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Improved Building Design Through the Psychology of Perception: Perceptual Selectivity Applied to Livability and Safety with Sample Performance Requirements

Nancy Starnes and Robert Wehrli

Architectural Research Section
Center for Building Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

and

Robert Cormack

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U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, *Secretary*
Edward O. Vetter, *Under Secretary*
Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

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INTRODUCTION

An element of human behavior which has not been accessible in any orderly way to building designers can be made available in usable form. The heretofore missing element is perception, that facet of behavior which relates us--sometimes reliably, all too often unreliably--to our physical surroundings.

The thesis of this study is two fold: one, that a designer's understanding of the mechanisms of perception can help him to create safer and more livable buildings; and two, that the method to incorporate this new material into a useful form which can be readily consulted lies in performance requirements--the creating and working of which are explained in Chapter 8.

As we gain a psychologists' knowledge of people, of physical environments, and of people's perception of habitation in, use of, and movement about their physical environments, we can use such knowledge to reduce accidents. For example, stairs are the second most hazardous consumer product, bicycles being first. For adult women stairs are the first. (See U. S. Consumer Product Safety Commission Annual Report, 1975). To achieve safety in stairway usage we could apply knowledge of perception in a number of conventional ways. Under the category, say, of education might come such activities as:

- Enlightening the public about the dangers of stairs, motivating them to be more careful.
- Advising people about the specifics of stairway accidents, telling them to what extent accidents are caused by inappropriate movements or by inadequate perception of the stair and its setting.
- Training people in the safe use of stairs.

Accompanying such education programs, and still not this study's concern, would be:

- Inventing safety gadgets for stairs. Just as seat belts were developed for automobiles, stair-climbing (or descending) safety devices could be useful, especially for children or the elderly.

In the following pages, however, a fifth way of applying principles of perception is set forth:

- Writing safety performance requirements based on perception, for the design and construction of future stairs which are safe. (See Chapter 8 for a sample of such performance requirements.) In the hands of concerned architects, builders, designers, and engineers, it seems likely that performance requirements which include an understanding of human perception can provide the means to build stairs which offer the user a higher level of safety than is presently the case with existing stairs.

Scope of Organization

Because perception is a term open to various interpretations, the preliminary sections of the study are devoted to defining it, especially its different meanings for psychologists and architects. Some discussion of how it works, and the word's philosophical origins are included as necessary groundwork for the chapters which follow. The report's analysis is based upon two desirable housing qualities, livability and safety, which can be enhanced by an understanding of some of the mechanisms of perception. The last part of the study discusses the constraining influence on design of many building codes and regulations, and suggests the potential liberating effects of standards couched as performance requirements. How such requirements are created is next explained with the concluding pages setting forth a number of such performance requirements. Stairs were chosen to demonstrate how safety can be increased through performance requirements which embody some awareness of perception's selective nature.

CHAPTER 1 PERCEPTION'S INFLUENCE ON SAFETY AND LIVABILITY

How can perception have anything to do with livability and safety? Certainly many accidents do not involve vision, hearing, and touching. If a building collapses, it doesn't matter how the crushed occupants perceived the building. The building is either safe or it isn't. Similarly, a building is either livable, i.e., can be lived in, or it isn't. Therefore, what could be important about perception?

Perception, of course, is of crucial importance when you consider that many accidents occur because people fail to perceive the environment which surrounds them. They fail to notice toys left on the stairs and trip over them, they don't perceive that the pan is hot and burn themselves, or they don't hear the kitchen timer and let the kettle overheat. Then let us consider livability--that much of it which has to do with comfort, security and privacy, recognizing that these factors are closely allied with perception. It is the "feeling" of comfort which people strive to obtain; or, they want to "feel" secure which they do when they "believe" that they are safe from intrusions. As for privacy, it exists not only when people cannot be observed, but also when they <u>feel</u> they cannot be observed.

Livability and safety, then, are not simply characteristics of dwelling. They are conditions which result from an interplay between a dwelling (including its site or neighborhood) and its occupants as interpreted by their behavior. To the extent that behavior is dependent on perception--and it is to a great extent--safety and livability are in turn dependent on perception.

Analyzing Behavior

To design well, some understanding of human behavior is needed, and ways to categorize it. It is perhaps trite, but nevertheless true, that human behavior is complicated. There are many ways of looking at man, and many ways of analyzing his actions and the processes which accompany these actions. One can categorize behavior according to the goal being sought; so that one can say a person wants to go downtown, shop for food, finish a task, try to win, or what have you. Or one can categorize behavior by locating it in any of several dimensions such as normal/abnormal, simple/complex, self-seeking/altruistic, sedentary/active, and so on. Another approach, one which permits useful analysis for many purposes, centers on how individuals process information. Such an analysis distinguishes between input (sensation and perception), throughput (cognition, thinking, emotion), storage and retrieval (memory, learning, recall), and output (speaking, walking, knitting). Because this latter approach is common in psychology, students often specialize in one or another of the approach's aspects.

Although there are disadvantages to specialization (since no one approach to the analysis of behavior is ever the "right" one), the narrow study of a particular kind of behavioral process allows for a thorough breakdown of the important variables by limiting the range of behavior studied, thereby simplifying the analysis. Therefore, the present study will limit itself to the process of perception, and will attempt to provide a partial analysis of this process as it applies to the problems of livability and safety in dwellings. The goal is to discover how designers can profit from applying some of these processes of perception.

Psychology and Design

We all know that dwellings are built for people. It is not unreasonable to expect that the design of dwellings takes into account the needs, wants, and limitations of those who will occupy them. This is not a new idea. Designers have always attended to the characteristics of their clients. What is new is that until recently, most of the characteristics attended to were either merely functional ones or ones which could be verbalized by the client himself. Information available on peoples' behavioral proclivities was largely anecdotal, or based on the personal experiences of the designer, which meant that much was left to the designer's intuition of how people behave.

During the last few years, however, a body of information linking the environment and human behavior has been developed. Several sources are converging to augment this collection of data, including traditional psychology, human factors engineering, environmental psychology, architectural psychology, anthropology, ethology, and bionics. The existence of this new body of information should permit the systematic application of behavioral factors to architectural design.

Deriving Design Requirements

Once architectural psychology information is brought together and organized according to some indexing system, it can be used in creating a pool of potential performance requirements. In Chapter 8 we have set forth a proposed list of requirements for stair safety which are based on a scientific rationale, these applications being offered in lieu of conclusions. The stair safety performance requirements are not intended, then, as a final product for they may (in fact, are likely to) violate many of the formal characteristics of good rule-sets such as those involving redundancy, exclusivity and independence.

Instead, the performance requirements can serve as a collection of possible requirements which will be filtered and refined by succeeding study and experimentation.

Chapters 1 through 5, and 7 give the reader background information needed to understand the rationale behind the stair safety performance requirements of Chapter 8. As the earlier chapters are read, the reader may want to refer occasionally to the contents of Chapter 8 which represent application of the earlier discussions.

It is the purpose of the present study not only to contribute to the pool of potential requirements but to bring together information which can be used to generate and select additional requirements. The objective, then, is to demonstrate the possibility, as well as desirability, of such performance requirements which incorporate a specialized knowledge of human perception into design.

First, answers are needed as to what perception is and how it functions.

CHAPTER 2 PERCEPTION: THE NATURE OF IT

Psychologists and architects have differing concepts of perception, differences which need underlining if common agreement on the term is to be reached. For this reason some various definitions of perception, something of its nature and subtleties, are examined in this chapter.

Origins of Perception in Philosophy

The psychology of perception grew out of the philosophical problems of epistemology. These have to do with how we know the world around us. Where does knowledge come from and how can its validity be tested? Part of the problem has to do with the evidence of our senses. Do they provide a true picture of the world? Would the world exist if there were no one to perceive it? Why does the world look the way it does?

All of these questions concern the philosopher because of his interest in knowing about the relationship between the world external to man and his knowledge of that world. And for him this all relates to perceiving the world. (It is interesting to note that "to perceive" has a legal meaning--to receive or take possession of knowledge about the world.) To the philosopher, then all stages of Figure 1-1 (see page 7a) are relevant. Today man knows that matter is made up of atoms and that the universe is 10 to 12 billion years old. Both these ideas have included all the perceptual levels of Figure 1-1.

Definitions by the Architect

A listing and discussion of definitions, while perhaps pedantic, is not irrelevant to the purposes of this report. If behavioral data from psychologists are to be used by the designer and builder, the data must be communicated

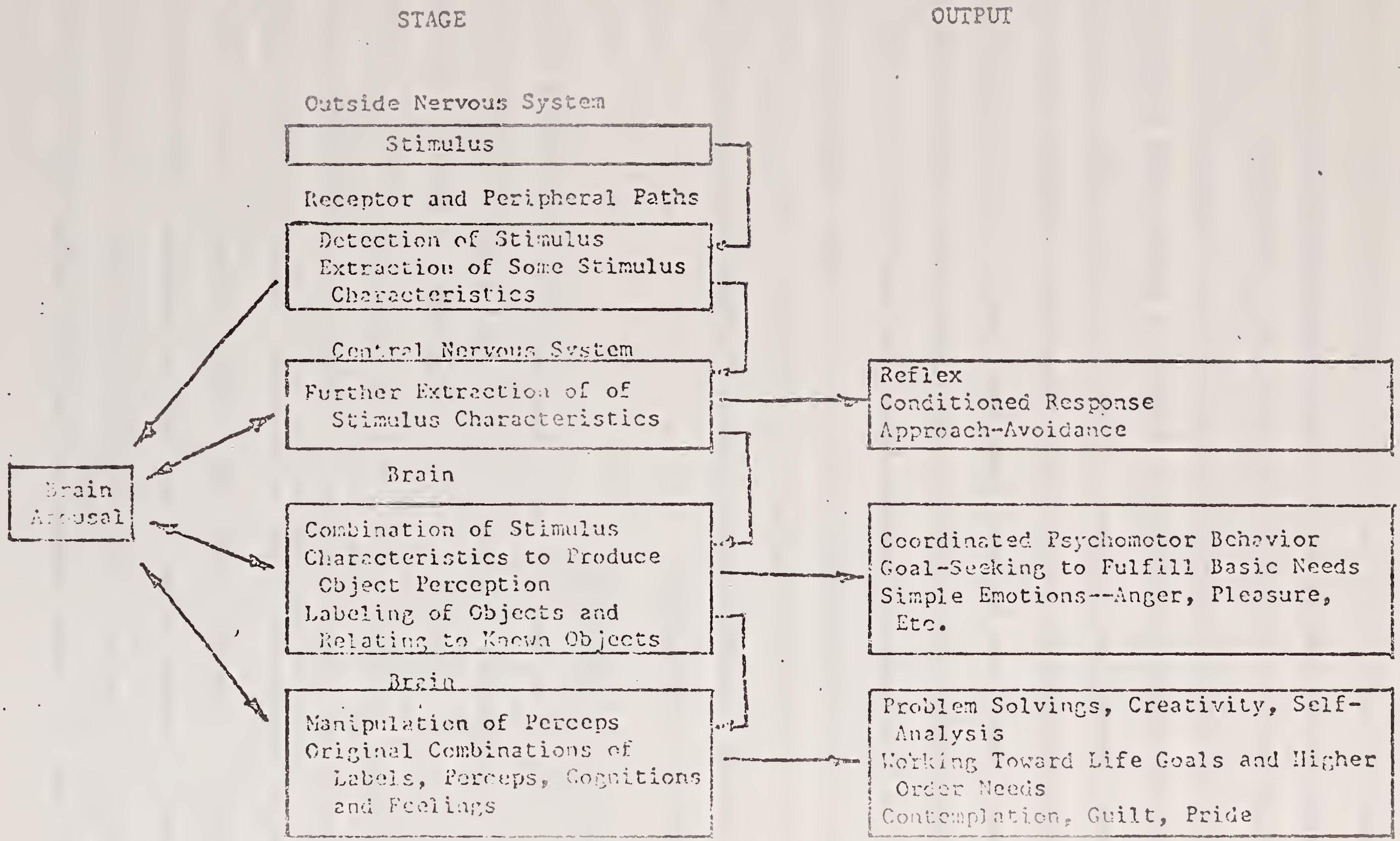

FIGURE 1-1 LEVELS OF PERCEPTUAL ACTIVITY AND ACCOMPANYING BEHAVIOR

in usable form, i.e., in language understandable by both. Architects and psychologists use the term "perception," but the variation in their definitions shows that they themselves do not always mean the same thing when they use it. (It does seem the case that, for the most part, psychologists use the word to refer to what might be called object perception or sense perception.) More commonly, architects (and non-psychologists in general) may refer to perception as insight, feeling or cognition. Frank Lloyd Wright (1949) writing of Louis Sullivan, the architect, noted: "His perceptions (insights) science later verifies." Kepes, who has made great contributions toward combining psychology and design, writes, "To perceive a visual image implies the beholder's participation in a process of organization. The experience of an image is thus a creative act of integration" (1944, p. 13). Kepes' remarks can apply equally to object perception and to processes which are less stimulus bound. In either case, Wright and Kepes suggest something more than simple interpretation of sensory input.

Definitions by Psychologists

It might be instructive now to look at several definitions of perception taken from psychology. Hilgard (1956) defined perception as "a general term referring to the awareness of objects, qualities, or events stimulating the sense organs." Harlow, et al. (1971) referred to it as "an interpretation of sensation in the light of learning." Sensation in contradistinction is used to refer to stimulation of the sense organs. Warren's (1934) Dictionary of Psychology gave several definitions of which we shall cite two: (1) "the awareness of external objects, qualities or relations, which ensues directly upon sensory processes, as distinguished from memory or other central processes"; and (2) "mental complex or integration which has sensory experience as its core." A more recent dictionary of psychological terms (English and English, 1958) gave many definitions of perception. Three were: (1) "an event in the person or organism primarily controlled by the excitation of sensory receptors, yet also influenced by other factors of a kind that can be shown to have originated in the life history of the organism;" (2) "a sensation together with a context of other experiences that give it meaning;" (3) "the process of discriminating the qualitative or quantitative differences between objects or processes." In all these definitions, perception is seen as something which involves stimulation of sensory receptors, but also as something which extends beyond stimulation. That is, emphasis is on the input side of the stimulus-organism-response (S-O-R) scheme.

There are, however, clear differences among the several definitions. For Hilgard, perception has an object, and that object is the thing which led to stimulation of the sense organ. This applies to Warren's first definition ("the awareness of external objects, qualities or relations, which ensues directly upon sensory processes, as distinguished from memory or other central processes") and to definition number 3 ("the process of discriminating the qualitative or quantitative differences between objects or processes") from English and English. In a less obvious way this also applies perhaps to the definition supplied by Harlow, et al. ("an interpretation of sensation in the light of learning"), and to definition number 2 from English and English ("a sensation together with a context of other experiences that give it meaning"). The "interpretation" referred to by Harlow, et al., and the "meaning" of English and English may have to do with identifying the object or event giving rise to the sensation. On the other hand, they might instead have to do with such things as assigning some degree of importance to the stimulation, or to feeling some emotion.

Perception as set forth in the two remaining definitions, number 2 from Warren ("mental complex or integration which has sensory experience as its core") and number 1 from English and English ("an event in the person or organism primarily controlled by the excitation of sensory receptors yet also influenced by other factors of a kind that can be shown to have originated in the life history of the organism")--such perception is even further removed from a particular object in the environment. These definitions simply refer to some process or entity initiated, sustained or influenced by sensory input, but unspecified as to content or nature. The process might be a dream set off by a noise in the bedroom, or the pleasure aroused by a beautiful painting.

Definitions by the Non-Specialist

We move even further away from external events when we consider some additional definitions of perception from Webster's International Dictionary, Second Edition: "Any act or process of knowing objects, facts or truths whether by sense experience or by thought . . .; an immediate or intuitive cognition or judgment; an insight analogous to sense perception in respect of immediacy and the feeling of certainty accompanying it, and often implying careful observation or subtle discrimination, as perception of mathematical truth or logical sequence (emphasis, the author's)." Lest it be thought that this definition is used only outside psychology, a final one from English and English: "an immediate or intuitive awareness of the truth about something."

These definitions allow for a perception which is divorced from immediate sensory input. They seem to open the term to include most aspects of thinking and awareness. The use of the term "sense perception" in Webster's dictionary shows a clear understanding (dare we say "perception") of this difference.

Concerns of Architecture

Small wonder that the designer's definitions differ from the psychologist's. The architect is faced with a different problem and must look at the question of perception quite differently. First of all, he is not at all concerned with the mechanisms underlying perception. He is concerned, of course, with producing certain effects--communicating certain ideas or feelings--and relies upon the perceptual mechanisms to do it. He does not select ideas or feelings to be communicated according to whether they are mediated by simple or complex processes. In fact, he is more likely to be concerned with precisely those results of information processing which have proven least tractable in the laboratory (e.g., beauty, peace, etc.). He wants to know how his design will be received (perceived) by fellow architects, if people will be confortable living in a dwelling, what is beauty, and what will foster self-esteem, and so on. These are hard questions, and not likely to be answered confidently in the laboratory or out of it, for a long time. They deal with the later stages in Figure 1-1, stages which are not well understood. Psychologists should not hold out promise of delivering more than they actually can in this area. There is serious question as to just how much that is relevant they can contribute.

Solutions by the Designer

Fortunately, not all the designer's problems are so difficult. Many of the simpler questions, as well as many difficult ones, architects have solved for themselves. Techniques for making spaces appear larger or smaller than they are have evolved over the years without the benefit of psychology. They work reasonably well. Entasis (the fattening and slightly curved profile of columns to make them appear straight) and camber (the slight upward arching of suspended horizontal surfaces to prevent the illusion of sagging) are well-known examples of this. Although the perceptual basis of these design solutions may not be understood, the techniques work and that is, after all, the important thing.

Application of Psychology

On the other hand, it would seem that if general principles of perception were known by designers, then they could apply them systematically to architectural problems. Rather than accumulating special solutions for each problem as it occurs, the designer could follow perception's general principles (the analysis of which is more specifically in the psychologist's domain), thereby anticipating important problems and by-passing trivial ones. It is to this end that the following discussion of perception is addressed.

Concerns of Psychology

There is no reason why the concerns of psychology should not mesh with and serve those of architecture, although the concerns are dissimilar. As psychology grew from philosophy, its concern with perception shifted as a result of two forces. One force was a trend toward empirical science. In any experimental science the subject matter is defined in part by the methods available. Work then proceeds from the simple to the complex. Therefore, emphasis became centered on relations between manipulatable stimuli and observable responses, usually in a laboratory setting.

The second force arose from the ever stronger influence of physiology. As new information about the receptor processes and the workings of the system became available, they had great impact upon the early stages of perception. Psychologists were eager to collect data relevant to hypotheses based on newly discovered physiological mechanisms. As time has gone on, the general tendency within psychology has been to limit further and further the scope of perception as a field of study. There have been some countertendencies, to be sure, but the overall trend is clear.

At the same time, psychology has investigated other mental phenomena. Thinking, imagination, emotion and the like have been studied, and much has been learned and written about them. In fact, topics such as knowledge, insight, imagination and imagery have been treated in some detail, but not as much as the study of perception. These studies arose from entirely different lines of epistemology, but converged on areas once seen (and outside psychology are still seen) as part of perception. Thus, aspects of behavior which were dropped from the study of psychology at one point have been reintroduced at another. Today psychological studies of perception concern themselves primarily with sense perception--with how the organs and brain process incoming stimuli to provide an organized sensory field. These physical, stimulus-related aspects of perception and where they lead are identified in the following chapter.

CHAPTER 3 THE ANATOMY OF PERCEPTION

To get a firm grasp on how people perceive their surroundings, some understanding of the "anatomy" of perception is necessary: how do stimulus and response register on our awareness through the central nervous system; how do our minds handle the stages of perception, the sorting out of sensory impressions which result in various behaviors?

What Is Perception

It has already been suggested that perception refers to the input side of the input-throughput-output system, also called the S-O-R (stimulus-organism-response) system. Input is a relative term, however. What is viewed as input at one point in the chain may be viewed as output at another. For instance, the information going up the optic nerve from the eye to the brain constitutes an input to the brain, but an output from the eye. This type of ambiguity has plagued the study of perception for a long time and has led to a great deal of argument about the nature of perception.

Stages in Perception

Here, an outline of a set of stages in perception might be helpful, wherein perception is assumed to be initiated or guided by sensory input. The stages are not complete; they do not include all kinds of processing; and, they are not mutually exclusive. That is, they overlap. The sequence of events following an input to the nervous system is not known well enough to make clear-cut divisions between stages. The outline, however, should clarify some distinctions about perception held by different disciplines. Figure 1-1 on page 7a presents the stages and is read from top to bottom.

Further understanding of perception's workings can be gained from examining the nature of the stimulus and the receptor.

The Stimulus

The stimulus is, of course, the initial input, the message from outside the nervous system. It comes in the form of energy (light, sound, pressure, heat, etc.) which impinges on a receptor (e.g., the eye, ear, skin, etc.). It is important to understand that just the input of energy alone, even in a form appropriate to the receptor, does not constitute a stimulus. Instead, stimulus is dependent upon some change, an increase or decrease, or an alteration in the spatial or temporal distribution of the energy. Changes which constitute the stimulus may be externally imposed, as when a light is turned on or when a bee stings; or it may result from changes in or actions of the observer, as when one glances from one place to another or walks around the room so that different scenes greet the eye. Whether external or internal a new pattern of stimulation impinges on the sense organs and this constitutes the stimulus.

Receptors

Sense organs are structures which allow or aid energy changes to make contact with receptors. Receptors are specialized cells which are sensitive to changes in some form of energy. Thus, the eye (a sense organ) selects and focuses certain rays of light onto rods and cones (receptor cells) arrayed inside its back surface. Hair cells in the inner ear are receptors to which vibrations in the air are directed by the various structures of the ear. Thus, a sonic boom leads to stimulation of these hair cells, and they, in turn, activate nerve cells.

Analysis Outside the Central Nervous System

From the receptors, information is carried to the central nervous system (brain and spinal cord) by way of peripheral paths (nerves). These paths are more than simple transmission lines; a significant amount of information processing occurs within these paths. What arrives at the brain seems to consist of messages about specific characteristics of the pattern of stimulation falling on the receptors, e.g., location of stimuli on the receptor surface, intensity of the stimuli, steepness and orientation of intensity gradients, and the like. There is no immediate and direct output, manifesting itself in some type of behavior, from the sense organs or peripheral paths themselves. Instead, all behavior and awareness is only mediated when it reaches the central nervous system. In the case of hearing, the sonic boom we referred to thus causes activity in these peripheral paths, but the person would not yet hear the sound. The perceptual activity must travel to higher levels before hearing can occur.

Analysis Within the Central Nervous System

The first stage of perception within the central nervous system consists of further extraction of specific stimulus attributes. In the case of vision such attributes as hue, brightness, contour, orientation and location in the visual field and so on are determined. Just how far this extractive or analytic process is carried is not known. Behavior produced at this stage in the processing of information is probably limited to reflexes (built-in behaviors like sneezing or swallowing) and perhaps conditioned responses (mouth watering at the smell of food). It is unlikely that any feelings or emotions result _directly_ from outputs at this level. The closest approximation would be simple approach and avoidance responses and perhaps startle (a reflexive behavior pattern). At this stage then, the sonic boom might cause the person to jump or make his heart beat faster, but he would not yet have identified the sound or feel any fear.

Synthesis of Stimulus Attributes

The next stage is very likely a synthesis of extracted attributes to form an awareness or identification of objects or events. This synthesis is probably directed or influenced by material recalled from memory and processes initiated by preceding experience with stimuli. This is simply another way of saying that the perception of an object is influenced by prior learning and by the conditions under which it is perceived. The behavior guided by this stage in perception might include complex coordinated activities (walking, driving a car, seeking food, some speech). Emotional concommitants might include anger, pleasure, fear, and the like. Our sonic boom at this level, would be identified for what it is, or perhaps misidentified as an explosion or some such event. In either case, a label and/or meaning would be attached to the sound. The person might feel fear, surprise, or some similar emotion.

Higher Level Perception

Guesses as to the next stage in perception are hazarded with a certain trepidation. How object preceptions are manipulated and combined with other mental processes to achieve insights, opinions, ideas, and predictions is beyond our knowledge. One would think that such manipulations must precede or accompany problem solving and creative critical analysis, as well as the emotional outputs which appear to evolve from them--outputs such as guilt and pride. Perception of our illustrative sonic boom might now include concern for property values or worry about the general problems of noise pollution. Further anger might accompany these perceptions. Or self-esteem could be lowered as the person considers having to live where he is subject to this intrusion.

Perception can be arrested at any stage in this scheme. Some inputs may arrive at the central nervous system but never be processed. Others may be processed all the way up the system and yet not result in any observable behavior--a person contemplating or day-dreaming might be oblivious to a sonic boom.

Feedback

In Figure 1-1 (see p. 7-a) the feedback, or sensory effects of the individual's own behavior, is illustrated by the arrows from the various outputs back to the receptors. Most people are able to perceive, and be conscious of, their own behavior when they want to, and this can have important effects on subsequent behavior.

Arousal

Also shown are lines from each stage in perception to a box on the left labeled "Brain Arousal," with lines from this box to the later stages. There is a system of centers in the brain which serves to keep the higher centers aroused or activated. If this system is disrupted, coma results. The arousal system is, itself, set into action by inputs from sense organs as well as inputs from higher centers. The mutual activation between the arousal system and the higher centers serves to keep the proper tonus or alertness during periods of activity even though outside stimulation may be minimal. Other centers, operating in a cyclic fashion, can shut down the arousal system for sleep and rest. The arousal system will be discussed in more detail later. Many more complications could be added in Figure 1-1. For the present purpose, it will suffice as it is. That purpose has been to describe in some detail the psychologist's view of perception for the benefit of the building designer.

CHAPTER 4 SELECTIVE NATURE OF PERCEPTION

One of the more interesting aspects of perception is its selective nature--what we decide to notice or not to notice in our environment. The connection between perception's selectivity and designing safer, more livable buildings is obvious. For this reason the present study limits its analysis of perception, as described below.

Scope of the Discussion of Perception

Further discussion focuses on visual perception, not that other modalities are entirely ignored. Many of the principles and ideas presented here have arisen from past studies of the physiology of perception, a broad field in itself. But relatively little additional physiology is needed for further discussion here. The emphasis is on known sensitivities of the perceptual mechanism, and on the factors which influence perception. As should be clear from the preceding discussion, emphasis here is on object or sense perception (earlier stages of perception). Where pertinent, remarks about later stages are included.

Unfortunately, we cannot possibly do justice in this report to the wealth of data which has been accumulated on visual perception, let alone perception in general. An exhaustive analysis would require several volumes. On the other hand, a superficial treatment of all areas and topics in perception would contribute little--little for the literature which already contains more complete treatment, and little for the purposes of this report which aims to show how an analysis of perception can contribute to the solution of design problems. Therefore, concentration is on a single aspect of perception from which we derive a limited number of principles. (As noted, in a later section of this report these principles are applied to generate performance requirements.)

The Selectivity of Perception

We must consider in some detail an important area of perception--its selectivity. As stated before, an understanding of the nature of perception's selective processes can lead to improved design for housing, which is the central message of this study.

The perceptual mechanism is constantly being bombarded by stimuli. Even in a relatively drab environment, the number of inputs to the organism far exceeds its ability to process them. Consider that the eye is capable of discriminating over 10,000,000 colors, and that these colors may be distributed across the retina in an almost unlimited number of possible combinations. Since the eyes move around constantly, fixating here and there, the scene on the retina is constantly changing. Events in the environment create further changes. The ears are capable of discrimating over 300,000 different pure tones (combinations of loudness and pitch), and can also discriminate between different combinations of tones presented simultaneously. All this must then be multiplied by the various spatial patterns of sound producing virtually limitless combinations of possible inputs. The other sense modalities contribute further inputs. In addition, it must be kept in mind that the sense receptors are never turned off. The eyes can be closed, but even then many patterns of light can reach the retina. The other receptors don't have shutters comparable to the eyelids.

To return to the selectivity of visual perception, a large sign or light is more likely to be noticed than a small one. Similarly, stimuli having sharp contrasts are more intrusive than stimuli lacking this feature: Black against white is more noticeable that dark gray against medium gray, and juxtapositions of bold colors stand out clearly. Temporal contrasts are as effective as spatial ones. A light coming on suddenly at full intensity is more attention-getting than one which increases slowly. Sharp changes from low tones to high ones are also more effective this way. Presumably, these stimulus characteristics affect us as they do because our mechanisms of attention are sensitive to them. Before we can turn knowledge about these selective processes to practical use, however, we must first understand the nature of them.

Adaptation

Although all the processes of selectivity have not yet been fully delineated, some aspects and principles are fairly clear. In the first place, our senses adapt to stimuli which are not too intense. By this we mean that given a constant level of input, the sensory apparatus adjusts in such a way that this level of input loses its impact. For example, the eye adapts to light over a wide range of intensities. However, once the eyes have adapted, the overall level of illumination is (or appears) neutral. This has important consequences; for as adaptation occurs, differences among stimuli close to this neutral point become discernible. When you first enter a movie theater from bright sunlight, your eyes must adapt to the darkness, and you can perhaps only discriminate the movie screen from the blackness around it. After your eyes have adjusted to the dark, the small brightness differences associated with the seats, other viewers, the floor, ceiling decorations and other details become apparent. When you emerge from the theater, if it is still a bright sunny day, at first all you can see is a dazzling whiteness and a few large dark objects. Shortly, however, adaptation to the brightness occurs and detailed vision is reinstated.

Notice that this works both ways. At the same time that small differences close to the neutral point become discriminable, small differences among stimuli far removed from the neutral point become less so. Thus, sensitivity in one region of the intensity continuum is bought at the sacrifice of sensitivity at other regions. While we are thus tuned to detect small differences from the background, we are rendered insensitive to the overwhelming effects of large differences.

Implications of Adaptation

Housing design should take into account the fact that vision adapts to ambient illumination and readapts slowly. Ware (1971) pointed out that in leaving a building of moderate illumination and coming onto a bright sunlit outdoor stairway, an individual may be so blinded as to be unable to see where the steps begin. Large differences in illumination between adjacent rooms in a building probably should be avoided, such marked transitions avoided especially if some hazardous task must be accomplished in one or both rooms.

Adaptation occurs for many sensory dimensions: color, odors, tastes, pressure, temperature, and so on. The rate of adaptation may vary from one dimension to another, and the specific mechanism may differ considerably.

Adaptation occurs whether or not stimuli are being responded to. Odors may seep slowly into an environment where a person is not paying attention to the odor. The odor may grow quite strong, perhaps indicating a dangerous condition, and yet the person (by now highly adapted) may not notice it. To someone just entering the room the odor may seem overpowering, but the one who has been there all along may be hard put to detect it, even after having it brought to one's attention.

This gradual adaptation might cause scalding accidents in the shower. Individuals who like hot showers can adapt to the hot water so that it feels only mildly warm. So they increase the heat, but then adapt further. However, there is a limit for adaptation to heat, and this cycle could lead a person unwittingly to burn himself while experiencing only comfortable changes in heat levels.

Habituation

A second process--besides adaptation--which operates to select incoming stimuli is habituation. In many ways this is much like adaptation; in fact, the two are often confused. Habituation refers to the tendency for stimuli to lose gradually their ability to produce behavior. When we first enter a room in which a fan is running, we notice the sound. After a while we are no longer aware of the sound. The blinking of a neon sign may at first irritate the observer, but later he may tune it out and not be bothered by it.

Habituation, however, is not a receptor mechanism like adaptation. The sensitivity of the sensory system is unaffected by habituation. Instead, it seems to have to do with the decrease in the novelty of a stimulus with repeated presentations. People seek novelty; they attend to it. When stimuli are repeated over and over, they lose their arousing properties. To put it another way, the stimuli become boring.

Implications of Habituation

Habituation, like adaptation, has implications for safety and livability in dwellings. For one thing, it means that we cannot depend on people to monitor or watch out for hazards for any length of time. Warnings, exit signs, and the like soon fade into background (psychologically speaking), thus losing their power to affect behavior. Threatening stimuli, unsafe conditions, or often repeated, dangerous acts soon become commonplace and vigilance lags. The hazards of such things are thus compounded by inattention to them. They no longer seem dangerous so precautions are ignored.

There is another side to habituation. The absence of the repeated stimulus can be novel and command attention. If the fan suddenly stops running, we are immediately aware that something has happened. We may not always know exactly what, but our attention has been caught and we are momentarily aroused. The cessation of a repeated stimulus can be as novel as the occurrence of an unlikely one.

More on Arousal

This discussion of habituation and the arousing properties of novel stimuli leads directly to a more thorough consideration of the general notion of arousal promised earlier. Work in recent years has shown that human performance (the effectiveness of behavior) is closely related to what is called level of arousal. By level of arousal is meant the degree to which the cortex of the brain is activated by lower centers. The details of the arousal system, as it is called, have been fairly well elucidated, but need not be detailed here. It is only important to understand that human performance is optimum (for most tasks) at moderate levels of arousal. Very high arousal (excitement, euphoria, terror) results in poorer human performance for most tasks. Also of importance is the fact that arousal level is raised by novel stimuli, or stimuli with high relevance for an individual (e.g., the person's own name, information about desired goal objects, etc.), or emotion provoking stimuli (e.g., objects arousing fear, hatred, or love and information about them). Arousal is lowered by repetitive stimuli, irrelevant stimuli and stimuli of no interest to the person. Other internal factors, as well as drugs, also affect arousal, but they are not of concern here.

Information Theory

To continue this exploration of perception's selective processes, we should next consider an important theory. According to this theory, the amount of information carried by a message (any event or stimulus) is inversely related to the probability of that message. That is, unlikely, unexpected occurences carry more information than highly probable, expected ones. To illustrate, suppose you release a ball and it falls to the ground. This tells you something, but not very much. You expect the ball to fall, and confirmation of the law of gravity is not very informative. On the other hand, if the ball travels upward, this would be news; it would surprise you and would carry much information by virtue of ths improbability. Notice that this is a very special meaning for the word "information" and does not necessarily conform to other definitions.

Information Processing in Man

For computers and other electronic communication systems, information theory has been developed to a high degree of mathematical sophistication, making possible an increase in the information-transmission capacities of the systems as well as indicating ways to decrease errors in transmission. Meanwhile, the information handling capacities for various parts of the nervous system in man have been studied intensively with several facts emerging. One discovery--the eyes and ears are capable of taking in much more information than the brain can use. Another fact--responses to signals with low information content are faster than those responses to signals with high information content. Also, tasks which require the processing of large amounts of information are performed less quickly and reliably than those requiring less such processing. Again, we are back to how perception's selectivity processes work.

It is important that the reader understand the similarity between the concepts of novelty and information, for the similarity can be harnessed to serve improved design. Novel stimuli are, in a sense, ones carrying much information because they are unexpected signals--thus the relationship between information and arousal. The nervous system is an information processing system. Low information inputs can lead to a lowering of arousal, possibly with a consequent drop in information-handling capacity. The central nervous system may then turn to another source of information (e.g., memory), and process wholly internal signals, thus engaging in fantasy, day-dreaming and the like.

Very high information inputs (highly complex stimuli) can cause high arousal and a concommitant loss of efficiency. Moreoever, the information processing system may become overloaded, thereby creating errors and inappropriate behavior. The individual may try to select only the most important information and process that, but it must be realized that this selection or search for relevant data is, in and of itself, information processing and occupies a portion of the perceptual mechanism. Unless there is some way to discriminate relevant from irrelevant information, the selection process may be more hindrance than help.

Redundancy

Before turning to a fuller discussion of the ways in which these ideas can be applied to problems of livability and safety, we must introduce one further concept from information theory. This concept is redundancy, and it has to do with the relation between the amount of information a signal can carry and the amount it actually does carry. If the same information could be conveyed by a shorter message, rather than a longer one, then part of the message is redundant. Let us look at an example. Suppose you are given this message: "The time is 12:05 P.M. The time is 12:05 P.M." The message consists of two identical sentences. Both convey the same information, so one sentence is completely redundant.

Repetition almost always involves redundancy. This is true whether the signals are in the form of language or in some other form. The ticks of a clock are highly redundant. So are a series of evenly spaced identical stripes or other figures in a pattern. Repetition of the same information in a different form also involves redundancy, as in, "The time is 12:05 P.M. It's five minutes past noon." A more serious example of the same thing occurs if you pick up a pan from a hot oven and drop it, saying, "Ouch." A helpful friend says, "You shouldn't do that, you could burn yourself." Your reply, "Thanks a lot!" indicates that you recognize the redundancy in your friend's communication.

Effects of Redundancy

Redundancy, however annoyingly obvious at times, is important for a number of reasons. Without it, reliable communication would be impossible, because any interference whatever could destroy some essential part of a message, and such interferences are commonplace. To understand this you need only recognize that when there is no redundancy, every part of the message is essential. Hence, without redundancy there is no allowance for destroyed parts of a message, or parts that have not been received due to various distractions or other perceptual interruptions.

Another important effect of redundancy is that it results in a slower transmission of information, and this provides more time for processing. Man's nervous system is limited in the rate with which it can handle information. If the limit is lowered by high or low arousal, the system can be overloaded. Given high arousal, redundancy also increases the probability that the information will be attended to. When the information is repeated there are simply more chances for the individual to respond to it. The attention mechanism can shift between repetitions or may be tuned to messages in a certain form. The more times and the more ways the information is presented, the more opportunities there are for it to be processed.

A less well-understood effect of redundancy is the tendency for repeated messages to be trusted or believed. This is possibly a learned response tendency based on the fact that things we hear more than once or from many sources turn out to be true more often than things we hear only once or from only one source. Later repetitions are taken as verification of the original message. In any case, people do tend to place more confidence in repeated information.

Finally, there is an almost paradoxical arousing effect attributable to repetition. Eventually, as we have seen, very high or complete redundancy leads to boredom or lowered arousal, but initially repetition can have the reverse effect. A person who is daydreaming may not hear his own name being spoken or his train being called, yet if the words are repeated, they can often rouse him. (This effect is not always seen--sometimes early repetitions show habituation instead of arousal, but it occurs often enough to be of interest.)

The fact that we find these effects paradoxical suggests that we do not understand fully the mechanisms of attention and arousal.

Now that we have examined the various processes of perceptual selectivity, let us see how they may be applied to practical design applications for livability and safety.

CHAPTER 5 HOW PERCEPTION'S SELECTIVITY CAN AFFECT DESIGN

The previously discussed processes involved in perception's selective mechanisms--adaptation, habituation, and arousal are all perception-related behaviors affected by the intensity, novelty, and redundancy of stimuli. All these factors can have significant implications for design as the following pages attempt to point out.

Arousal, Information and Housing Design

To begin with, the implications of arousal, information and redundancy are many for dwelling design. In view of the decrease in perception's efficiency produced by extremes of arousal (high or low)--which, in turn, affect the reliability of a person's performance--steps should be taken to avoid environments which induce such extremes. Conversely, if extremes of arousal are unavoidable, then design features should not require high levels of human performance.

Low arousal is more likely with the low levels of stimulation caused by repetitive, drab, uninteresting stimuli. Sometimes we want this, as when we want to get to sleep. Therefore, we make it possible to turn out the lights and turn down the stereo, thus cutting ourselves off from arousing stimuli.

When we wish to avoid low arousal, we must make available novel, relevant and interesting inputs. However, we cannot depend on an environment whose arousing properties are based only on highly intense, large, and high-contrast stimuli. We have already seen that when people habituate to such stimuli, they are no longer activated by them. Such physical characteristics certainly may be incorporated into design features, but they must be part of an environment with features which are not so susceptible to habituation.

Designing for Resistance to Habituation

There are ways to make an environment resistant to habituation. One is to make it complex enough so that it maintains its novelty or interest for a long time. A complex stimulus-object conveys enough information so that it is never processed all at once, so that what information there is can be processed in many different combinations. At the same time, the information must be clear enough to have meaning for the observer. Perhaps the best examples of such stimulus objects are good works of art. Almost any great painting can be characterized as a rich, complex message. It can be analyzed (perceived) on many different levels--balances of light and color, the object it portrays or represents, the symbolisms or conventions it includes, or the techniques and materials it employs. People almost never tire of looking at such work. They say it is always "fresh" (i.e., novel). The amount of information transmitted is very high, but also clear and understandable. Good architectural design in itself shares these characteristics and can also be supplemented by judicious use of available works of art (paintings, music, prints, sculpture).

Another way to reduce habituation is to design for change. If an environment is modifiable, if features can be and are changed, then habituation is precluded. People go to great lengths to rearrange furniture or change curtains and wall colors. It is important that such changes be made easily and inexpensively, and without compromising other design requirements such as safety, comfort and the like.

Preventing High Arousal

It must be remembered, of course, that the goal is not to produce high arousal, but rather moderate arousal. As it turns out, the kinds of features mentioned above generally do not produce extreme arousal. Very high arousal is produced by, among other things, startling, fear-producing, or highly frustrating stimuli. Sonic booms, pain or the sight of one's house on fire are examples here. Much effort has been expended to reduce or eliminate these unwanted, well-known stimuli. The arousing properties of the view down from high places is common enough to warrant attention. Windows and balconies in the upper floors of tall buildings should incorporate features to reduce vertigo and panic in individuals prone to such effects. High sills and sturdy appearing guard rails may be used. Even better, the floor can extend out far enough beyond the window or railing so that the view directly below is obscured. Obviously the balcony or window should be safe, but in the interest of preventing high arousal, the emphasis here is on the appearance of safety and the absence of fear-provoking stimuli.

The Dilemma of Warning Signals

Warning signals (fire alarms, pressure-cooker whistles, emergency signs, etc.) are designed to command attention and, as a consequence, are highly arousing. Unfortunately, the very condition--danger--which requires this compelling arousal signal also is likely to require effective, reliable human performance. The designer is thus faced with a dilemma. Either he uses a non-arousing warning stimulus and risks failure to catch the attention of the victim, or he uses a highly arousing stimulus and risks panic or other inappropriate behavior in the part of the victim.

Emergency Drills

Although there is no single easy way out of this dilemma, several things can be done to ameliorate the situation. Clearly, the designer cannot make the signal too weak. The attention of the endangered dweller must be captured. The most effective solution is very likely beyond the reach of the designer, which is to see to it that the person practices emergency procedures. Well-learned behaviors are much less susceptible to the effects of extreme arousal than marginally-learned behaviors, and conditioned responses are less susceptible than thinking. Fire drills are valuable for this reason, but many residents are not motivated to participate in such activities.

Simplifying Emergency Procedures

Since simple tasks are degraded least by high arousal, a "next-best" approach is to make emergency procedures simple. This is not always easy but obvious, well-lighted, and unobstructed exits are a first step. Emergency shut-offs for plumbing, electrical distribution systems, and gas should be accessible, clearly marked, and easy to use.

Making Emergency Information Available

The designer should probably assume that the resident will not know what to do when an emergency arises. He should take pains to make it possible for the occupant to obtain the information at this time. The designer must remember that he is communicating with a person under high arousal who is not processing information at an optimum level. Several things can be done to aid rapid intake of information without increasing errors. These things are based on the principle that everything possible shall be done to make it easy for the person to discriminate between important, relevant information and unimportant, irrelevant information.

For example, warning labels and emergency information (signs, exit lights, stickers, etc.) should stand out from their surroundings and do so in such a way that their function as emergency communicators is clear. Such items should differ from their surroundings in more than one way (e.g., hue and brightness, brightness and distance, texture and saturation, etc.). This follows from our discussion of information theory in which we learned that probability of attention and reliability of communication are improved by redundancy, meaning here the repetition of the same information in different forms.

Standardization of Emergency Signs

Some standardization of emergency signs (see American National Standard D 6.1 - 1971) should be employed, thus reducing the requirements for searching (a task humans do poorly under the best conditions) among highly similar signs to find the single relevant one. There are many systems of standards. In some cases several of these can be used in combination. The American National Standards Institute and the National Safety Council recommend the following standard color code (American National Standard Z 53, in press) for special information and warning signs:

Red	Fire protection equipment and apparatus Danger Stop
Orange	Dangerous parts of moving machinery
Yellow	Physical hazards that might cause stumbling, falling, etc.
Green	Safety, first-aid kits, stretchers, etc.
Blue	Caution against movement or use of equipment
Black and White	Traffic direction and sanitation

It might be pointed out that color coding is an effective redundancy. If a sign is red (meaning fire, danger, or stop) and the sign reads "danger--flammable materials," it is stating the same thing twice for quick, clear communication.

Another potentially valuable form of standardization would involve location. Perhaps all warning instructions or emergency signs should be placed at some standard location on appliances and at some constant height on walls and posts. All this is not to suggest that houses and apartments be plastered with emergency signs. But such indications as are already found on furnaces, water heaters and other potentially dangerous items--plus exposed signs in furnace rooms and similar locations--should be placed where people can expect to find them and can read them with ease.

Home Resident's Manual

One way in which standardization could be augumented would be to place duplicates of all instructions, warning labels, and emergency signs in a home residents's manual. Such a manual could contain a wealth of data--indexed and color coded--for emergency or routine use. One difficulty with such a manual would be updating it from time to time as building modifications are made. Presuming this were done, the manual would be useful if it contained the following types of items:

1. Detailed maps of all plumbing, electrical wiring and HVAC (heating, ventilation and air conditioning) systems
2. Emergency instructions and routine instructions for turning on and off electricity, water, gas, and HVAC systems
3. Instructions for changing fuses and lighting pilot lights
4. Instructions for replacing light bulbs, faucet washers, and other minor repairs
5. Whom to call about repairs and emergencies
6. Map of emergency exits and fire extinguishers
7. Charts of color codes
8. Operating instructions for appliances
9. List of cleaning materials to be used or avoided (solvents, drain cleaners, etc.)

The duplication (redundancy) of emergency data in the home resident's manual, as well as on signs and labels, would provide an additional easy source of quickly needed information.

Human Performance Under Moderate Arousal

Our discussion thus far has centered on the special conditions which obtain under extremes of arousal. However, even when arousal is neither too high nor too low, there is good reason to provide clear unambiguous information. This is especially true when the information concerns hazards and other things of importance to the individual. Discontinuities in working and walking heights (counter tops, steps, ramps, thresholds, etc.) are treacherous, and should be clearly demarcated by contrasts in more than one visual dimension. The redundancy involved in setting a ramp off from its surroundings in, say, brightness as well as hue (to say nothing of tilt which may be virtually indiscernible) may well prevent a bad fall. Open overhead cabinet doors in a kitchen which swing out should cast shadows on the counter surface below as an additional cue that they are there, and hazardous cavities such as ovens, furnace interiors, washers, or dryers should be arranged so that the user has binocular vision of the interior whenever he has to reach inside.

Deception

Although it is not technically correct in information theory, there is a sense in which the opposite of redundancy is deception. When an object is designed so that its appearance (one source of information) corresponds to its function (another source of information) that is redundancy. When an object is designed so that its appearance belies its function so that it can be improperly perceived for its intended function, that is deception. Deception can be innocuous or even desirable, as when a room is made to appear larger than it is through careful use of mirrors, color, and furnishings. But deception should be applied knowingly, for its use can be dangerous when it causes inappropriate behavior.

For example, glass panels and doors which give the illusion of open spaces have caused many serious accidents. Furniture which looks substantial and sturdy, but which is not, may be used to climb on or support heavy objects to someone's sorrow. Various racks, rods, and fixtures which appear able to support great weight may be placed where they are likely to be used for support. Thus a towel rack may come free in the bather's hand or a chandelier in the repairman's.

If warning labels and emergency signs caution against performing an act, but repeated usage fails to cause harm or damage, two conflicting messages are being transmitted: One, the sign says "danger", the other, experience, says "no danger." This is deceiving and can change one's perception of other warnings. Signs should give as accurate an indication of the risk of an accident as possible.

Other Factors in Selectivity

There are additional factors, not discussed in detail here, which influence the selectivity of perception in important ways. The complexity of the nervous system, with its large number of feedback systems, insures that just about everything that goes on within the nervous system affects everything else. Of great importance in the selectivity of perception are motives, expectancies and emotions. The environmental stimuli which one responds to when tired and hungry may be different from those responded to when rested and full, and this illustrates the importance of motivation. The response to a noise by a person watching a television comedy may be different from that to the same noise by the same person walking through a graveyard at midnight. The person's expectancies and emotions are different.

These factors, along with a host of others, have an impact on perception. Each factor by itself constitutes a major area of study within psychology covering too much ground to be treated here. The exclusion of factors not mentioned here should not be taken as an indication that they are of less importance or relevance to safety. If, for example, education and training can lead to a higher motivation for safety, people may become more sensitive to safety-related stimuli. These and other considerations will have to await fuller treatment of perception than presented here.

CHAPTER 6

Analysis of Livability

Before applying some of the previously discussed perception theory to design problems, an analysis follows of the two factors--livability and safety--to which this study has limited its application. This chapter explores the meaning of "livability." The following chapter examines "safety" in a similar vein. The concluding chapter touches on how present building code provisions might be revised through the performance concept. The study ends with a set of performance requirements which apply perception's selectivity to stairs to improve their attributes of safety and livability.

What Is Livability?

The word livability is being used here to denote features of dwellings which contribute to a pleasant state--a state which includes a feeling of well-being and security. In a sense, livability is what housing is all about. People can and do live without houses or apartments. They backpack, live in tents or campers. They may even live in station wagons and sedans for short periods. A modern dwelling, however, provides the means for carrying out a large variety of functions, important in today's society, with relative ease. Our standards of personal cleanliness and grooming, our appetite for a varied diet, our intolerance for extremes of temperature and humidity, our modesty, and--above all--our need for time to accomplish tasks not directly related to survival, all demand a residence with comfort and convenience features which might, in some other age, have been deemed luxuries.

Need for Considering Livability

In fact, such features are often called luxuries today, especially by critics of welfare and urban improvement programs. This position generally argues that lower income and deprived families need homes which only afford protection from the elements and which are thus low enough in cost to leave money for food and clothing; extra conveniences and comforts are for such families luxuries which, while pleasant, are needed less than other things.

There certainly is merit in the notion that cost should be kept down and that attention should be paid to priorities among housing features. Care must be taken, however, to see to it that the housing provided for the less privileged does not lock them into a cycle of poverty and low achievement. The higher habit patterns and skills needed to function effectively in a complex society will not develop if all the residents must use all their time doing chores which don't call for those special habit patterns and skills. An overly spartan environment can very likely wreak as much havoc with the lives of the dwellers as an unsafe environment. It is important then that we try to understand the nature of livability and the features of houses which contribute to it.

Two Sets of Factors

First, it should be clear that livability involves two related, but distinct, sets of factors: factors of the physical environment as it exists, and factors as to how that environment is perceived. As an example, privacy figures importantly in livability, but there are two aspects to privacy. First, there is the degree to which a person or his actions are open to observation by others. A person alone in a sealed room with no windows or other viewing apertures has visual privacy, as does a person in an outdoor dressing room with high walls but no roof. Yet people may "feel" that they have more visual privacy in the former than in the latter. Since knowledge of the existence of one-way viewing mirrors has become widespread, some people feel they have little visual privacy in classrooms or other places with built-in mirrors. Thus equally (if not more) important then visual privacy is the perception or feeling of visual privacy. In many cases, one implies or leads to the other, but not always. Care must be taken to provide both.

A similar dichotomy can be applied to most elements contributing to livability. Therefore, any complete analysis must pay attention not only to features which directly affect relevant variables of the physical environment but also to those which affect the perception of and behavior toward such variables. One pertinent suggestion here is that when little-known methods for accomplishing some requirement for livability are employed, it should be seen to that residents understand and trust them. Otherwise, the effort may have been partially wasted.

Individual Differences

A second point of relevance here is the magnitude of individual differences among people with the consequent wide range of conditions which lead to maximum livability for different people. Although certain general factors, such as privacy, freedom from intrusive stimuli, lack of need for excessive exertion, and the like are almost universally desired, individual differences in backgrounds, habit patterns, and preferences make it difficult to weigh the importance of these factors. People want privacy, but they do not want to feel isolated; they don't want intrusive stimuli, yet too quiet an environment may drive them to distraction; they wish to avoid excessive exertion, but what is excessive? This ambiguity contributes to the problems involved in selecting appropriate brightnesses, colors, room sizes, ambient sound levels, and so on. Add to all this the interaction between the relatively stable individual differences already discussed and other more transient factors--such as time of day, mood, physical health, and the like--then the problem becomes enormously complicated.

Need for Personal Control of Variables

One way to cut the Gordian knot is to place the control of those variables for which large individual differences exist in the hands of the residents. Whenever the optimum value of a factor can be expected to change greatly from one person to another, or from one time to another, design should allow for manipulation of that factor by the people living in the dwelling. This approach to design, advanced for somewhat different reasons by Kane (1971), has some valuable suggestions from the author for its implementation. Other writers (e.g., Sommer, 1969) have also stressed the importance of design flexibility to give residents needed personal control.

Designing for Personal Control

The implications of the foregoing to the present study are fairly clear. Requirements for livability demand the flexibility of modifiable features in dwellings. Unless there are very strong reasons for making a feature permanent, it should be designed in such a way as to be changeable. This line of reasoning argues against built-in furniture and appliances unless they are unusually flexible. Space should be adaptable to serve different functions at different times. Also the cost, skills and efforts needed to change various aspects of the dwelling should be minimal. To repeat, maximum control of relevant variables should be in the hands of the residents.

Factors in Livability

What are the relevant variables? It is probably impossible to give assurances that any listing of the variables involved in livability will be complete or consistent. The concept as used here is necessarily ill-defined and overly-broad. Still, it is not difficult to put down some general categories (with more specific items in each) which certainly include the major variables. Table 3-1 on page 45 represents an attempt to do this.

The remainder of this chapter discusses the various items in Table 3-1, but before proceeding with this, one general observation should be made: The two major categories in Table 3-1 refer to threats and gratifications. Clearly there is an interacting force between these categories and two accompanying motivational factors, pain and pleasure.

A fundamental notion underlying many theories of behavior is that people act to avoid pain and to obtain pleasure. Whether or not this pain-pleasure paradigm can provide the basis for a complete analysis of all human behavior, it is certainly true that pain and pleasure are powerful motivators. We work to obtain money--money which will enable us to escape the pain of starvation and sickness, and money which will make possible the pleasures of recreation and leisure. Similarly, we build or rent houses to escape the pain of exposure and insecurity, and to gain the pleasure of comfort and beauty. Perhaps dwellings might be evaluated in terms of the extent to which they provide pleasure and prevent pain, and that performance attributes of dwellings could be organized around these guiding concepts. This is a matter of further work.

Now let us examine, if somewhat briefly, the items in Table 3-1. Under category I.A. are physical threats. Those concerned with safety accidents are so extensive and important that they are be treated separately in the next

TABLE 3 - 1

Factors for Livability in Dwellings

I. Threats

A. Physical Threats

1. The elements (rain, cold, etc.)
2. Safety accidents
3. Intrusions (theft, vandalism, etc)
4. Damage to belongings (flood, fire, etc.)
5. Noxious materials (pollen, other allergenic materials, etc.)
6. Infectious materials

B. Frustrations

1. Intrusive stimuli from outside
2. Internally generated disturbing stimuli
3. Required vigilance and inhibitions
4. Unwanted disclosure of body or behavior
5. Unwanted disclosure of letters, diary, pictures, etc.
6. Excessive exertion required
7. Compelling and undesirable schedules
8. Requiring new or different habit patterns

II. Gratifications

A. Primary Needs

1. Food
2. Water
3. Etc.

B. Secondary Needs

1. Stimulation (beauty, luxuries, and entertainment)
2. Recreation
3. Social interaction and approval
4. Self-esteem

chapter. The control of any threatening agents not listed in Table 3-1 is a topic outside the scope of this report; further discussion herein is being limited to feeling or perception of security regarding items in this table.

<u>Physical Threats (See Table 3-1, p.45) and Perceived Safety</u>

While probably all people need to feel that they are safe from harm in their homes, there may be considerable differences from person to person as to what constitutes an acceptable level of perceived safety. It is possible that an unusual person could be disturbed greatly by a home which feels too safe or secure. This is especially true if safeguards which seem superfluous can be ignored by those who wish to take risks. For instance, good quality locks are important to guard against intrusions, but some people do not lock their doors even though the lock is there. Nevertheless, it would appear that, unless additional factors dictate otherwise, perceived safety should be maximized.

The next question is, what features of a dwelling contribute to a feeling of safety or security, a concept set in motion by Oscar Newman's studies of architecture's relationship to security and users of buildings (see Newman, 1972). Obviously, one set of features consists of real safety and security features. Everything else being equal, a safe house will seem safer than an unsafe house. However, as we discussed in the context of privacy, one may be quite safe and secure, yet feel otherwise. Some people could never feel safe in a house which juts out over a cliff, even though they know it to be strongly anchored. Others feel insecure unless chainbolts are hooked on doors (this in spite of the fact that some chainbolts can be broken by a healthy eight-year old).

Quantifying Perceived Threat

Two approaches to this problem suggest themselves. One involves applying the concepts of severity and frequency. (These are described in detail in the next chapter.) It might be conjectured that for most people the severity of threatening incidents plays a more important role in determining perceived security than frequency of such incidents. Several arguments support this guess. For one thing, a single case which may be highly dramatized in the news media serves to demonstrate the severity of an incident, but gives no information as to its frequency (except that it is greater than zero). Of course, the news media do report statistical averages and trends, but these may be abstract, hence less forceful than the dramatic picturization of an accident or crime. Moreover, each person is unlikely to have personal experience with enough actual incidents to enable him to discriminate any but the largest differences in frequency. Thus the main differences known to and understood by him are those concerning severity.

It is well known (Hebb, 1966) that people tend to remember dramatic and unusual incidents and forget more mundane ones. This distortion of memory could serve to make more severe occurrences seem more likely while minimizing the apparent frequency of minor ones.

Finally, like memory, in the news media and in casual conversation more attention is paid to exciting events than to everyday occurrences. Thus the overall sample of accidents and other unusual incidents coming within the purview of an individual contains an inordinate number of severe or extraordinary events.

In view of the above considerations, as a first approximation for determining perceived threat, greater weight might be given to severity. For example, severity figures could be squared and then multiplied by frequency.

Another approach to the problem involves rewording the original question. Instead of asking what features of a dwelling contribute to perceived security, we might ask, "What do people fear?" There appear to be no data directly related to the home environment on this, but many studies have investigated common fears in man. A list compiled from several textbooks in psychology includes: darkness; falling; spiders; snakes; high places; strangers; strange, sudden or intense stimuli; humiliation; ridicule; work failure; loss of prestige; helplessness; drowning or suffocation; separation from loved ones (Hilgard, 1956; Hebb, 1966; Harlow, et al., 1971).

More directly relevant data should be quite easy to collect. Appropriate samples of residents could be asked the degree to which they fear various possible threats to safety or security. Any of several rating or ranking techniques could be employed. The results could be used in deciding which factors should be given priority in designing an apparently safe dwelling.

I. B.: Frustrations (see Table 3-1)

Frustration is a term widely used in psychology. It derives from the following notion: People do things for a reason. The reason might be represented as some objective or goal. For instance the person may wish to complete a task or obtain food. Alternatively, his reason might be represented as achieving some state like relaxation, nourishment, etc. When a person is somehow prevented from obtaining a goal or achieving a desired state, frustration is said to occur. The emotions accompanying this state of affairs have been implicated as causal factors in a number of unfortunate actions and behavior problems. The nature of the effects of frustration and the causal chain relating frustrations to their results need not be of concern here. It is sufficient to recognize that people generally avoid frustration when they can.

I. B. 1 and I. B. 2: Peacefulness

The factors listed under frustrations in Table 3-1 are grouped roughly according to different aspects of a home environment. Numbers 1 and 2 might be said to refer to peacefulness, or peace and quiet. Of course, what is nice and quiet for one person may be deathly still for another. Silence can be just as much a stimulus as noise or music. The kind and degree of stimulation in a dwelling ought to be under the control of the residents. This requires, at the least, good acoustic, vibratory, illuminatory and odor insulation. It also requires the potential for removing or circumventing barriers to sensory contact with the outside world when this is desired. This may be as simple as opening windows and doors. Under other circumstances, it might involve intercoms and other communication aids. Of central importance here is that controllable stimuli are not enough; the residents must know that they are controllable and how to do so.

I. B. 3: Feeling at Home

An important but not easily specifiable or quantifiable factor is feeling at home. Part of relaxing and making oneself at home involves letting down one's guard. For many people, home is where you don't need to put up appearances and where behavior can be less formal. This would seem to require that fewer prohibitions for behavior exist here with a wider range of actions acceptable. Translated into design features this would mean: a place safe to walk in bare feet; fixtures not damaged by feet, dirty hands or casual treatment; few enough hazards and good enough warning systems so that one does not have to maintain vigilance. To some extent this kind of relaxation also involves privacy which will be discussed below. It may involve layout, too. When a baby sleeps too far from the living room, the mother can't enjoy relaxing there because she is afraid she will not hear the baby cry.

I. B. 4 and I. B. 5: Privacy

Privacy has already been discussed to some extent. Achieving it has been of increasing concern to people because crowding has become more severe in urban areas (Chermayeff, 1963, and Jourard, 1966). Two major aspects should be distinguished: One is privacy from external observation; the other is privacy from one another for individuals living together. Both are important.

With privacy, as with other factors, the degree should be controllable, not imposed. Within some families, nudity, elimination, bathing and the like are not particularly private behaviors, while within other households they are. Many families, and many authorities, see a need for private places for each individual where he or she can keep personal things. There is evidence that people tend to use a simple but effective test to determine whether they have privacy, and that is to see if others have privacy from them. For example, people assume that if they can hear their neighbor, then the neighbor can hear them.

I. B. 6 and I. B. 7: Convenience

The factor of convenience, covered by items 6 and 7 in Table 3-1, interplays with virtually every other item. If the control of other variables involves too much effort or requires that they be done at inconvenient times, the value of that control is seriously compromised. If tasks are overly time-consuming, then gratifications offered by design features of the dwelling cannot be obtained. Particular care must be taken that features designed to make the dwelling more livable in one respect not be so inconvenient as to become, on balance, negative features.

I. B. 8: Confidence

Finally, we have features which may jeopardize the confidence of the occupant in himself or in the dwelling. If the design calls for knowledge not possessed by the resident, or if ingrained habit patterns lead to blunders and mistakes, the occupancy will not be a pleasant one. Old habits are not easy to change. This is especially true when the habits are part of a tradition or when they serve more than one purpose. Washing and drying dishes together can be an important daily social event for some members of a family. A small kitchen (with an automatic dishwasher) appropriately designed for one person may require new habit patterns, and criticisms of the dishwasher may reflect frustrations not with its effectiveness, but with its obviating a pleasant social activity.

Structures which appear unsafe or unreliable can undermine confidence in design features. Stairs which rattle or sway may cause apprehension even though they may be quite strong. If the dweller does not have the skills or knowledge to determine for himself whether they are safe--to him they appear dangerous. Innovative designs such as enormous cantilevers, may not look substantial to the uninitiated because the usual cues to structural integrity are missing. Effort spent to make items appear that they can do the job may be well-spent.

II. A. Primary Needs

The primary needs listed under II. A. in Table 3-1 (see p. 45) need no elaboration as they do not concern us here. The samples given are illustrative only and the list is not meant to be complete.

II. B. Secondary Needs

The secondary needs of II. B. (see p. 45) are of concern here. Secondary needs represent a theoretical construct and there are various theories as to their nature and origin. There is agreement that, unlike primary needs, they are not absolutely required for the life of the individual or for the continued existence of the species. It is also agreed that at least partial satisfaction of these needs is important if the individual is to contribute to society and interact with others as an alert, happy person. Beyond that, there is much disagreement. Different theorists list different secondary needs, giving them varying degrees of importance. As of now, psychology is far from being able to speak with much authority on the topic of secondary or higher-order needs. The four items in II. B. represent an amalgam or compromise of the work of several authorities (Hilgard, 1956; Harlow, et al., 1971; Hebb, 1966; CRM, 1970).

II. B. 1: Stimulation

There does seem to be general agreement that people require sensory inputs above some minimum level and that these inputs be spatially and temporally patterned. Further, it appears that patterns are not equally effective, different patterns having different effects. Under some conditions (conditions not likely to be found in any modern dwelling) the effects of certain unpatterned and patterned stimuli can be devastating, causing hallucinations, seizures and the like. Even under less extreme circumstances some people attribute headaches, nausea, and general discomfort to visual, auditory, proprioceptive (internal cues from the muscles) and olfactory stimuli.

The cautious designer may respond to all this by avoiding distinct, high contrast patterns and use instead bland unobtrusive ones. It must be emphasized here that low contrast contours and bland colors cannot be equated with low stimulation. Such inputs may constitute extreme stimulation if they are temporally related to other stimuli. Further, low stimulation can be as distracting as high stimulation.

The concept of individual control over relevant variables is perhaps more important here than with any other factor of design. The architect cannot begin to design an interior which provides the appropriate stimulation for different people and for different situations. But he can provide an interior which can be modified by the occupants.

II. B. 2: Recreation

There seems to be little disagreement that for most people, recreation is an important function, and unless there are exceptional facilities available elsewhere, at least one room in a family dwelling should include recreation features such as a room that is as indestructible as it is feasible to make it so that children can indulge in free, uninhibited play.

II. B. 3: Social Interaction

Features contributing to social interaction and approval must satisfy two somewhat opposing requirements. First, they must make available space for various forms of social intercourse. Second, they must make it possible for people to stay out of each other's way. The dwelling should also be such that the occupants are proud, or at least not ashamed, to have guests inside.

II. B. 4: Self-Esteem

The degree to which design can contribute to the last item in Table 3-1, self-esteem is not at all clear. That one's perception of oneself is an important concomitant of behavioral integrity is unquestioned. For some people, the facilities to live a dignified life and to be in control of important aspects of their environment may contribute to this self-image. Certainly, at the very least, design features of a dwelling should not rob a person of his individuality or make him feel inadequate. It is likely that a great many of the variables discussed above converge on this nebulous but important factor.

CHAPTER 7

Analysis of Safety

Just as design features should not rob people of their sense of individuality, of their chance for social interaction, or any of the other desirable features which "livability" implies, design should not ignore the contributions which principles of perceptual selectivity can make to safety in dwellings.

Definition of Accident

In the last chapter we promised to consider in detail the physical threats to livability. Such threats often express themselves in the form of accidents, and the prevention of such accidents is the function of safety. This chapter delimits those aspects of safety which can involve perception. As a first step, let us look at a definition of "accident".

"Accident: An event that takes place without one's foresight or expectation; an undesigned and unforeseen occurrence of an inflictive or unfortunate character; a mishap resulting in an injury to a person or damage to a thing (Webster's New International Dictionary, Second Edition)."

Kinds of Accidents

There are many kinds of accidents of varying degrees of severity or consequence. Some result merely in extra work or minor cost. For instance, a boy hits a baseball through a window. Or, an accident may simply be embarassing as when the roller shade on a street level window snaps up while one is in a state of undress. Accidents can disturb relaxation and concentration, producing tension and irritation; for example, when the wind slams a door loudly.

The above-mentioned accidents are obviously trivial compared to safety accidents, which cause injury or death, and which architectural design might help prevent. In real life, the distinction between safety accidents and other accidents may be very fine. Good luck may prevent a potentially severe accident from being nothing more than a scary disturbance, as when a heavy object falls from a high shelf and just misses one's feet. Since lucky breaks are just that, obeying the laws of chance or probability, an examination of actual safety accidents should include a proper proportion of events which could have gone either way.

Safety Is Not Everything

A central concern in the present study resides in the making of dwellings as safe as possible. But this is a gross oversimplification. Houses could be made vastly safer than they are if the occupants were only willing to forego privacy, comfort, recreation, pleasant surroundings, and the like. It is hard to hurt oneself in a padded cell; and if one is willing to eat cold food, a whole set of accidents involving stoves and ovens could be avoided. Further, if one were willing to hire a contingent of safety experts to monitor the household to warn of danger, and if one were to carry out each recommendation of the experts, a great increase in safety would be possible theoretically, but not practically, cost alone ruling out such expensive and confining approaches.

Although the above methods are not being advanced as serious suggestions, neither are they advanced in jest for they illustrate an important point. Safety is not everything. Freedom from death and hurt is purchased at a price, and people are willing to pay only so much to achieve safety. Martin Wohl of Ford Motor Company made this point when he said:

> It is hardly sensible to adopt a policy that attests that "lives and limbs" are priceless. No matter how final one's death or loss of vital parts may be, neither can be regarded as priceless. To argue the contrary, for example would be to argue that people would be willing to sacrifice their homes, recreation, food, clothing, traveling--in a word, everything--in order to reduce traffic safety hazards and guarantee their chance of survival and noninjury (quoted by Parsons, 1970).

Factors to be Considered

All this has implications for an analysis of safety accidents. Close attention must be paid to the way in which requirements for safety interact with requirements for cost, comfort, and effectiveness. Accidents must be quantified in at least some rough way so that the greater ones can be dealt with, and the units of measure must be such as to allow some kind of comparison with the other factors.

The physical structures or devices involved in the accidents must be identified. This is not always as straight forward as it may seem, as when some feature of one structure or device leads a person to make a mistake in using another.

Finally, the causal factors involved in the accident must be recognized. Two general classes of factors are variously labeled design vs. behavior, and building vs. people (or as will be used here, device or structural defect vs. human error.) In addition, there are some factors which cannot be wholly assigned to either category.

The assigning of accidents to design or individuals cannot be a hard and fast thing. Accidents in the last century involving kerosene lamps and stoves would likely have been ascribed to human error. The designer who today specified kerosene lighting might well be blamed for any accidents which ensued. Design can only be as good as the state of the art permits and can only be held responsible within the limits of standard and popular usage.

Factors to be Ignored

Before discussions of quantification, structures and causal factors are begun, mention should be made of one feature of safety accidents which will not be discussed, namely the specific bodily damages (punctured eye, broken finger, amputated leg, etc.) which may result from accidents. Unless there is some compelling aspect of a particular kind of accident which involves such details, the nature of the bodily injury will be ignored.

Quantification of Safety Accidents

Various schemes for quantifying or ranking safety accidents have been devised, (BOSTI, 1971a; and Shuford, 1970). The three variables most often mentioned are severity, frequency, and cost. These variables have been defined in many ways by different writers depending on the purpose. For this reason, it is important that the purposes to which the quantifying or ranking system will be applied be kept firmly in mind.

Severity of Accidents

Severity refers to the consequences of an accident, the degree of injury. From a medical standpoint, the treatment involved, the probability and degree of recovery are dimensions of interest. For the insurance company, the costs are important. If the victim survives, the pain, disability and cost are all important. If survival is in question, that obviously will be of concern. All these factors are important, but if they are to be useful in an analysis of accidents, they must be reducible to a common unit of measure.

It might be helpful to point out that our concern is not with fine comparisons among accidents, but with the large differences among the following classes of injuries: no harm, negligible injury and little expense with no chance of death or disability (bruise, nick, perhaps a few drops of tincture of arnica, etc.), and so on. That is, decisions must be made as to whether a problem is severe enough to warrant the attention of designers.

A Measure of Severity

These considerations make it appear that severity might best be reduced to dollar equivalents as a unit of measure. The dollar equivalent could be measured in any of several ways. In the BOSTI Interim Report #1, Project #70-13, the following cost criteria are listed:

1. Cost of ambulance service, prorated according to number of persons served;
2. Transportation costs related to medical treatment;
3. Costs of professional services of doctors, surgeons, and dentists;
4. Costs of private nursing services, in the home or hospital, not included in the hospital bill;
5. Hospital charges for all services, drugs, etc.;
6. Costs of drugs, supplies, eye glasses, braces, and special equipment such as wheelchair or crutches, not included in doctor fees or hospital bill;
7. Value (gross earnings) of work time lost by the injured party;
8. Value of work time lost by persons other than an injured party taking leave from their employment to care for the injured party or look after his interests;
9. Costs of additional or substitute domestic or household services;
10. Fees paid to legal advisors representing an injured person or a survivor, exclusive of legal costs of an insurance company;

11. Surplus damages, i.e., the amount by which damages actually collected from a third party exceeded the total of all other costs incurred because of personal injury;

12. Present value of the loss of future earnings by those fatally injured, and by those with a permanent impairment, either total or partial;*

13. Replacement of damaged clothing and personal property;

14. Cost of temporary living accommodations necessitated by damage to residence;

15. Rental income lost through damage to leased residential property;

16. Additional cost of life insurance bought subsequent to occurrence of accidental injury, and attributable to that injury;

17. Costs of repair of damage to residential property;

18. Welfare costs of accidents typically occurring within low-income populations.

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*NOTE: Parameters 1 through 12 are taken from "Moter Vehicle Accident Costs: Washington Metropolitan Area," Wilbur Smith and Associates, Washington, D. C., 1966, page 18.

All the above seem reasonable and relevant. In practice, the task of computing costs for many different accidents will be complicated and time-consuming. Remember that most of the items (especially 7 and 12) will vary with the socio-economic status of the injured. This will mean that average figures for various accidents will have to be determined.

Subjective Factors in Severity

While the severity items listed above are all relevant, they do not comprise a complete list. To elaborate on Item 11 above, what of the pain, mental anguish, embarassment, interference with recreation, and other activities? These should count for something. The question is, how are they to be reduced to dollar equivalents and how are they to be combined with the more straightforward items in the list above?

It is proposed that the dollar equivalents for the more subjective factors be obtained by means of a scaling technique. One of the subjective estimate methods (absolute judgment or rating) would seem best suited. Basically, this would involve writing descriptions of the various outcomes of accidents and asking people to place a dollar value on these outcomes. Stevens and Galanter (1965) presented data showing that judgments like this can be made and that under appropriate conditions they are linearly related to an underlying physical continuum. Torgenson (1958) outlined the conditions which must be met in order to achieve this linearity and discussed ways of meeting the conditions.

Several alternate specific approaches are available for collecting the needed data. On the one hand, dollar equivalents for very specific disabilities could be determined. For instance, loss of an eye, not being able to father children, or giving up all active sports would be rated separately. Then these ratings would be added together to determine the subjective severity of an accident which involved all three.

On the other hand, common constellations of specific disabilities generally accruing to given accidents could be presented together for overall scaling. This approach would have the advantage of automatically adjusting (at least in part), for non-additive or interactive factors, (e.g., loss of foot is perhaps less important for a paralyzed person). The number of possible combined outcomes might make this approach unworkable.

Further discussion of the specific nature of the scaling procedures needed to obtain dollar equivalents for the subjective outcomes of safety accidents is beyond the scope of this report. For now, it should be possible to determine an accident's value by using factors in the BOSTI list of cost criteria. This would give us an overall severity in dollars for various accidents.

The use of this severity index will probably require one more adjustment. It has already been pointed out that what is needed is not a fine discrimination of severity, but rather information relevant to whether or not to act to prevent the accident. This requires an indication of severity, but only in broad categories. It should now be pointed out that differences in severity at one end of the continuum are probably more significant for the purposes of design decisions than equal differences at the other end of the continuum, e.g., the difference between a $0.00 accident and a $5,000 accident is important--the difference between a $100,000 accident and a $105,000 accident may not be. (NOTE: This would not necessarily be true for the purposes of insurance underwriting or other decisions.) This suggests that a log or exponential transform might be appropriate for systems decisions. Accidents could then be categorized by means of a linear subdivision of the transformed scale values.

Frequency of Accidents

The importance of the frequency of occurrence of accidents need not be explicated here. Several studies of the frequencies of safety accidents in the home are available (See references in Shuford, R., 1970 and BOSTI, 1971b). Frequency figures for home safety accidents should refer to the relevant population, i.e., the socio-economic and geographic groups for whom housing is being designed. A standard unit of frequency such as number of accidents per person per year should be used.

Cost of Accidents

When the frequency and severity of an accident type are known and the severity is expressed in dollars (or some transform), cost becomes the product of the two. Cost then becomes the primary datum in determining whether (and how much) effort should be expended in attempting to prevent each type of accident. Also when cost is frequency times severity, then safety becomes the reciprocal of cost, i.e., safety consists in reducing cost (frequency and/or severity)--to zero if possible.

Built Elements and Attributes Involved in Accidents

For the purposes of this report it would seem appropriate to categorize accidents according to the built element and attributes of that element. The same indexing scheme used for "Built Element" and "Attribute" in Operation BREAKTHROUGH should be employed (Pfrang, 1973). This simplfies integration of material with already existing data.

Causal Factors in Safety Accidents

There are many ways of organizing the factors which cause or contribute to safety accidents. The outline presented in Table 4-1 (page 64) and discussed below represents an attempt to place such factors into categories according to the way in which they can be dealt with or reduced.

Table 4-1

Causal Factors of Safety Accidents in Dwellings

I. Device or Structure Defect
   A. Design Inadequacy
      1. Presents Physical Hazard
      2. Encourages or Requires Inappropriate Behavior
      3. Lacks Safeguards

   B. Material Failure
      1. Material Defect
      2. Deterioration and Aging

II. Human Error
   A. Individual Abilities
      1. Infants and children
      2. Aged, sick and handicapped
      3. Ignorance or a typical social background
      4. Too strong, too heavy, too tall, etc.

   B. Extreme or Unusual Emotional or Mental State
      1. Fear, anger, fatigue, etc.
      2. Hypnotism, somnambulism
      3. Homicide, assault, suicide, self-mutilation

   C. Error in Judgment
      1. Unintended use of device
      2. Intentional disregard of relevant information
      3. Unintended disregard of relevant information
      4. By-passing of safeguards

III. External Intrusions; Earthquakes, Tornados, War, Riots, etc.

I. Device or Structure Defects (See Table 4-1)

There are a number of ways in which the design of an item has contributed to an unsafe condition. It is not unreasonable to comment here on the limits of the responsibility of the designer in the area of safety.

It is not always clear where the cause of an accident lies. For one thing, in most cases causal factors are confounded. It may be human error to place a heavy object high on a shelf where it is difficult to get down. But in view of the known problem, it may also be a design error to make it easy to place such an object on a high shelf. Generally speaking, we might say that if an accident is frequent, it doesn't matter what the causal factor is. In any case, the designer needs to do something about it. It might appear that some type of accident is caused by human error, but if a great many people are making the error, then it must be considered human nature to behave that way and design should take such characteristics into consideration. An example is flying an airplane when the ground is obscured from view by clouds, fog, snow, or rain. It is human nature not to fly the plane true and level, hence aeronautical engineers had to invent instruments and aids to blind navigation.

A further problem lies in the fact that design requirements for different purposes may conflict. This must be dealt with realistically. For safety, perhaps all stair nosings should be marked in fluorescent colors. However, comfort, relaxation and aesthetics may require less garish stimuli. It must also be recongized that preferences in appearance change and that what is attention getting depends on the surroundings. (Fluorescent warnings would not stand out against a fluorescent background.) All this would seem to require highly imaginative and creative designs.

I. A. 1: Physical Hazards

Built elements should not present exposed hazards to the user. Obvious examples of this are uneven floors which can trip, or projections from the wall at eye level. Loud noises which could cause ear damage or which might mask important auditory signals would also fit this category, as would glare which could hide the edge of a drop-off. Less obvious, perhaps, would be banisters or railings which were designed too weakly to support a typical person. The general principle here is that building products, components or devices should not have hazardous elements designed into them. Where hazards are a sine-qua-non of adequate built-element performance, as for example ranges and ovens, measures must be taken to prevent their adversely affecting the user.

I. A. 2: Inappropriate Behavior

Not always obviously different from the immediately preceding, but certainly different in principle, is the notion that built-elements should not encourage or require that the user behave so as to bring himself into contact with other hazards. He should not have to hurt himself to use the device. Here would be included devices which require too much strength to operate, or ones which are so designed that the operator can't see what he is doing. A towel rack needn't support much weight but, if it is placed in a position where people are likely to use it for support, it will encourage dangerous behavior. Also in this category would be range controls whose location suggests that they operate one burner when in fact they operate another. Examples could be extended indefinitely. The critical aspect is that while not hazardous themselves, built-elements often require or encourage actions which lead to hazardous situations. This should be avoided.

I. A. 3: Missing Safeguards

Where hazardous conditions exist, either because of unavoidable operational aspects (range elements have to be hot to work) or because of outside influences (gravity pulls people down when they step off of balconies), built-elements should include features which insulate people from the hazards or which prevent inappropriate behavior. These are called safeguards. Here would be found railings, closed risers, small elevators (so that weight limits could not be exceeded), polarized connectors and incompatible receptacles for different voltages, stairs well-lighted and easily discernible in their surrounding, and so forth. Obviously, not all hazards can be identified and low-probability or low-severity hazards may not be worth the cost of changing. Generally, however, if a hazardous feature is associated with a built-element and cannot be eliminated by design change, a safeguard should be provided to prevent the hazard from injuring the user.

I. B. 1: Material Defects

Sometimes structures or devices present hazards to the user, not because of any design deficiency, but because of poor quality control in manufacture or installation. The doors of unevenly hung cabinets can swing out and present obstacles to the unwary; electrical insulation failure can be very dangerous; wrong labels on controls for hot and cold water or for oven and surface elements can lead to serious accidents; loose carpet on stair treads can cause trouble. Good design may aim at minimizing the likelihood of this kind of hazard but still not eliminate it. Quality control in manufacture and installation is essential.

I. B. 2 Deterioration and Aging

Virtually everything wears out eventually. Safeguards and other parts whose failure would constitute a hazard should last longer than other parts. Often the reverse is true. One of the first things to become useless on many devices is the instructions. The warning plates become scratched and dirty. Indicating marks on controls become obliterated. Aging and durability specifications should be more severe for safeguards than for other built-element features. Where deterioration cannot be prevented, periodic inspections are important.

II. Human Error

There seems to be a consensus that of the two major factors contributing to safety accidents (design and human behavior) all that can be controlled is design. Yet, the most significant characteristic of human beings is that they do change their behavior; they are flexible, learn, form habits, modify attitudes. It might be said that modern man in Western society owes much of what he is--for better or worse--to behavior modifications unwittingly imposed by the design of his home, his towns, and his institutions.

In designing and building a dwelling, the designer is creating stimuli and conditions which can have a major impact on the habits and lifestyles of the people who will occupy it. For the most part, the effects are unanticipated. Designers usually don't have ways to predict what changes will occur. Perhaps the designer will be resigned to this, and even believe that his building benefits its occupants. The point to remember, however, is that the designer, in any case, is controlling behavior for better or worse. Whether he wishes to manipulate or not, cause-effect relationships will be built into his projects. The important question, then, is whether the control is deliberate or accidental;

whether the building is designed to preserve and enrich the lives of its occupants or is helter-skelter--helpful or harmful.

We cannot ignore the issue for, as we learn more about human behavior, we will be faced with the prediction and control problem more and more directly. When the designer knows that design "X" will increase tension or weaken family bonds, or whatever, not to use an alternative design is to deliberately increase tension, lessen family bonds, etc.

It is worth considering, for instance, if the removal of all safety hazards (assuming we could do it) might not contribute to the development of people who lack important protective habits; people who are insensitive to important signals which warn of danger. Such people might be a hazard to themselves and others in different situations. Perhaps such a protective environment could foster the development of very dependent personalities who would feel insecure and apprehensive away from home. Unlikely examples, perhaps, yet these and less dramatic possibilities are worth looking into. It will be assumed for the present study that we are far from capable of designing dwellings so safe that they could have the kind of impact suggested. Furthermore, before we deliberately attempt to create or inhibit behavior patterns to any great extent, we should explore thoroughly the ethical and social questions involved as well as the methodology to create such "perfect" dwellings. These are beyond the scope of the present report.

On the other hand, we cannot ignore behavioral tendencies and habit patterns which we now know exist. And for the designer's purpose, it does not matter whether such patterns are innate or learned.

Problems in design arise from one obvious area which is considered in the next few pages--the limitations, or the differences among various individuals using a single dwelling. Not only do different people perceive their surroundings differently but the same person, in various states, perceives his environment in different ways.

II. A. 1 Infants and Children (See Table 4-1 on p. 64)

Built-elements are designed to fit some intended user. It is expected that certain elements will not be used by people incompetent to do so, and that, in the case of children, parents or other adults will provide some measure of control to prevent inappropriate behavior. There is possible disagreement as to the extent of control desirable, but there is general agreement that some is needed. Parents of toddlers often install gates at the heads of stairs, they lock floor cabinet doors, and the like. When children do use built-elements designed for adults, accidents may occur.

II. A. 2 Aged, Sick and Handicapped

The aged, sick, and handicapped represent another group which may fall outside the category of "intended user." (Of course, for nursing homes and other specialized dwellings this may not hold true.) The designer cannot be expected to design for the most infirm; the result would probably be inappropriate for the healthy, robust, adult. The use of ordinary dwellings by the infirm will usually entail some risk.

II. A. 3 Ignorance or A typical Social Background

Not only does the designer assume an intact mature user for most dwellings, he also assumes some minimum social and cultural programming. People relocated from rural and slum areas may have little idea of how to use modern design features and appliances. They may have little understanding of the dangers of electricity, refrigeration coolants, etc. Increase this ignorance by a couple of orders of magnitude and severe accidents can occur.

II. A. 4: (See Table 4-1) Too Strong, Too Heavy, Too Tall, etc.

People whose characteristics fall at one extreme or the other of the normal distribution cannot always be accommodated. People 8-feet tall or 500 pounds in weight, or people who don't know their own strength may present problems. The rarity of people with such extremes in stature precludes much expense on their behalf, and accidents from this source will continue to occur.

II. B. 1: Fear, Anger, Fatigue, etc.

Often, people who fit the characteristics of the intended users may temporarily be in a state which interferes with good perception, judgment and behavior. Extreme emotions represent one class of such states. Fear or anger may lead a person to do things which place him in great danger. Many accidents are explained by saying "but I was so flustered" or "I was afraid that . . . ". Modern society can produce many tensions and conflicts which may lead to extreme emotional states, so the problem is a real one.

II. B. 2: Hypnotism, Somnambulism

Other temporary states such as hypnotism, somnambulism, and the like, although infrequent, have caused accidents.

II. B. 3: Homicide, Assault, Suicide, Self-Mutilation

"Intentional accident" is a conflict in terms because if it is intentional, it is not an accident. Nonetheless, such acts as suicide, homicide, self-mutilation and attacks on others represent real dangers. The mentally disturbed can constitute threats to safety. Perhaps all that can be done here is to make dwellings secure from intrusion and try to provide design that, at least, does not contribute to such acts by the residents. Another factor here is that motives for self-inflicted injury may derive from many sources. Of special interest are intentional "accidents" for profit. These may involve real injury, but often they do not. Careful design may make it harder for persons to collect excessive damages for minor accidents or any damages for intentional "accidents."

II. C. 1: Unintended Use of Device

Even when people are representative of the designer's intended user and in full possession of their faculties, they may still make mistakes or behave inappropriately. One common error in judgment is to use a device for the wrong purpose. People should not put their hair in a clothes wringer or dry it in a gas oven. A toilet is not a garbage disposer. Stairs are not storage shelves. When possible, built-elements should be designed so that unintended use cannot be accomplished.

II. C. 2: Intentional Disregard of Relevant Information

Another common error in judgment is the disregard of relevant information. The saying, "When all else fails, read the directions," rises out of human nature. People often neglect directions--they don't think they need them. They ignore warnings not to smoke, or to wait five minutes before relighting a water heater. The reasons for such deliberate disregard are probably many and complex. Where no good reason for a warning can be perceived or where disregard in the past has not has serious consequences, the by-passing of warnings is probably higher.

II. C. 3 Unintended Disregard of Relevant Information

Sometimes information is simply not perceived. Such inadvertent disregard of information may result when the warnings or instructions are not correctly placed, or when they are marginally perceptible. At other times, the selective attention mechanism of the human perceiver (a poorly understood mechanism) seems to filter out important information instead of unimportant information.

II. C. 4 By-Passing of Safeguards

Try as the designer might to include fool-proof safeguards, he never succeeds. Some fool will find a way to get around them, removing the ground-lug from electric plugs, putting cheater cords into T. V. sets after removing the backs, holding a safety switch on appliances after opening them, etc. One case of improved design here is the electric circuit breaker which replaced the old fuse in dwelling electrical systems. The fuse could be easily and effectively (but hazardously) bridged by a penny or other metal object, whereas the circuit breaker cannot.

III. External Intrusions

Some accidents are not attributable to design or to behavior. The catastrophic effects of war, unlikely arrival of meteors, sudden violence of riots, and the like are still virtually impossible to design against and are thus outside the scope of this study.

CHAPTER 8 INTRODUCING PERCEPTION INTO DESIGN THROUGH THE PERFORMANCE CONCEPT (AND PERFORMANCE REQUIREMENTS UTILIZING PERCEPTUAL SELECTIVITY)

Having pointed out the ways in which perception's mechanisms of selectivity can affect design (Chapter 5) and analyzed areas of livability and safety (Chapters 6 and 7), it is now time to consider ways in which this knowledge can be introduced in usable form on the present scene of design. This requires a glance at conventional building codes with an explanation of how they are presently being made more flexible through the performance concept. (The concluding section of the study lists potential performance requirements which incorporate principles of perceptual selectivity as applied to stairs.)

Constraints

The constraints placed on the designer of a dwelling come from various sources. Zoning laws and covenants are prime examples of such influences. Building and housing codes constitute important sets of constraints and generally have to do with safety and health features of buildings. Often building code provisions are highly restrictive and specify the particular size, composition, and/or method of construction of elements for buildings. However, ways of preventing undesirable or even dangerous building practices are necessary; therefore, building codes fulfill a public need. At the same time, if overly prescriptive, they are not without undesirable side-effects.

Prescriptive building codes can lock in a particular solution to a problem and prevent the use of other solutions. They may specify materials which beneficially could be replaced with new products of materials research. Thus, prescriptive codes may add unnecessary costs which could be reduced or eliminated by different construction methods.

These problems are minor compared to the inhibiting effects they may have on innovative design and experimentation. Codes which are too tightly drawn simply disallow novel or different solutions to architectural problems.

Performance Concept

There are also influences on designers which serve as a spur to innovation and inventiveness. The designer's pride and feedback from colleagues constitute such influences, as do the challenging exigencies of an openly competitive economy. Building codes can have positive effects. This is furthered when the codes are so written that instead of specifying particular materials, dimensions, and the like, they set down some intended result. This leaves the particular path to the result up to the designer and allows for alternate solutions.

However, even such desirable codes can retain some inherent disadvantages. For one thing, there are in the U.S. a large number of conflicting codes since various states, counties, and cities have different codes. This serves to inhibit industrialization or large scale production of housing units. For another, since the code provisions are often arbitrary giving only the desired result and not the reason for the result or any scientific evidence which supports the code provision itself, the designer has no basis for arguing against the code's provisions. Thus, he may be virtually forced into using known and accepted design solutions.

These and related points have led many who are interested in stimulating creative design to look for an alternative approach. A promising approach--namely, the performance approach--was used in Operation BREAKTHROUGH, a housing experiment initiated by the Department of Housing and Urban Development. This experiment was predicated on the viability of the performance requirement approach to building and housing design and evaluation. For Operation BREAKTHROUGH, building and housing code provisions were replaced by performance requirements and criteria.

Performance Requirement Format

Performance requirements bear a strong resemblance to codes which specify an end result rather than a particular construction material or method. That is, performance requirements state how some structure or built-element must perform. In addition, however, the performance requirement as used in Project BREAKTHROUGH makes explicit the reason for, or need being fulfilled by, the required performance, and includes criteria and tests to be used to judge final performance. This is organized into the so-called RCTC (Requirement, Criterion, Test, and Commentary) format which is used in the Guide Criteria for the Evaluation of Operation BREAKTHROUGH Housing Systems (December 1970) (Guide Criteria) developed by the Center for Building Technology of the National Bureau of Standards (See Pfrang, 1970).

In this format, the first item, the Requirement, is a qualitative expression (e.g., Item K.4.3, any smoke generated by the nonmetallic parts of lighting elements integrated with the heating, ventilating and air conditioning system should not exceed safe limits). The second item, the Criterion, sets down the qualitative expression against which actual performance is to be judged (e.g., item K.4.3, the specific optical density generated by the smoke of the nonmetallic parts should not exceed 300). The Test, the third item, gives the procedures for comparing actual built-element performance with the criterion (e.g., item K.4.3, ASTM STP 422, "Method for Measuring Smoke from Burning Materials," by D. Gross, et al. NBS Building Science Series 18). The final element, the Commentary, presents the reason for the performance requirement and any relevant evidence (e.g., item K.4.3, see Table 5-1 on page 77-a, limiting smoke generation is a new fire safety requirement, the introduction of which is based on demonstrated need in this area. The smoke levels represent our best judgment and yet permit the use of most materials commonly considered safe. Although the problem of toxic gases is recognized, at this time there is insufficient data to specify limits. However, the toxic levels will be evaluated in comparison with those produced by cellulosic materials).

How Perceptual Selectivity Enters Design Through Performance

As an illustration of the ways in which an analysis of perceptual selectivity can be applied systematically to design problems, the concluding pages present performance requirements for stairs, an appropriate element in view of the high frequency and severity of stair-related falls.

The performance requirements are arranged under the factors of livability and safety to which they most directly apply and are listed according to the outlines introduced in Table 3-1 (page 45) and Table 4-1 (page 64).

The numbering code for the performance requirements is keyed to the Guide Criteria in Table 5-1 (see page 77a) and to factors in livability and safety. As an example, let us examine the notation "L.3 (stairs) (S.I.A.3.2)." The first two characters - L.3 - key the item to the Guide Criteria. In Table 5-1 we see that "L" refers to Enclosed Spaces and "3" to Health and Safety. The word in parenthesis identifies the built element more specifically. This could later be integrated into the Guide Criteria code if desired.

The initial letter in the second set of parentheses identifies the outline to be consulted, either safety (S), see p. 64; or livability (L), see p. 45; and subsequent characters conform to the numbering and lettering used in the

TABLE 5-1

Built Elements and Attributes for Guide Criteria for the Evaluation of Operation BREAKTHROUGH

Built Elements			Attributes								
			Structural Serviceability	Structural Safety	Health and Safety	Fire Safety	Acoustic Environment	Illuminated Environment	Atmospheric Environment	Durability/Time Reliability (Function)	Spatial Characteristics and Arrangement
			1	2	3	4	5	6	7	8	9
	Structure	A									
Interior Space Dividers	Walls and Doors, Inter-Dwelling	B									
Interior Space Dividers	Walls and Doors, Intra-Dwelling	C									
Interior Space Dividers	Floor-Ceiling	D									
Exterior Envelope	Walls, Doors and Windows	E									
Exterior Envelope	Roof-Ceiling, Ground Floor	F									
	Fixtures and Hardware	G									
	Plumbing	H									
	Mechanical Equipment, Appliances	I									
	Power, Electrical Distribution Communications	J									
	Lighting Elements	K									
	Enclosed Spaces	L									

TABLE 5-1

Built Elements and Attributes for Guide Criteria for the Evaluation of Operation BREAKTHROUGH

Performance Statements' Criteria and Tests are Missing

The performance concept--in this case the social, rather than the physical, performance of a building's element (stairs, in this case)--is based on user needs, or how people will use stairs. Performance specifications are a set of performance statements, each statement consisting of three essential sub-statements and a possible fourth one when necessary. These parts are the requirement, criterion, test, and commentary. The last three require further research and are not included with the exception of occasional, incomplete commentaries to indicate for the reader the nature of this sub-part's role in a performance statement. Definitions of the four parts follow for the readers unfamiliar with them.

The requirement identifies a building component or space and the attributes needed to describe it. These are qualitative elements involving such normative attributes as safety, comfort, privacy, etc. Second, the statement converts the attribute to a criterion which a designer, builder, or manufacturer can follow. The criterion is the quantitative element and identifies how wide, how strong, how much illumination, etc. Third, the statement establishes the procedures for testing the criterion (to see if the proposed building will, or the constructed building does, in fact, perform as specified; i.e., is it that wide, that strong, etc.) And the fourth and optional part of the statement, the commentary, provides the place for explaining how the performance statement was researched or identified, references of interest, or any other background information to clarify the performance statement. In this way, any statement can be challenged and revised as fresh information from research becomes available.

SOME ILLUSTRATIVE PERFORMANCE REQUIREMENTS FOR STAIRS

Obviously, the following performance requirements need further research to develop their validity. Although presently in an incomplete form, they nevertheless are presented here as illustrative of how principles of perception can systematically enter into designing the built environment to increase its safety and livability. Therefore, listed below are only requirements, which are the quantitative portion of the performance statement's four parts (see p.78a). As noted earlier, developing criterion, test, and commentary would require in-depth research which is beyond the scope of this study.

In addition, the livability and safety outlines on pages 45 and 64 make no promise of being comprehensive, again beyond the scope of the report. Therefore, requirements may have many potential subparts which have not been supplied, such as B.1 requirements in Table 3-1's Factors for Livability in Dwellings. Also commentaries which could have been filled out in lengthy detail with data now available have been excluded from this sample list, such as Requirement S.I.A.3.1's "All stairs should have strong railings" which could have had a full commentary based upon a wealth of accessible information <u>if</u> time and funding had permitted for this study.

Principle L.3. (Stairs) (S.I.A.1)

Stairs should not present physical hazards.

Requirement L.3. (Stairs) (S.I.A.1.1)

Stairs should not encroach on floor at top or bottom.

Commentary L.3. (Stairs) (S.I.A.1.1)

Vertical wall corners are used as visual cues to the location of the beginning of stairs. Encroachments disrupt this relationship and can cause accidents, (1) directly when people use the corners as cues, and (2) indirectly by causing people to distrust these cues.

Requirement L.3. (Stairs) (S.I.A.1.2)

At the top, stairs should be set back from a door by at least one tread length. At the bottom, somewhat more distance should be allowed so that people can stand at floor level while opening the door.

Commentary L.3. (Stairs) (S.I.A.1.2)

Attention is distracted by the opening of a door. Lighting is often interfered with or not yet turned on.

Requirement L.3. (Stairs) (S.I.A.1.3)

Doors should never swing into a stairway unless a landing is provided.

Commentary L.3. (Stairs) (S.I.A.1.3)

If a person is attending to the stairs, he may not notice a door being opened in his face. Also, the task of swinging a door inward toward oneself on a stairway can be treacherous.

Requirement L.3. (Stairs) (S.I.A.1.4)

There should be no stairs or ramps or other discontinuities of elevation between any bedroom and the associate bathroom.

Commentary L.3. (Stairs) (S.I.A.1.4)

Sleepy, inattentive persons should not have to cope with obstructions especially when illumination is being held low to avoid disturbing other sleepers.

Requirement L.3. (Stairs) (S.I.A.1.5)

Stairs should not possess sharp edges, splinters or materials which shatter or present hazards.

Requirement L.3. (Stairs) (S.I.A.1.6)

Railing should not have features which could catch clothing, hands, or feet.

Requirement L.3. (Stairs) (S.I.A.1.7)

Railings should be close enough to or far enough from walls so that children cannot get their heads caught between railing and wall.

Requirement L.3 (Stairs) (S.I.A.1.9)

Illumination in stairways should not differ dramatically from that in areas immediately below or above the stairs.

Commentary L.3. (Stairs) (S.I.A.1.9)

The eyes adjust to large illumination changes over a period of seconds or even minutes. Large changes (in either direction) produce functional blindness (glare or blackness) and create a hazard. Especially to be avoided here is sudden exposure to sunlight. If this cannot be avoided, ambient illumination should be very high in places leading to such exposure.

Requirement L.3. (Stairs) (S.I.A.1.10)

Stairs with fewer than three steps should be clearly marked.

Commentary L.3. (Stairs) (S.I.A.1.10)

From below, short stairways do not intrude into the visual field unless fixation is directed downward. From above, the parallax and perspective cues to depth are relatively weak for a short flight of stairs and may not compel attention. This makes stumbling a highly probable event. When three or fewer steps cannot be avoided, the upper and lower floors should contrast in at least two visual dimensions, to help draw attention to the hazardous discontinuity in floor elevation.

Requirement L.3. (Stairs) (S.I.A.1.11)

Windows with low sills, glass doors or panels should not be located at the bottom of stairs.

Principle L.3. (Stairs) (S.I.A.2)

Stairs shall not encourage or require inappropriate behavior.

Requirement L.3. (Stairs) (S.I.A.2.1)

All steps in a flight of stairs should have the same dimensions (risers, treads, nosing).

Commentary L.3. (Stairs) (S.I.A.2.1)

As a person climbs or descends stairs, he sets up a rhythm and forms expectations about subsequent steps. Unequal dimensions interrupt this rhythm and violate the expectations, thereby making missteps likely.

Requirement L.3. (Stairs) (S.I.A.2.2)

Railings should be comfortable and afford a secure grip.

Commentary L.3. (Stairs) (S.I.A.2.2)

If railings are rough and unpleasant to touch, they will be avoided. Instead, their use should be encouraged.

Requirement L.3. (Stairs) (S.I.A.2.3)

Lighting fixtures and windows over stairs and landings should be easily accessible for cleaning and repairs.

Commentary L.3. (Stairs) (S.I.A.2.3)

Stairs should not require that ladders be set up at awkward or dangerous angles. People should not be required to lean out over railings to replace light bulbs.

Principle L.3. (Stairs) (S.I.A.3)

Stairs should possess adequate safeguards.

Requirement L.3. (Stairs) (S.I.A.3.1)

All stairs should have strong railings.

Requirement L.3. (Stairs) (S.I.A.3.2)

No stairs should have open risers.

Principle L.3. (Stairs) (S.I.B.2)

Materials used in stairs and associated structures should be highly resistant to deterioration and aging.

Requirement L.3. (Stairs) (S.I.B.2.1)

Stair treads and rails should meet (durability requirements) in excess of those for materials used in less critical locations.

Principle L.3. (Stairs) (S.II.C.1)

Stair design should discourage use for anything except traffic.

Requirement L.3. (Stairs) (S.II.C.1.1)

There should be minimum enticement for children to play on stairs.

Commentary L.3. (Stairs) (S.II.C.1.1)

This may be unrealistic considering the inherent attractiveness of stairs as a playground.

Requirement L.3. (Stairs) (S.II.C.1.2)

Storage space should be provided near the head and foot of stairs.

Commentary L.3. (Stairs) (S.II.C.1.2)

People tend to "save-up" things to be carried up and down stairs to reduce the total number of trips. Storage of such items on the stairs themselves is tempting but dangerous and should be discouraged.

Principle L.3. (Stairs) (S.II.C.3)

Stairs and associated structures and devices should provide the user with relevant information in clear unambiguous fashion and in such a way that it is hard to ignore.

Requirement L.3. (Stairs) (S.II.C.3.1)

Railings should give a tactual or kinesthetic indication of the first and last step.

Commentary L.3 (Stairs) (S.II.C.3.1)

If the railing bends, narrows, has a different tactile clue, or otherwise indicates the first and last step, a misstep is less likely.

Requirement L.3. (Stairs) (S.II.C.3.2)

Landings should provide a different "feel" to the feet than the steps.

Commentary L.3. (Stairs) (S.II.C.3.2)

This will provide a tactility cue which cannot be avoided--although, of course, it may not be attended to. A different thickness of padding under a carpet, or a slightly different resiliency could provide the cue. (The value of this as a cue must be measured against the possibility of the different "feel" itself producing an accident. Data are needed.)

Requirement L.3. (Stairs) (S.II.C.3.3)

A visual indication of the beginning and end of a stairway should be provided at eye level, and observable with peripheral vision.

Commentary L.3. (Stairs) (S.II.C.3.3)

This often occurs naturally, except where there is an encroachment! See L.3. (Stairs) (S.I.A.1.11.1) The bend in the wall, a change in wall color, a vertical molding in a contrasting color, or a change in lighting can signal the top or bottom of the stairs to a person whose vision is obstructed by an armful of packages. The redundancy involved in using at least two dimensions (lightness, hue, saturation, texture, and pattern) increases the likelihood of observing the steps and makes the accurate discrimination of position and depth easier thereby making missteps less probable. (In this regard, lightness is more critical than, for example, hue and saturation.)

Requirement L.3. (Stairs) (S.II.C.3.5)

A combination of diffuse and direct light should be used to illuminate stairways.

Commentary L.3. (Stairs) (S.II.C.3.5)

Diffuse lighting should be used to provide good overall illumination, and to reduce glare. Carefully selected direct illumination can be used to provide depth cues and to make apparent objects (toys, etc.) left on stairs. This involves the production of shadows and highlights. Consideration should be given to the possibility of floor level edge lighting for stairs. In conjunction with other lighting, this could mark clearly the borders of steps and bring into relief objects left on steps and any obstructions (tears in carpet) residing there. This is not advised as the sole illumination for stairways.

Requirement L.3. (Stairs) (S.II.3.6)

Step surfaces should be patterned so as to provide easy discrimination of nose edges from tread below (when seen from above), and of risers from tread and nose (when seen from below).

Commentary L.3. (Stairs) (S.II.C.3.6)

The practice of carpeting entire stairways with bland, virtually featureless materials is to be deplored. This provides almost no depth cues of discriminable edges. Redundant patterns (stripes, blocks, etc.) or bold large-grain textures are much preferable and afford good visual gradients and contour perception. Patterns with contours parallel to the nose of the steps should be avoided in favor of patterns with contours perpendicular (or nearly so) to the nose. This is because maximum perspective effects are obtained with lines and contours extending away from the observer. Such effects act as depth cues.

Requirement L.3. (Stairs) (S.II.C.3.7)

In dwellings with more than one stairway, dimensions and safety design features should be similar--identical, if possible.

Commentary L.3. (Stairs) (S.II.C.3.7)

Stairs can be made safer by capitalizing on expectancies built up through experience with other stairs. The information provided in each stairway will be in the same form. Conversely, if stairs differ in these aspects, the confusion which might result could cause a serious accident. Where these features cannot be made identical, other features (not concerned directly with safety) should be made highly dissimilar so that it is obvious to the dweller which stairs he is using. That is, the dissimilar features can become associated with differences in critical dimensions, etc.

Requirement L.3. (Stairs) (S.II.C.3.8)

Stair lighting should be controllable from the top and bottom of the stairs.

Principle L.9. (Stairs) (L.1.A.3)

Stairs should not constitute a source of intrusions (theft, vandalism, rape, etc.)

Requirement L.9. (Stairs) (L.I.A.3.1)

Heavily carpeted stairs which give no auditory cues from foot falls are to be avoided where said stairs are accessible to the public.

Commentary L.9. (Stairs) (L.I.A.3.1)

Stairwells provide an ideal hiding place. Unless there is a special reason for acoustic privacy, auditory information as to the presence of people in the stairway should be available. See also Requirement L.3. (Stairs) (S.I.A.1.8).

Principle L.9. (Stairs) (L.I.B.2)

Stairs should not generate or expose people to disturbing stimuli.

Requirement L.9. (Stairs) (L.I.B.2.1)

Open stairways should be designed to minimize the possibility of vertigo.

Commentary L.9. (Stairs) (L.I.B.2.1)

The motion parallax and other "visual-cliff" type depth effects which result from looking down from high places (especially while moving) produces in a significant number of adults (but in very few children) an unpleasant dizziness or vertigo. This can be minimized in several ways. One is to extend the steps beyond the railing 18 inches or more so that the person cannot see straight down. A firm thick opaque railing and kickboard or low wall can help. For high stairways an enclosed stairwell is best.

Requirement L.9. (Stairs) (L.I.B.2.2)

Sound generated by walking up and down stairs should not interfere with other activities.

Principle L.9. (Stairs) (L.I.B.4)

Stairs should not contribute to unwanted disclosure of body or behavior.

Requirement L.9. (Stairs) (L.I.B.4.1)

Stairs should be designed so that females can prevent others from looking up their skirts.

Commentary L.9. (Stairs) (L.I.B.4.1)

Transparent stairs, or open stairs at a high angle from rooms used for entertaining should be avoided.

Requirement L.9. (Stairs) (L.I.B.4.2)

Stairways should not provide visual access to private living areas from halls and other more public areas.

Principle L.9. (Stairs) (L.I.B.3)

Stairs should require as little vigilance or attention as possible.

General Commentary L.9. (Stairs) (L.I.B.3)

Many requirements already listed can contribute to this principle. The following are especially relevant:

L.3. (Stairs) (S.I.A.1.1)

(S.I.A.1.3)

(S.I.A.1.5)

(S.I.A.1.8)

(S.I.A.1.10)

(S.I.A.2.1)

(S.II.C.3.1)

(S.II.C.3.2)

(S.II.C.3.3)

(S.II.C.3.4)

(S.II.C.3.5)

(S.II.C.3.7)

L.9. (Stairs) (L.I.A.3.1)

Principle L.9. (Stairs) (L.I.B.6)

Stairway should not require excessive exertion.

General Commentary on L.9. (Stairs) (L.I.B.6)

Some other requirements already listed can contribute to this principle, especially L.3. (Stairs) (S.I.A.2.3); L.3. (Stairs)

Requirement L.9. (Stairs) (L.I.B.6.1)

All areas used for carrying out a given task should be on one level. Emergency items should be available on each of widely separated levels.

Principle L.9. (Stairs) (L.I.B.8)

Stairs should not require new or different habit patterns.

General Commentary L.9. (Stairs) (L.I.B.8)

Some requirements already listed can contribute to this principle especially L.3. (Stairs) (S.I.A.2.1); L.3. (Stairs) (S.II.C.3.7)

Principle L.9. (Stairs) (L.I.B.9)

Structures which must be depended upon for structural or personal support should appear as strong and trustworthy as they are.

Requirement L.9. (Stairs) (L.I.B.9.1)

Stairs should feel firm. They should not vibrate or make squeaking noises.

Requirement L.9. (Stairs) (L.I.B.9.2)

Railings should not feel untrustworthy. Supports should be close enough together so that there is no perceptible sway or bending.

Principle L.9. (Stairs) (L.II.B.1)

Stairs should detract as little as possible from the pleasant appearance of a dwelling and where possible should contribute to its beauty.

Requirement L.9. (Stairs) (L.II.B.1.1)

The scene from the top or bottom of stairs should not be one which is hard to prevent from looking drab, cluttered or messy.

Commentary L.9. (Stairs) (L.II.B.1.1)

The scene should be as neat, lively and uncluttered as possible.

To Conclude

The previously listed performance requirements for stairs are offered as the concluding section. Hopefully, the report's earlier chapters (Chapters 1 through 4) supplied enough detail to show how perception influences people's behavior and to illustrate how design requirements such as the preceding ones can be drawn from such principles of perception. To sum up briefly, the reader was next offered differing definitions which architects and psychologists bring to perception, a short description of the anatomy of perception, and the selective nature of design.

To finish a thumbnail overview of the report, the remaining chapters (Chapters 5 through 8) explored in greater depth how perception's selectivity can affect design by presenting analyses of livability and safety along with an explanation of a performance statement's four sub-parts. The last

pages set forth some sample performance requirements for stairs. As the reader now knows, a performance statement's criteria, tests, and commentaries will have to wait on completion of research, now in progress. Even so, the authors hope that the present approach to introducing principles of behavioral science to design for safety and livability will prove useful in helping improve the future built environment.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

For over a decade, architects have been calling for applications from social science which would contribute to building design better suited to the building's users. This report provides such applications relying upon the state-of-the-art knowledge of the psychology of perception, showing how human perception operates in the everyday use of buildings, and then drawing upon this rationale to present building requirements to guide the design and construction of safer stairs in future buildings. The building safety "requirements" have been written in the format and style of the Guide Criteria for the Design and Evaluation of Innovative Housing Systems, a housing performance specification written by NBS for HUD's large housing experiment, Operation Breakthrough. The report is directed toward both building designers (who could consider the use of the stair safety requirements for their own building projects) and architectural psychology researchers (who could take the proposed requirements as a set of hypotheses in further research and experimentation).

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