure to a stimulus.

The definition is presented with specific reference to Helson's (1964) adaptation-level theory, not only because this theory represents the most systematic and comprehensive attempt to encompass adaptation phenomena over a wide range of behavior within a consistent framework but also because it appears

[5] There is indeed some evidence on this point available from laboratory research in which degree of patterning in a stimulus configuration has been subjected to systematic variation (e.g., Vitz, 1965, 1966). Of particular interest is a recent study by Schwarz and Werbik (1971).

useful in conceptualizing the effects on behavior of prolonged exposure to a given stimulus environment. Two points in particular warrant comment in regard to this definition.

First, by defining adaptation as a shift in the distribution of responses, it may seem that we are leaving out of account adaptation phenomena involving a simple neutralization process, i.e., a reduction of the power of a given stimulus to evoke a response—as in the case of adaptation to smell or noise. Yet in most, if not all, such cases it is generally possible to reformulate the phenomenon in terms of shifts in distribution, by considering variations in response as a function of *intensity* of stimulation. Thus one way of formulating the phenomenon of adaptation in the case of smell, for instance, is in terms of a change in the intensity of the stimulus required for it to be detected or affectively reacted to—a view which is close to that implied in such aspects of biological adaptation as immunization (*cf.* the change in the response of an animal to differential dosages of a toxic substance such as an insecticide).

The second point relating to our definition is that, by the criterion adopted, adaptation must be differentiated from *adjustment,* which, following Sonnenfeld (1966), may be viewed as a change in behavior which has the effect of modifying the stimulus or stimulus conditions to which the individual is exposed. The distinction is nicely illustrated with respect to temperature: the American on a visit to Great Britain in the winter is apt to feel uncomfortably cold at the prevailing indoor temperatures, and so may put on an extra sweater or leave on his overcoat. This would represent an adjustive response. After a prolonged stay in England, however, he may no longer experience a 65°F temperature as uncomfortable: he has become adapted to it or, more precisely, his level of adaptation has shifted downward.

This distinction, as Sonnenfeld has shown, is an important one in evaluating long-range behavioral effects of environmental conditions on the individual; we will return to it below. Meanwhile, let us illustrate the concept of adaptation level by reference to an investigation that demonstrates convincingly the relevance and applicability of this theoretical framework to the individual's assessment of particular features of his environment (Wohlwill and Kohn, 1973).

In a pilot study, two groups of migrants—one from metropolitan areas, the other from small-town or rural areas—were compared with respect to their assessment of various aspects of the community to which they had moved: Harrisburg, Pennsylvania, an urban environment of intermediate size. Roughly half of the sample were adults, the other half high-school age adolescents. A set of rating scales was employed to obtain evaluations of the environment with respect to such conditions as pollution, noise and crowding, recreational opportunities, shopping facilities, and social conditions. On several of these dimensions, significant differences were obtained in a direction conforming to that predicted by adaptation-level theory—e.g., rural migrants perceived noise and pollution

levels as higher than migrants did. The study is subject to several severe limitations: the samples were very small and made up disproportionately of blacks and, in the case of the adults, of females; further, it was not possible to equate the two groups on several characteristics, notably that of age, though the results obtained are not readily attributable to that variable. It is also noteworthy that in most cases where significant differences were obtained, they were accounted for in large part by the adults in the sample rather than the adolescents. This result might be interpreted either as due to more firmly established adaptation levels in the older respondents or as due to an actual difference in the *effective* stimulus environments to which the rural adults and the adolescents had become adapted (e.g., high-school children's adaptation to noise might be relatively high, even in rural areas, through exposure to rock music, etc.).

In a recently completed doctoral dissertation, preliminary results from which are reported in the paper cited above (Wohlwill and Kohn, 1973), Kohn has extended the adaptation-level framework in two directions. First, he has obtained ratings along several of the environmental dimensions used in the Harrisburg study for sets of communities varying in size (from small villages to a metropolis), these being presented in the form of sets of nine photographs presenting a cross-section of views taken in each location. Functions relating these ratings to community size were then plotted separately for each of three groups of respondents, originating respectively in small-town, medium-sized urban, and metropolitan environments. Most of the ratings (notably perceived pace of life, noisiness, crowding, and frequency of crime) were related positively and consistently to the size of the communities portrayed (though the size dimension was never made explicit for the respondents); at the same time, the three families of curves differentiating the three groups of respondents differed generally in close accord with adaptation-level principles—e.g., subjects from small town perceived a community of any given size as noisier than did those from metropolitan areas. Also, adaptation-level principles ceased to apply when ratings of the New York City environment itself were obtained: for a large number of environmental attributes, New York City was rated very similarly on the part of migrants who had come from small towns, medium-sized cities, or metropolitan areas—presumably owing to the extreme position of the stimulus being judged.

ADAPTATION LEVEL AND OPTIMAL LEVELS OF STIMULATION

These results basically serve only to provide concrete evidence on the importance of frames of reference established through the individual's experience in determining judgments of environmental variables. What is the significance of such adaptation-level processes for the optimal level of stimulation hypothesis and, more generally, for the manner in which the individual responds

to particular levels of environmental stimulation? Their relevance resides in the strong possibility that such optimal levels, rather than representing an intrinsically determined characteristic of the effects of stimulus dimensions on the individual, are a function of his history of experience with such dimensions, resulting in the establishment of relatively stable adaptation levels to which expressions of preference or other affective responses become related.

The evidence on this point derives mainly from the results of short-term laboratory experiments in which a relatively brief exposure session is utilized to create an adaptation level, and subsequent tests are carried out to determine the point or level on the stimulus dimension corresponding to maximal preference or liking. Since adaptation level represents, by definition, a neutral zone with respect to the evaluation of the stimulus dimension, it might be supposed that maximal preference would be shifted in a direction away from that level; indeed, this is the prediction that one would make on the basis of adaptation-level theory.[6] A certain amount of support exists for this proposition, based on research with dimensions as diverse as temperature (Haber, 1958) and stimulus complexity (Unikel, 1971), but this work suffers from extended exposure to a single stimulus, used to establish the AL (adaptation level). Furthermore, in a recent study on the dimension of auditory frequency (Schoenpflug, 1971), systematic shifts away from the AL zone were not found; rather, affective responses were most positive in the region surrounding the AL that was experimentally induced, varying in curvilinear (i.e., inverted-U shaped) fashion to either side of that region.

More interesting for our purposes would be evidence on the role of long-term exposure to stimulus levels or conditions on preference or liking, but systematic data on this point are difficult to come by. A study by Sonnenfeld (1967) is of interest, since it deals with preferences for such general aspects of the topography of our environment as mountainous *vs.* plain terrain, degree of vegatation, presence or absence of water, and the like, and relates these preferences to the environments in which the subjects were living at present and to those to which they were native. For several of these dimensions, certain of the comparisons between groups (e.g., between Native Eskimos and Americans who had moved temporarily to the Arctic) were significant, preferences being in accordance with the type of stimulus environment to which the individual had become adapted. Yet the data were far from internally consistent in this respect. Of relevance in the same connection is the survey undertaken by Robbins (1966)

[6] In Helson's version, adaptation-level theory does not deal explicitly with the relationship between adaptation level and affect or preference. This extension of the theory has, however, been made by McClelland *et al.* (1953), who postulate a bimodal, "butterfly"-shaped function, according to which small discrepancies of a stimulus in either direction from the adaptation level are maximally preferred, with larger deviations being responded to progressively less positively and eventually negatively (*cf.* Haber, 1958).

of the relative dominance of rectilinear as opposed to curvilinear elements in the art of different cultures, which he related to the dominance of these two kinds of elements in the actual physical environment of these cultures: Robbins found that the relationship was an inverse one; i.e., those cultures in a predominantly rectilinear environment emphasized circles and other curvilinear forms in their art.

The preceding discussion leads to an important corollary, namely, that the levels or zones of stimulation along particular dimensions that are maximally preferred, or otherwise optimal, should vary considerably from one individual to another, depending on the AL that has been established with respect to that dimension. While there is no direct evidence available on this point, it is significant that, for the dimension of stimulus complexity, Vitz (1965) and Dorfman and McKenna (1966) have independently demonstrated that the inverted-U shaped preference function (peaking at an intermediate level of complexity) that was derived from the optimal-level hypothesis is in fact an artifact of the summation of a diversity of individual functions. Thus when the preference functions for subjects are grouped on the basis of the subjects' most preferred stimulus, a family of curves results that varies all the way from functions peaking at the high end of the complexity scale to those peaking at the opposite end, though, not unexpectedly, those peaking in the middle are the most common. It would seem plausible to attribute such individual differences to differences in experience or adaptation level. A subsequent finding by Vitz (1972) points in the same direction: for a set of auditory stimuli varying in amplitude, an overall inverted-U shaped preference function was shown to be a composite of individual functions with maxima distributed over most of the scale; in contrast, data for ratings of liking of tones varying in *frequency* showed a virtually uniform peak in the center of the scale for all subjects. This is just as one would predict from the operation of individual adaptation levels, which would vary substantially from one individual to another in regard to the loudness of tones, since this attribute is subject to individual self-selection and control, whereas one would expect little variation across individuals in the spectrum of tone frequencies to which they have been exposed in the past.

Finally, we may cite two studies of sensory deprivation that provide somewhat more direct evidence on the operation of adaptation levels established through prior experience; they indicate, furthermore, that such adaptation levels are of relevance not only to an individual's response to specific aspects of his stimulus environment such as loudness, complexity, or the like but also to the overall level of stimulation that it contains. The first of these studies, by Gendreau *et al.* (1968), was carried out with prison inmates as subjects. Not only did these individuals appear to be able to tolerate a 7-day period of solitary confinement, under conditions of sharply reduced background illumination and auditory stimulation, without difficulty (i.e., without the typical incidence of sub-

jects in this type of experiment who demand early release), but also the experience served to reduce still further their adaptation level with respect to brightness stimulation as shown in the marked drop in their preferred level of background illumination from a base-level measure to one taken upon termination of the exposure period.

The second study, by Haggard *et al.* (1970), demonstrated more directly the influence of previously established adaptation levels on the individual's response to conditions of sensory deprivation. These investigators brought a group of young men from the northern regions of Norway, who had been living in virtual isolation as hermits, to their laboratory in Oslo to be subjects in a standard sensory deprivation experiment and compared their responses to those of a group of control subjects from Oslo. On a variety of responses, mostly measures of personality, the hermit group showed significantly less severe reactions than the control group.

We should not of course assume that adaptation to such (to us) extreme stimulus conditions is ever complete and uninfluenced by absolute levels. It is unlikely that temperatures of -40°F are experienced as pleasurable even to the Native Alaskan, or that the commuter comes to relish the conditions of congestion, of crawling traffic, etc., in the city at rush hour. The evidence and the postulates derived from adaptation-level theory do indicate, however, that there is at least a neutralization of the negative affect that is evoked by these conditions in those who have been exposed to them, as well as a shift in the preference function, such that the optimal preferred level of stimulation remains displaced away from the norm and toward the extreme represented in the exposure conditions.

THE PROCESS OF ADAPTATION

So far, we have treated behavioral adaptation to the environment as an essentially passive process, consequent on mere exposure to a given stimulus condition. But this is undoubtedly an oversimplified view of the matter, even with respect to variables of physical stimulation (as opposed to interpersonal or social conditions), and even for adaptation proper, as opposed to responses of adjustment, i.e., behaviors available to the individual which effect an actual change in the stimulus conditions impinging on him. What, then, are some of the mechanisms which the person has at his disposal to facilitate his adaptation to a potentially unpleasant or noxious stimulus environment?

We have little direct evidence on this question, but Miller (1960) has suggested a number of such possible mechanisms in his systems-theoretical treatment of the problem of *information* overload, i.e., of the overtaxing of a system's power to process information required for a particular purpose. One of

Miller's mechanisms, that of *filltering*, is of obvious relevance to the individual's adaptation to environmental stimulus conditions. This term refers to the person's refers to the person's tendency to process only a portion of the stimulus input impinging on him and to reject, i.e., shut out from awareness, the remainder. This mechanism cannot readily be applied to such primary stimulus dimensions as temperature, loudness, and the like, but it does apply to higher-order variables of stimulation such as complexity (e.g., in the sense of diversity), density of people, or any other aspect of the stimulus environment that can be described in terms of quantities of discrete elements, creating an opportunity for selection or tuning out to occur.

This mechanism of filtering is undoubtedly of great importance in adaptation to conditions of sensory overload, such as may be presumed to exist in our major urban centers. It demands a definite price, however, since it impairs the individual's ability to respond to information that may in fact be of relevance for him. Thus it has been suggested that a possible contributing factor to the retardation in language development commonly found among "culturally deprived" children may be attributable to the overdose of visual and auditory stimuli, both verbal and nonverbal, with which they are bombarded at all hours of the day—from the TV screen, the ever-present horde of brothers and sisters, the neighbors brawling at close range, the human and vehicular traffic on the street below.

Milgram (1970) has presented a persuasive analysis of a particular aspect of this problem, i.e., of adaptation to overload in our urban environment which results from the concentration of people. He cites a variety of mechanisms which individuals may resort to in adapting to this condition, all of which have the effect of warding off some of the information originating in social stimuli or reducing their impact on the individual. These mechanisms take such forms as a deliberate tuning out of signals emanating from certain classes of people perceived as "strangers," of restricting communication with those known to the individual (e.g., by using an unlisted telephone number), and of reducing contacts with other individuals to a minimum level of personal involvement. This analysis is applied to such phenomena of urban life, confirmed by empirical data, as the reluctance to give assistance or information to strangers and similar manifestations of a weakened sense of social responsibility (e.g., the value placed on anonymity). In this case, it is apparent that this form of adaptation is in part at the expense of those with whom the individual comes into contact and, in a larger sense, of his society. Yet there is also a price to the individual himself, in the form not only of a restricted range of social experience but also of behavioral consequences such as the residue of tension or irritability that frequently appears to accompany avoidance responses to other persons.

It should be noted that sheer numbers of people is not the only determining factor in this type of adaptation syndrome; the perception of the possi-

bility of danger or harm to the person undoubtedly contributes to the suspicion and distrust toward strangers, and there are other related cultural factors involved as well.[7] Milgram has recognized this point in the comparisons he makes between diverse American and European cities, utilizing both impressionistic evidence and data from empirical studies. Nevertheless, the suggestion that overload in the form of an excess of social stimulation forces the individual to disregard, tune out, or avoid information from other persons, in order to keep from being overwhelmed by the concentrated dosages of it that he would otherwise be exposed to, does appear to be pertinent in considering the psychological stressors associated with urban life.

THE COST OF ADAPTATION

The concept of the *cost* to the individual of adapting to particular environmental circumstances has been stressed by biologists, notably René Dubos, as basic to the understanding of disease. It has received less systematic attention on the part of psychologists, except perhaps those involved in work on psychosomatic illness. There is at least one set of studies, however, which deserves to be cited on this point, since they not only provide convincing experimental evidence, under carefully controlled laboratory conditions, of the reality of adaptation to a noxious stimulus, but also raise in interesting fashion the question of the "psychic cost of adaptation"–an expression taken from the title of one report of this research. This is the work of Glass and his associates (Glass and Singer, 1972) of individual's adaptation to noise.

These investigators found evidence, at both the physiological and behavioral level, for adaptation to a situation in which subjects had to work at an arithmetic task while exposed to bursts of intermittent noise. Yet on two posttest measures of resistance to frustration, as well as on a proofreading task, there was clear evidence that for the group originally exposed to unpredictable noise this exposure had left a residual effect, manifested in lower task performance and reduced frustration tolerance. As Glass and Singer recognize, this evidence leaves in abeyance the question whether this residual effect does indeed represent the "price" of the adaptation that had occurred, i.e., whether it took place *because* of or *despite* the adaptation during the original exposure period. The authors cite subsequent evidence which appears to point rather to the latter alternative, but at this point the possibility of adaptation itself exacting a toll from the individual, as Dubos argues is the case in the realm of physiological processes, cannot be lightly dismissed, particularly for long-term adaptation.

[7] Evidence relevant to this point may be found in Milgram's own study, in the not too surprising finding that in both urban and small-town residences, people were much more ready to admit the female than male experimenters into their homes for the alleged purpose of using the telephone.

There is a closely related source of ambiguity in the research of Glass and Singer. We do not know to what extent either the GSR data or the postadaptation measures are to be attributed to the effort exerted by the subject to cope with the disruption by the noise of his performance on the arithmetic task, as opposed to the mere exposure to the aversive noise. In other words, if the subjects had had no task to perform, would they have adapted (i.e., at the physiological level) to the noise? And would there have been any residual effect?

This question is of some importance for looking at the effects of the physical environment, since it is quite conceivable that the effects, not only of aversive stimuli such as noise in our environment but also of overstimulation, may depend on the extent to which the stimulus conditions interfere with or disrupt some ongoing activity by the subject. Thus, a visitor to a busy factory, airport, or other environment replete with intense, diverse, and unpatterned stimulation may fail to respond aversively to it and may even find fascination in watching it, whereas the person who is performing a job demanding concentration under these conditions may experience a much greater degree of stress. This point may underlie the predominantly negative results which investigators such as Zuckerman *et al.* (1970) have found in investigating the effects of overstimulation. Thus, in the study being referred to, an 8-hr period of exposure to a remarkable conglomeration of visual and auditory stimulation of all kinds failed to exert any very marked effects on a variety of behavioral measures; indeed, the subjects rated their experience in predominantly favorable terms. A variety of physiological effects of exposure to overstimulation were, however, found; interestingly enough, these were in several instances comparable to those encountered as a result of sensory *deprivation* for an equivalent period of time. Perhaps we see here a manifestation of the aptness of the bipolar sensoristasis model (for looking at hyper- and hypostimulation) to which we referred at the beginning of this paper.

Conceivably, then, it is only where we are dealing with information rather than sensory overload—to revive the distinction offered in an earlier section, i.e., where the individual has to respond differentially to overlapping or competing channels of stimulation—that a major breakdown in performance will be registered. Miller's (1960) study of this phenomenon, referred to above in connection with the concept of filtering, is illustrative of the all too limited evidence we have on this point, and on the mechanisms utilized by the individual to cope with this kind of overload.

THE PLACE OF ADAPTATION, AND ALTERNATIVE MODES OF RESPONSE

To conclude this overview of behavioral adaptation to environmental stimulation, it is appropriate that we try to place the problem of adaptation in

somewhat broader perspective, by considering it from a functional point of view and relating it to alternative mechanisms available to the individual to cope with potential or actual environmental stressors. More specifically, we will address ourselves to two interrelated questions: First, how adaptive is adaptation? And second, what are the pros and cons of adaptation, compared to adjustment, as mechanisms for dealing with unpleasant or harmful environmental conditions?

As regards the first question, the adaptive value of adaptation to our stimulus environment, in the sense that we have discussed it, while far from being a matter of tautology still might hardly seem subject to doubt. The individual cannot afford to respond continually to stimuli or aspects of his milieu of stimulation that are a constant feature of his environment (or nearly so) with the intensity or magnitude of affective arousal he exhibits on his initial confrontation with that environment. It is essential, in other words, that neutralization of affect occur, at least with respect to negatively experienced aspects of the stimulus environment over which the individual cannot exert any control.

At the same time, it is apparent that such a neutralization or habituation process can be considered adaptive in a functional sense only as long as no undue price is exacted from the individual for resorting to it. We have already discussed the subject of the price of adaptation, but the problem in the functional sense is basically one of long-term effects of adaptation to environmental stressors confronting an individual over an extended period of time; on this point, our knowledge is very limited as yet, particularly at the behavioral level, though we do have more evidence on prolonged adaptation of bodily functions to extreme environmental conditions such as life at high altitudes (Baker, 1969), as well as to environmental insults of various sorts (e.g., Dubos, 1965).

From an evolutionary perspective, this problem is of relatively recent origin. We may take it for granted that until the advent of modern technology, with its pervasive and far-reaching alteration of the human environment, human beings, and human societies of the more recent historical past, were fairly well fitted to their habitats, and relatively few sources of chronic environmental stress existed that placed heavy demands on the individual's adaptation processes. Presumably, where extremes of temperature, altitude, etc., did impose an undue burden on the adaptive capacities of the individual, either human life would have eventually vanished from those areas or selection would have produced a type of individual better able to withstand those conditions.

Technology has brought about two kinds of changes which, curiously, operate in opposite directions. On the one hand, it has brought about a vast array of new types and sources of environmental stressors placing an increasingly heavy burden on the individual's capacity for psychological and biological adaptation—to conditions of noise, crowding, congestion, pollution, and other forms of environmental degradation and insult; to externally imposed alterations of the diurnal cycle; to life under highly artificial conditions and in such highly unusual

environments as those of Sealab and the space capsule. At the same time, technology has provided us with an alternative to adaptation which is being resorted to increasingly to reduce the frequency or severity of the individual's exposure to environmental stressors—through central heating, air conditioning, and soundproofing in our homes and places of work; through the private automobile, which has reduced our exposure to the elements while in transit; and through various other ways, some of which are being devised to deal specifically with some of the newly created noxious stimuli in our environment. Furthermore, technology, as well as affluence, has increased our ability to avoid or escape from such environmental conditions, as evidenced in the flight to the suburbs and the boom in the second-home business.

We are, in short, constantly confronted with the choice of adapting to environmental circumstances or resorting to a response of adjustment, whether by altering the environmental stimuli directly or by avoiding or escaping from them. We referred earlier, in introducing the topic of adaptation, to this distinction of Sonnenfeld's (1966) between adaptation and adjustment; this not only is of great conceptual and theoretical importance but also has far-reaching practical implications as well.

Sonnenfeld himself has argued provocatively that we have given insufficient recognition to adaptation as a mechanism for dealing with stimulation from the environment and that accordingly the need for changing the environment to eliminate such stimuli and to create an aesthetically more satisfying one may have been overstressed. In contrast, Dubos (1965), among others, while concerned less with meeting individual preferences in regard to environmental aesthetics and more with providing a satisfying milieu for all human beings, has argued just as forcefully that we may be relying unduly on our capacity to adapt:

> Millions upon millions of human beings are so well adjusted to the urban and industrial environment that they no longer mind the stench of automobile exhausts, or the ugliness generated by the urban sprawl; they regard it as normal to be trapped in automobile traffic, to spend much of a sunny afternoon on concrete highways among the dreariness of anonymous and amorphous streams of motor cars. Life in the modern city has become a symbol of the fact that man can become adapted to starless skies, treeless avenues, shapeless buildings, tasteless bread, joyless celebrations, spiritless pleasures—to a life without reverence for the past, love for the present, or hope for the future. (Dubos, 1968, p. 278ff)

It is impossible within the context of this paper to do justice to this intricate problem, however great its importance and interest and however deserving of searching examination on the part of all who are concerned over the human condition. It is not only an issue of extreme complexity, from a cost-benefit point of view, but ultimately one that raises difficult questions of value, both personal and societal, which would need to be answered if one were to arrive at a rational decision as to the relative emphasis to be given to these

alternative mechanisms. It is appropriate, however, to raise here a question which a complete account of the nature, purpose, and limitations of behavioral adaptation must face up to.

The question is suggested by Glass's findings that adaptation appears to take place differentially at different behavioral levels. In his own research, there was clear evidence of adaptation at the physiological as well as task-performance level, but at the same time the post-test measures revealed marked residual effects of the original stressor stimuli on measures of persistence of behavior, as well as of attentional efficiency. The relevance of this finding in the present context is that an individual's decision as to whether to adapt or to effect an overt adjustment in his environment is apt to be based on considerations of his own subjective experience of satisfaction or comfort, as well as on the opportunities available to him for resorting to adjustment, in terms of cost, feasibility, etc. The consequence may be that where the individual is able to neutralize negative aspects of a stimulus environment in terms of his own subjective experience or awareness, he will see little necessity for adjusting his environment, even though at other levels adaptation may be far from complete or bought at a high price.

Conversely, a situation experienced as uncomfortable may create demands for adjustive mechanisms, whether through technology or avoidance behavior, even though in terms of efficiency of behavioral functioning or physiological health the situation is not particularly stressful. There is thus the possibility that we may be tempted too readily to resort to adjustment when it is relatively unnecessary and when it may place a heavy burden on our technological resources or our societal institutions, while at the same time we are content to adapt to situations which are in fact harmful. Thus we demand air conditioning, where a few decades ago we accepted high room temperatures in the summer; at the same time, we "put up with" the stresses of daily commuting to work through heavy traffic, even though there may be little if any adaptation occurring to these stresses at the physiological level.

The foregoing discussion, without providing any answers, should serve to bring out the complexity of adaptation as a multilevel problem and the importance of considering a combination of criteria, both physiological and behavioral, in assessing the effects of environmental stresses on the individual and his capacities to adapt to them. It is possible that our behavioral conception of adaptation, particularly under the influence of adaptation-level theory, has remained too exclusively focused on perceptual and affective judgment, leading us perhaps to a too facile relativism in our conception of the effects of environmental stimulation on personal satisfaction and well-being. Only by extending both the range of behavioral and physiological variables employed in our study of adaptation and the time scale over which the problem is investigated can we hope to arrive at a more adequate functional understanding of the virtues as well

as the limitations of adaptation, and of the roles to be accorded to it in our efforts to arrive at a healthier environment for human activity.

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