The Visual Perception of the Built Environment
Symbolic presentation of the interior of a theatre, seen through the pupil of an eye (Theatre of Besancon). About 1800.

This well-known print after a drawing by Claude-Nicolas Ledoux aptly summarizes the theme of this book. Ledoux drew his building in this way to emphasize the importance of good visibility from all seats in the theatre. The beam of light ('rayons visuels') is an allusion to the sight-lines.

'Il faut de la régularité & de la bizarrerie, des rapports & des oppositions, des accidens qui varient le tableau, un grand ordre dans les détails, de la confusion, du fracas, du tumulte dans l’ensemble'

M.A. Laugier, Observations sur l’architecture (La Haye, 1765) p. 313.
The Visual Perception of the Built Environment
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References
1. Visual perception

1.1. The problem and the credibility of the solution

Modern urban man is surrounded by buildings every hour of the day, and usually every day of the week. How does he perceive these buildings? That is roughly the question this book tries to answer.

How does he see these buildings? — if he really sees them, because it is quite well possible that he pays but scant attention to them. The form of the built environment, so dear to many architects, may well be of marginal interest to urban man. Nor are the visual aspects the only, or even the main determinants of form. The functional aspects are more important. For the purpose of providing shelter for people, activities or commodities, money is set aside, a program is drawn up, a design for a building is made and the building is constructed. Available building materials and techniques of construction also exert a strong influence on the forms that are built. In addition to practical and technical constraints, the aesthetics of architect and client play a part in the design too.

Already in 80 A.D. the Roman architect Vitruvius distinguished the following determinants of form in buildings: the function or usefulness (utilitas), the strength of the construction (firmitas) and beauty (venustas). The final form of the building is the product of all three factors.

Vitruvius discussed the design and production of buildings. His analysis may help us to understand how a built form originated, as a conjunction — often as a compromise (Prak 1968) between the three determinants. But a building can also be analyzed from another point of view. Instead of looking at the origins of forms, we can study their effects on human behavior. Although there will be a considerable overlap between the results of both kinds of analysis, they will not be completely coincident. Doors, stairs and windows will often be used for the purpose for which they have been designed; yet in most buildings some parts of the design are not used at all (e.g. vents which cause a draught are blocked; some operable windows may never be opened, etc.). The analysis of the built environment in this book is made from the latter point of view, and focuses on perception.

Architects are aware that the buildings they have designed have an effect on other people's perception. They speak and write about 'crisp' facades, 'lively' masses, 'intimate' effects and 'hard' forms. The use of such terms is based on the tacit understanding that everybody will experience these forms in the same way as the architect. But the beliefs and attitudes of the architect are products of his professional training and practice. Such beliefs have grown and been developed primarily within the subculture of architects and architectural critics. It may well be that such terms as 'crisp' or 'lively' refer to a system of norms and beliefs that is valid only within that subculture; a sort of professional lore that is handed down from generation to generation in the architectural schools.

The question how people perceive forms has been extensively studied. Starting with Fechner (1871) and Mach (1886) a growing number of psychologists has experimented in this field. Although these experiments did not give rise to one single, complete and coherent theory of visual perception (Zusne 1970, Pastore 1971), there is sufficient agreement (de Groot 1961) between different schools on important areas in the field to allow a number of scientifically objective statements to be made. A review of such statements (as will be given in this book) might provide architects and urban designers with an insight how their buildings are being perceived.

Books and papers on psychology generally use abstract, two-dimensional figures consisting of points, lines, blots, etc. (in section 1.4. we will discuss the reasons for this). Our review might consist of a series of descriptions of experiments with their results, which
are relevant to our purpose. Applying the conclusions of such experiments to the perception of buildings might be left to the reader. The advantage of such a procedure would be that scientific rigor would remain unimpaired; the descriptions would never go beyond what had been established in the experiments. The disadvantage would be that the majority of readers would probably have no idea how to apply these experiments to situations in everyday life; they would seem too barren and abstract to them.

This discussion leads to a more precise formulation of the problem set in this book. We will try to apply the results of the experiments to architecture. This implies a generalization of the results beyond the boundaries of the original experimental material and group of subjects. To set off such generalizations from the original experiments, we will collect them in the text at the end of each chapter under the paragraph-heading ‘Application’. (This distinction will be omitted under the photographs, which are nearly all applications).

The problems of architectural design and aesthetics can be approached from various angles. In an earlier publication (Prak 1968) I tried to construct a general theoretical model which might help to explain the choice of a particular set of forms by a particular architect. In this book I will focus on the others: those who 'experience' architecture without any knowledge of the architectural jargon. The main question of the earlier book was: 'what is that form supposed to convey?' Here I will concentrate on: 'what is actually transmitted?'.

The first three chapters deal with the perception of form and space. The material that is discussed in these chapters can be considered as (relatively) reliable, factual and proven. This does not hold, at least not to the same degree, for the experiments and results discussed in the last two chapters. The need for variety, contrast and complexity can only be demonstrated indirectly; the existence of such a need in the human subjects seems probable, but not certain. The discussion of the meaning of forms is even more tentative. Experiments in this area are few and far between, and we have to rely partly on the interpretation of individual cases. The arrangement of the chapters follows roughly a descending order of reliability.

1.2. The visual system

What we see is determined not only by what there is to be seen, but also by the qualities of our eyes, our optical nerves and our brains. For instance: our eyes are insensitive to infra-red light, something which several types of photographic film are sensitive to. The infra-red sensitivity of such films has created the possibility of infra-red photography; these films ‘see’ more than we do. Another example is the limited speed of reaction of the human eye. Beyond a certain frequency per minute, succeeding images are no longer perceived as separate. This flicker-fusion made film and television possible.

The visual perception of our environment is carried out by our eyes and the part of the brain to which they are connected, the visual cortex (Fig. 1). Patterns of light travel through the transparent parts of the eye till they reach the retina. The transparent parts of the eye: cornea, aqueous humour, lens and vitreous humour, project an image on the retina with a point-to-point correspondence with some part of the outside world. An annular muscle around the lens allows the focusing of this optical system on a variety of distances.

The entire visual system is adapted to obtaining a maximum of information with a minimum of effort and means. Just as most animal eyes, human eyes are adapted primarily to the discovery of changes in the environment, and particularly of movements (Lettvin, Maturana, McCulloch and Pitts 1949, Hubel and Wiesel 1962, Gregory 1966). Such adaptation is obtained through function specialization of the different parts of the visual system.

The constituent elements of the retina: cones, sensitive to color, and rods, sensitive to light and dark only, are well-known. The most sensitive area of the retina, the fovea, located approximately in the optical axis, contains only cones, about 100,000 on a surface of 1/16 inch in diameter. Outside the fovea, the density of cones decreases and of rods increases (the density of rods decreases again in the proximity of the lens). The
Fig. 1. The human visual system: eyes, optical nerves and visual cortex. The optical nerve of each eye is divided in two: the left (hatched) half of each retina is connected with the left-hand side of the visual cortex, the right half with the right-hand side.
number of neural connections of the fovea, and the area of the visual cortex to which these connections lead, is proportionately much larger than those of the peripheral areas of the retina. Which is why only the fovea allows sharp and detailed vision.

Changes in the periphery of the visual field are only globally and vaguely perceived by the peripheral parts of the retina. These changes (movements, points lighting up etc) warn the perceiver that 'something is going on', after which he can focus the fovea on such a change.

Electrical pulses transmit the stimuli on the retina to the brain. Combinations of photo-receptors (light-sensitive cells) and neurons produce a pulse if a point lights up; other combinations — sometimes having a few cells in common with the first — produce a pulse when a light-point is 'switched off'. Some combinations produce a pulse on 'switching on' as well as on 'switching off'. This shows once again how much the visual system is adapted to the perception of changes.

Through cross-connections, a pulse from a combination can inhibit the electrical activity of an adjacent area of the retina. This lateral inhibition enhances contrasts between (light)stimuli, as the electrical activity — and with that the perception — of an adjacent area is weaker than it would have been with independent operation of all photo-receptors. Lateral inhibition causes simultaneous contrasts. A grey spot looks lighter on a dark, background than on a white one; it looks greenish on a red ground and reddish on a green one. Simultaneous contrast makes grey letters on a white page look darker, which increases legibility (Voorhoeve, Walter and van den Brink 1968). Simultaneous contrasts are visible in Figs. 2 an 9.

The diagram of Figure 1 shows those parts of the brain which are directly connected with the eyes. This diagram may lead to the erroneous idea that these parts are the only ones involved in the perceptual process. But the visual system is not like some electrical appliance, connected by a ‘plug’ to the rest of the brain; it is on the contrary closely intermeshed with other areas and many other mental functions participate in the act of perception. For instance, we blink our eyes and duck when something comes flying at our heads. Recognition of objects or people involves memory; if we cry out on a dark night, ‘I see a falling star!’, the image has usually disappeared at the time we speak about it, so that involves memory too.

Indeed, if we study somebody else’s perceptions through his reactions to some visual stimulus, we can never disentangle perception and memory, for there is always a time-lapse between the onset of the stimulus and the reaction (Garner, Hake and Eriksen 1956).

The next section (1.3) will give a brief outline of the interaction between muscles in movement and perception. Perception involves far more than the visual system alone.

Our eyes are continuously moving. The movements are necessary for perception, as the experiments with stabilized retinal images show (Riggs, Ratliff, Cornsweet and Cornsweet 1953, Yarbus 1957, Heckenmueller 1965). A miniature projector is attached to a contact lens; a figure on a transparency in this projector moves with the eyes and therefore always stimulates the same photo-receptors. Such a stabilized image fades after one to two seconds, leaving only a perception of a uniformly lit field. Apparently our visual system is adapted solely to the perception of changes. In the perception of stable objects (such as this page for instance) the changes are effected by eye-movements. The smallest eye-movement, a tremor over an arc of half a minute with a frequency of 50 - 150 oscillations per second (nystagmus) is unnoticeable, involuntary and automatic and continues even if we focus on a fixed point.

1.3. Moving images, but a stable environment

The retinal image must shift continuously to be seen, but we are usually not aware of such movements. Our environment looks pretty stable, even if we roll our eyes, turn our heads or walk around. Apparently the shifting retinal images are processed together with the innervations which activate the muscles of the eyes, the head and the limbs to form a single complex perception (von Helmholtz 1866, von Holst 1954, Gregory 1958).
Fig. 2. Lateral inhibition. Tonal contrasts between black and white are enhanced around the dividing contour: the white becomes whiter, the black turns blacker. At the intersections of the white lines there is no black to make the white appear whiter; therefore the white remains unenhanced and greyish at these points, and we see the small grey squares.

A simple method to ascertain this coordination between retinal stimuli and muscular innervations is to press with two fingers against the lower eyelids. This produces eye-movements without the concomitant innervations of the eyemuscles, and now the environment does move indeed.

The coherence between retinal images and muscular innervations is also clearly shown in the following experiment by Kohler. The subject wore for 20 consecutive days a pair of glasses. The left half of each glass had a blue color, the right half was yellow. The strong color contrasts between the two halves tended to fade during the experiment. The visual system of the subject adapted itself. Aftereffects were found at the end of the twenty days when the glasses were taken off. A pair of uniformly blue glasses would have caused the environment to look yellow at the end of the experiment (just as a red neon sign produces a green afterimage). The aftereffect in Kohler's experiment turned out to depend on the direction of vision. At the left side of the visual field (blue glass during the experiment), the environment looked yellowish, whereas the righthand side (yellow glass during the experiment) looked bluish. The interesting point is that the same region of the retina was involved in this, i.e. the fovea and immediately adjacent areas. The visual
system had apparently adapted itself to the color of the glasses in conjunction with the direction of vision, as it was 'known' to the visual cortex from the innervation of the eye-muscles (Kohler 1964).

The visual world is also stable in another sense of the word. The amount of light reflected by a white sheet of paper in sunlight is many times the amount reflected by the same sheet in the shade. In fact, a black sheet in the sun may reflect more light than a white sheet in the shade. Therefore, the amount of light received by the retina is different in these different cases. Yet the white sheet remains white when it is transferred from the sun to the shade, and does not turn gray, and the black remains black.

In making a photograph we will often tell somebody to move back a bit further, for otherwise 'his feet will be cut off'. In this procedure we make use of the fact that the projected image on the film shrinks with increasing distance. In the same way the projection of a person on our retina shrinks with increasing distance. Yet we do not really see him shrink in size; he remains the same. A slice of baloney which we turn around on a fork projects a series of images on the retina, varying from a circle to an eclipse and a line; yet we perceive it always as a round slice (Thouless 1931, Koffka 1935, Gibson 1950, Ittelson 1951-a). We do not see perspectival images, with trapezoidal walls and ceilings, with longer and shorter legs on the same table, with enormous babies close by and tiny adults in the distance, but a world without perspective, in which walls and ceilings remain rectangular, people keep their sizes and objects their shapes. Apparently here too, a mechanism is operating which coordinates perspectival retinal images and apparent colors, shapes and sizes in one single coherent and stable perception of the outside world.

It is this constant, often rectangular world which children draw (Metzger 1936, Arnheim 1956) and which we see in many non-Western pictures (Figs. 3, 4, and 5). It is far from simple to translate the perspectival retinal image in a perspective drawing, as anyone knows who has ever tried.

1.4. Incomplete perception

We collect visual information by scanning our environment with our eyes. This information is partly stored in our short-term memory. (Voorhoeve, Walter and van den Brink 1968) and produces in conjunction with the area on which we focus at the moment a picture of the environment. Storage in short-term memory is indispensable, for otherwise we would have forgotten when we were looking at the lower right-hand corner of a painting what we had seen in the upper left-hand corner. Without storage we would be able to understand a sentence only when we could perceive all its words at the same time.

The mosaic of forms and colors that is picked up in parts and processed in a single perceptual unit is very complex (Fig. 6, 7). If every point of light that stimulated the retina were duly stored and processed, the perceiver would be able to recall every single detail. One sweeping glance over the contents of a shop window would suffice for the recall of every item and each price tag. An hour's shopping in a department store would produce a visual memory resembling a mail order catalog. Fortunately for us we do not have to cope with such an overwhelming collection of data. Our perception is selective, rather than inclusive. Although the retinal mosaic contains innumerable details, attention is paid only to some of them. Parts of the mosaic which stand out from their surroundings through contrasting color, size, intensity or movement or through novelty draw involuntary attention. We may speculate that these attention-drawing characteristics are a part of our biological inheritance from the time that Neanderthal man was an agile and weak hunter in a hostile environment who had to depend on his wits and his perceptions for survival. Large, novel or moving things might be potentially dangerous or might be a desirable prey. Advertising makes extensive use of the involuntary drawing of attention to size, contrasting color and movement.

The selection of parts of the visible mosaic for more attentive inspection is influenced by our past history, e.g. as when we suddenly recognize a friend in a crowd or a long lost tool in the garage. Fatigue or preoccupation may restrain the mechanism of attention. 'Wrapped in thought' we may not recognize the friend or run into a lamppost during a walk.
Fig. 3. Representations of three-dimensional reality on a two-dimensional surface are not perspectival as a matter of course. In this child’s drawing of a church the rear and side façades are both shown in frontal view; the rear façade has been flipped over.

Fig. 4. This mosaic in Sant’Apollinare Nuovo in Ravenna contains a similar representation of a church in the upper left-hand corner. Here it is the entrance façade with the projecting portico which has been flipped over to the same plane as the side elevation.
Up to a point we can influence the selective mechanism ourselves, e.g. when we look for a lost key or thimble, or when we ‘concentrate’ on the road when driving over a difficult stretch. This voluntary attention is of course also influenced by fatigue, competing interests, etc. (Broadbent 1958, Buckner and McGrath 1963, Lynn 1966, Sanders 1967, Mackworth 1969 and 1970).

The preceding section (1.2) described how changes on the periphery of the retinal image draw attention, after which foveal vision is brought to bear upon them and we can inspect such changes in detail. The system of sharp foveal vision and global peripheral vision is geared to maximal efficiency, i.e. to do much with minimal means. We can see now that a similar efficiency characterizes selective perception in the mechanism of attention and storage. Parts of the retinal mosaic stand out through movement, novelty or conspicuous size or color. The mechanism of involuntary attention was very useful once for hunting and escape from dangers and is still useful and efficient in driving a car or making your way through a crowd; it is less useful when it is exploited by advertisers. Voluntary attention is efficient in perception when we are hunting for something we lost or for the performance of a difficult task. In addition, the parts of the retinal mosaic are so organized in the perceptual process that the informative ‘new’ elements amongst them stand out over the redundant ‘familiar’ ones, as the next chapter will show. Selective attention and this reduction cause some parts of the environment to be seen (received on the retina), but to remain ‘unnoticed’. It is of great practical importance to study and know these processes of selection and simplification, because that may show for instance which visual stimuli can still be adequately handled by a pilot or a driver, and which cannot.

Such knowledge cannot be obtained under normal visual conditions. For a normal environment offers a surfeit of visual information, which makes it hard to determine

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Fig. 5. Indian miniature of about 1600, also showing frontal views of planes which are perpendicular to each other: the bed with the cushion and the side-elevation with the door.
which stimuli — and why exactly these and not some others — are selected or how simplification takes place. A considerable reduction in the amount of visual information offered for inspection is necessary if we want to find out something about the general tendencies of visual perception. Such a reduction allows control over the variables involved in perception. That is the reason behind the frequent use of relatively simple abstract figures in perceptual experiments.

The experiments are based on the assumption that some tendencies in perception are universal and can be discovered by systematic investigation. This assumption is a prerequisite to the generalization of experimental results: what holds for 50 subjects must hold for everybody else as well.

The problems involved in generalization are quite large. Imagine a psychologist reporting an experiment with 50 teenage girls from Detroit as subjects. An obvious question to ask would be whether he would have got the same results if he had used boys instead of girls, adults instead of adolescents, rural instead of urban Americans and people from a non-Western instead of from a Western culture. Therefore, a simple assumption of generality is insufficient.

It is assumed that certain aspects of visual perception are universal, i.e. shared by everybody who can see. Other aspects are thought to vary because of genetic factors; yet another set of aspects is assumed to be due to environmental factors; these may be biological, such as reading too much by candlelight or taking hallucinatory drugs; or they may be due to learning. In every unique individual, these factors are completely intermeshed. Perception is simple and direct for him. He sees ‘what there is’, i.e. what he believes to be objective reality. Only by appropriate sampling and comparison of statistically large enough groups can the psychologists hope to unravel this intricate web of influences on perception. This work is still far from completed. Some genetic variations,
Fig. 7. Figure 6 is a detail of this photograph, turned over 90 degrees; it is part of a group of houses reflected in a canal. Fig. 6 shows how complex the mosaic of light and dark patches is that stimulates the retina. As soon as the mosaic is 'recognized', all blots and patches fall into place in an orderly pattern of windowframes, doors, walls and water.

Fig. 8. Reduction and simplification in a drawing of a 4-year old girl. The child concentrated on the elements which are meaningful to her: head and limbs, omitting bodies. Head, nose and mouth are drawn as ovals; limbs as single lines. Of course children do not see people that way; it is no more than a demonstration of selective attention and an indication of the direction which simplification might take.
such as color-blindness or myopia, are easy to establish, but many other individual genetic variations may yet be discovered. Individuals have been shown to vary in their dependence on visual clues for establishing the vertical direction in an environment (Witkin 1954, Holzman and Klein 1954).

Strenuous efforts have been made by psychologists to disentangle the environmental from the other factors. It is very difficult to construct culture-free or culture-fair tests which can be applied to both Western and non-Western groups of subjects (Lloyd 1972). The results reported in this book can therefore be considered only to apply to Western subjects.

It is difficult to isolate the influences due to learning. The human being is born with a functioning visual system which he uses immediately. He starts to accumulate visual experience from the day of his birth, yet he cannot be interrogated about what he learns. According to Gibson (1966), the nature-nurture controversy has lost a great deal of its significance and its edge in recent years; it ought to be more a question of proportions than of irreconcilable antithesis. Some reactions are probably more innate than learned: the distinction between figure and ground (von Senden 1932, Gregory and Wallace 1963); the perception of space and depth (Hess 1956, Walk and Gibson 1961); the ability to recognize figures and photographs as pictures of real objects (Hochberg and Brooks 1962). The Gestalt tendencies are probably also more innate than learned, as the results of some experiments with animals (Hertz 1928) and with non-Western subjects seem to indicate. The controversies over nature versus nurture, in combination with a number of contradictory experimental results, have led to different theories of visual perception (Koffka 1935, Ames 1946, Hebb 1949, Gibson 1950, Neisser 1967).
2. Perception of forms

2.1. Figure and ground

The human visual system can be interpreted as an information-processing apparatus, comparable to such instruments as telephones or wireless-sets. Electrical instruments are much simpler to take apart or to change; a study of their properties may illuminate some of the properties of the visual system. Therein resides the advantage of such an interpretation.

Information-processing apparatuses never reproduce completely all the information that was put into or through them. Inherent to information-processing is distortion of information. Most of the tones and overtones produced by a speaker are transmitted by radio or telephone, but some are lost in the process of transmission. Every information-processing apparatus had built-in limitations in its capacity for handling information. The limitations determine the channel-capacity of the apparatus: the maximum amount of information which the apparatus can process or transmit.

Some of the limitations of the human visual system were discussed in the first chapter. One of them is the speed of perception: movies are based on a rapid succession of still pictures at a rate of change which exceeds the channel-capacity of the human visual system. Also, it was pointed out that the visual system is geared to the perception of changes in the environment. One of these changes is the change in tonal value on either side of a contour. Lateral inhibition enhances these differences (Fig. 2). The enhancement of tonal differences is also visible in Fig. 9. Comparison of Fig. 9 with Fig. 10 shows that other differences may also be enhanced in perception. Both figures use essentially the same compositional scheme: a series of concentric squares with the darkest square in the center, the lightest on the outside, and a gradation from dark to light in a number of equal steps. However, the entire field of Fig. 10 is subdivided in small equal rhombs.

The row of equal rhombs, with only small tonal differences, may conceivably lead to the interpretation of a row of fully identical rhombs from left to right. The visual system provides a ‘warning’ against this obvious but mistaken ‘reading’; the corners of the overall squares, where the same tonal value changes its direction, are enhanced. This leads to the perception of a diagonal cross of slightly darker rhombs. (Such an enhancement is not possible in Fig. 9, because every surface of the same tonal value was left intact, see below). Besides an enhancement of tonal differences we have now also an enhancement of changes in direction (see also Attneave 1951).

The enhancement of tonal differences on both sides of a contour helps us in the reading of texts and the perception of objects. Only on a dark night, far from any illumination, do the forms of trees, shrubs and haystacks lump together in one black mass; with a ray of moonshine we see everything separate again.

Lateral inhibition helps to distinguish between figure and ground in perception. The distinction between figure and ground is the first quality perceived by successfully operated blindborn patients (Von Senden 1932, Gregory and Wallace 1963); it is therefore probably inborn.

The differences between figure and ground can be investigated with such figures as Fig. 12, in which the ‘figure’ can be interpreted as ‘ground’ and vice-versa.

It appears that:
- the figure is harder, more material and more a ‘thing’ than the ground; the ground is conversely weaker, more diffuse and indeterminate;
- if one form is entirely enclosed by another, the larger is perceived as ‘ground’ and the smaller as ‘figure’ (Figs. 13 and 9);
- without enclosure (Fig. 14) the smaller form is still perceived as ‘figure’ and the
Fig. 9. In this concentric series of squares we see the same hue of grey appear lighter against a darker surface and darker against a lighter ground. Lateral inhibition causes this simultaneous contrast, which makes the same grey appear to change from one edge to the other.

larger as ‘ground’;
– the ground continues behind the figure; the figure seems therefore to lie before or on the ground; consequently the ground has no contour at the contour of the figure. (Rubin 1915, Woodworth and Schlosberg 1954, Weitzman 1963, Zusne 1970).

The distinction between figure and ground makes each of them to be perceived as one separate and distinct whole; small differences in tonal values within either the figure of the ground therefore remain often unperceived. The ‘unity’ in the color of the squares of Fig. 9 prevents the perception of enhanced corners such as in Fig. 10.

The distinction between figure and ground stands out clearly in figures with a sharp and well-defined contour. But it is not confined to such figures; it applies also to such soft-edged forms as wisps of steam or clouds of smoke. The same effects pertain to them, with the exception of the contour of the figure.

Our perception of the environment is by and large stable, objective and reliable. The overwhelmingly realistic character of visual perception makes it hard to believe that the process is far from simple and not always reliable. Lateral inhibition provides a simple example of ‘misperception’ (Fig. 2). For this reason, and also because it allows a simple
transition to the perception of contours and figure and ground, we discussed it in section 1.2. Though contour-perception is important, it is only one of the perceptual mechanisms. The perception of texture — which cannot be reduced to contour-perception — is another (Gibson 1950).

2.2. The Gestalt-laws of form-perception

Human and animal visual perception is particularly well adapted to the perception of differences and changes in the environment. Examples of such differences are the contrasts between two tones on both sides of a contour (enhanced by lateral inhibition) and the drawing of attention by movements. Perception tends to focus on the different rather than on the similar, and on the new rather than on the familiar.

Most of the scenes we perceive in daily life are made up of a mixture of new and familiar parts. The streets through which we drive to our places of work we know well enough; the movement of cars along them is the new and unpredictable part of percep-
Fig. 11. Figure and ground, after Rubin. The figure has been designed for approximate equivalence of figure and ground; either the light or the dark parts can be perceived as ground.

Fig. 12. A similar design as Fig. 11, with different tonal values.

Fig. 13. The ground is the largest, enclosing form, the figure the smaller, enclosed one.

Fig. 14. Generally, the smaller form is perceived as the figure, the larger one as the ground. In this design, figure and ground can be interchanged, as in Figs. 11 and 12, because they are similar in form and neither encloses the other.

tion and on that we (better) concentrate. The office or classroom is perfectly familiar; a secretary with a new hairdo or a new student are noticed because they are (partly) novel elements in the familiar setting.

Familiarity and novelty are complementary in these perceptions. The new face and the new hairdo stand out against the background of the all too familiar scenery. Driving in an unknown city is more difficult than in our hometown, because we have to attend to the names of streets, one-way signs, traffic lights at unexpected places in addition to the other cars.

The complementary character of the new and the familiar is emphasized in information theory. Information theory arose from the study of electronic communications and focuses therefore on messages. At any point during our hearing or reading of a message we can try to predict what comes after on the basis of what we heard or read before. What cannot be predicted in the latter part of the message is called: information; the predictable part is called: the redundancy. As the message proceeds, the information decreases and redundancy increases.
The concepts can be applied to our previously mentioned perceptions: our hometown Main Street is familiar and redundant, but the position and speed of cars on it is ‘information’. The office is redundant, the new hairdo is information. Any visual thing can be partly hidden and we can try to predict the invisible half from what we see and know, as indeed we often do in perception. From our familiarity with dogs we can guess correctly the whole dog if we only see a snout; but it is impossible to infer the shape of an unknown animal (or a bush, a rock, etc.) from a small visible part.

‘Information’, in the sense where it is used here (and elsewhere) in this book, is a far more restricted term than the ‘normal’ word (though it does not run counter to normal usage). It has the advantage that it refers both to the object (text, figure, animal, interior, etc.) perceived, and to the knowledge of the perceiver. Well-known classic pieces, such as Handel’s ‘Watermusic’ or Beethoven’s Fifth Symphony can be recognized from their opening bars, and are therefore fairly redundant. In the same way, opening lines such as: ‘To be or not to be . . .’ or: ‘Four score and seven years ago . . .’ recall the famous texts that follow them, for those with a good memory even down to the last line. Such music and such texts are redundant because of the knowledge of the perceiver. Texts such as: ‘it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains, it rains’ are redundant in themselves, just as the rhythm of a metronome or the repetition of windows in an office building.

One of the advantages of redundancy in a perception is that it allows us to concentrate on the information. In an unfamiliar (i.e. less redundant) Main Street we have to divide our attention over the traffic and the street signs, name plates, numbers, etc.

Too much redundancy leads to a lagging of interest. Repetitive texts (‘it rains, it rains, it rains’, etc.) or overfamiliar popular tunes are boring. It might seem therefore that only the information is important and the redundancy can be deleted or forgotten. But this is not true, as some examples may show.

Academic textbooks contain more information per line and per paragraph than thrillers or novelettes; therefore they are harder to read. Some lines may be so full of information that they have to be read twice to be understood. Some paragraphs in mathematical treatises can only be understood after prolonged study.

Consider the following sentence from a textbook on experimental psychology: ‘In terms of adaptation-level theory, the indifferent zone moved in the direction of stimulation, thereby serving to neutralize stimulation that would otherwise continue to be as annoying as it was on the first presentation’. (Corso 1970, p. 546) Although every single word is familiar to a high-school senior, the whole sentence is unintelligible to him. In order to extract the information it contains, he must know what ‘adaptation-level theory’, ‘indifferent zone’, and ‘stimulation’ mean; or, put differently, these words must be redundant to the reader.

Knowledge proceeds from the known to the unknown. Predictability depends on an amount of prerequisite knowledge to allow an ‘educated guess’; without such knowledge it seems senseless to try to predict the latter half of the quoted sentence from the first half. We read texts because we think that something unknown will turn up; but if everything is unfamiliar, we lose interest. Highly redundant texts are boring because we can accurately predict what will follow; texts with too much information are boring because we cannot make sense of them.

The argument can be extended to the visual perception of other things than texts. Simple checker-board patterns or grids are highly redundant and therefore boring when they cover large areas (Fig. 92). Conversely, very complex patterns, for the perception of which we lack the prerequisite knowledge, are of little interest too. Examples of such patterns are for most of us Indian sculpture, or X-ray photographs of the intestines. The latter are full of information for radiologists, because they know what to look for; the layman sees merely a set of vague discolorations.

Two limiting conditions for perception appear to emerge from this discussion. As an information-processing organism the human being is adapted to the perception of differences and changes. But he must be able to perceive a difference as a difference, i.e. there must be something known to compare it to (Fig. 6). Therefore a certain amount of redundancy is a prerequisite. Perceptions without redundancy are just as uninteresting as highly redundant ones (Moles 1971).
This section is intended to serve as a general background for the discussion of the so-called Gestalt-laws of form perception. A group of German psychologists started in the twenties to investigate how we perceive forms. Information theory did not exist at that time; also they set themselves a different kind of problem. They were interested in the ways in which complex patterns were organized in perception: were these always seen as simple additions of their elements, or were they combined in some way? If a figure consists of a single closed outline, is it always seen as a single unit, or is it sometimes seen as two? (Fig. 19) With the help of ambiguous figures they were able to discover a series of tendencies of perceptual organization. Four of such tendencies are applicable to the perception of the built environment and will be described in some detail below.

Each of these four can be viewed, in the light of the foregoing discussion, as a tendency of human perception to maximize the redundancy. Repetition is immediately recognized (2.2.3) patterns are predicted to continue as they started (2.2.4), and are organized in the largest units possible (2.2.1, 2.2.2, 2.2.5). The tendency to maximize the redundancy shows the efficiency of perception, for the information contained in the pattern of visual stimuli stands out more clearly that way. Organizing the pattern of visual stimuli for maximal redundancy allows us to concentrate on the new and unpredictable elements in it, i.e. on changes and differences (Wertheimer 1923, Koffka 1935).

2.2.1. The law of Prägnanz
Psychological organization of visual stimuli will always be as ‘good’ as the prevailing conditions in the outside world allow. The term ‘good’ remains undefined and embraces such qualities as ‘regular’, ‘symmetrical’, ‘simple’, etc.

The law of Prägnanz (an untranslatable German word) indicates that, as far as possible, the visual system integrates the separate visual stimuli in a (meaningful) whole. Thus we do not perceive a number of grey patches on some pages of this book, but a white page with one or more photographs and text. The whole will always be as large as possible: Fig. 15 is more easily perceived as a trapezoid with a diagonal drawn across it than as the addition of two triangles.

2.2.2. The law of proximity
Forms which are close to one another tend to be perceived as a coherent group (if the prevailing conditions allow it). The law of proximity is a direct consequence of the law of Prägnanz: groups in a configuration reduce the number of elements and are therefore a ‘better’ organization than when all elements perceived are separate (Fig. 16 a). The role of the ‘prevailing conditions’ can now also be clarified: if the dots are unequal in size, the law of proximity does not hold (Fig. 16 b).

2.2.3. The law of equality
Equal or similar elements are immediately recognized as such. Equalities or similarities are redundancies in perception. The recognition of equality or similarity depends on the adjacent elements in the figure. As the difference between similar and dissimilar elements decreases, it becomes harder to recognize the similarity (or equality), because it is less conspicuous (Fig. 17).

2.2.4. The law of continuity
There is a tendency for perceptual organization to continue a figure as it was started: a straight line as a straight line, a zigzag as a zigzag, a curve as a curve, a plane as a plane, etc.

The law of continuity states that in continuing a figure there is a tendency not to add new information; the redundancy is maintained (Fig. 18 a). For turning an angle or changing a direction implies something new, which is additional visual information. The existing and visible parts of the figure provided no clues for something unexpected, such as a change of direction.

Because the information is ‘concentrated’ at the points of change of direction, viz. the angles, a complete figure is perceived even if only the angles are given. The law of continuity makes us ‘fill out’ the missing lines. The effect is called closure (Fig. 18 b).

2.2.5. Simplicity of form
Perception organizes the visual stimuli in as large and as simple forms as possible. ‘Simple’
Fig. 15. Most people see this primarily as a trapezoid with a diagonal, rather than as two superimposed triangles, though the other interpretation remains possible too.

Fig. 16. The law of proximity. The top row is perceived as consisting of points in pairs. If the points are unequal in size, grouping takes place, not according to the law of proximity, but to the law of equality, in pairs of equal points.

Fig. 17. Whether the equality of elements in a configuration will be recognized depends – as always – on the prevailing conditions. The squares on the left are easily recognized as being equal, because they also differ in size. On the right, the squares and circles are equal in size, and therefore harder to distinguish. On the left, a difference in form is enhanced by a difference in size. The recognition of similarities or equalities becomes still more difficult if variations in form and size do not coincide, e.g. with large and small squares and large and small circles.

Fig. 18. Continuity and closure. Perception has a tendency to continue lines as they started: a straight line as a straight line, a zigzag as a zigzag, a wavy line as a wavy line, for such continuation does not add information. Closure is shown on the right: the four angles are sufficient to perceive a rectangle, though only a minor portion of its total outer edge is drawn. Information is concentrated at the corners, where the edge changes its direction. The intermediate parts of the edges are filled out by the law of continuity. Center: closure works, even if the edges are not straight, as in this 'triangle' with its quasi-bent edges.
can mean 'regular', 'symmetrical', 'without (or with few) reentrant corners', etc. This law is an elaboration of the law of Prägnanz for spatially contiguous stimuli (Fig. 19).

The Gestalt-laws indicate how the visual system operates with maximum efficiency in the area between information and redundancy. The visual system recognizes redundancy (law of equality), encompasses separate elements in groups (law of proximity), adds no new information (law of continuity) and organizes contiguous stimuli in forms as large and as simple (redundant) as possible (simplicity of form). Symmetrical forms are redundant because parts on both sides of an axis of symmetry are equal. A rectangle is more redundant than a trapezoid, for all angles are equal. The relation between the concepts of information and redundancy on the one hand and the Gestalt-laws on the other is evident, but attempts to quantify visual stimuli in information-theoretical units (such as bits) have failed so far (Attneave 1951 and 1959, Garner 1962, Leeuwenberg 1968, Zusne 1970, Neisser 1967).

The Gestalt-laws are conditional, as the first law already states. They are not laws such as the laws of physics or of biological heredity; perhaps they are better called tendencies. There is no fixed hierarchy amongst them, in which one law always prevails over another. On the contrary, in some cases the second prevails, in others the third or the fourth (Figs. 20-23).

Fig. 19. Simplicity of form. The two upper rows show that continuity or discontinuity of the edge determines whether one or two rectangles are perceived. Even if the dividing line is missing, a single outline can be perceived as two hexagons.

Fig. 20. More examples of simplicity of form and continuity. At the top: a curved line and a rectangular line going up and down are perceived, rather than a set of irregular trapezoids, because the first interpretation is simpler than the second. Below: simplicity of form prevails over closed outlines. The first resolves itself into figure and ground, but the second does not because the two triangles are simpler than the last two figures of the bottom row.
2.3. Perception of directions

Various experiments show that the visual system has a special sensitivity to the perception of directions. Beck investigated the relative effectiveness of perception of two groups of figures with differences in form and differences in direction. Twenty-four equal figures, all inclined at an equal angle, were scattered in an irregular pattern among a group of 40 equal upright T's, also distributed in an irregular pattern. The two groups were projected on a screen with separate projectors. Originally the intensity of light of the two groups was the same, but during the experiment the intensity of one of the groups was gradually reduced. Subjects had to indicate the moment at which they saw the 24 figures.
as a separate pattern. The difference in the intensity of light between the two groups served as a measure of the figural distinction between the two groups; the more the difference in form stood out, the less the necessary difference in light-intensity would be, according to the hypothesis (see also Fig. 17). For the 24 figures T's and +'s were used at various angles. T's and +'s under 45° needed significantly less difference in light-intensity to be perceived as a separate pattern than T's and +'s turned 90° and 180° (Beck 1967). In peripheral vision (figures projected on the retina outside the fovea) short lines with a different direction are also more easily perceived than short parallel lines (Beerens and Bouma 1970).

Bouma and Andriessen set up the following experiments on the perception of direction. A dimly lit circular screen of 1' diameter was placed in front of the subjects eyes at 1'-8" distance. Slightly off center a point of light was visible; by pushing a button the subject could see for 0.1 second a short illuminated line-segment at 2" distance from the point of light, pointing approximately toward the point. The subject was asked to move the point over the screen till it was exactly in the direction of the segment (Bouma and Andriessen 1968).

The mean error of placement across subjects and experiments was largest if the segment made an angle of 45°, (135°, 225°, 315°) with the horizontal, and smallest if the segment was horizontal or vertical. As the angle of the segment approached the horizontal or the vertical (e.g. 15° or 75°), errors were no longer regularly distributed, but tended towards the nearest horizontal or vertical. In other words, the point was moved closer to the horizontal (or vertical) than it ought to be if it were correctly placed. Bouma and Andriessen concluded that the visual system is more sensitive to horizontal and vertical directions than to others. This conclusion is supported by the discovery of a special sensitivity for directions in monkeys and cats (Hubel and Wiesel 1962, 1968).

The presence of another line-segment, against which the first (test-)segment abuts, influences the movement of the point. (In all these experiments, the location of the point is supposed to be evidence for the perception of the direction of the test-line). If the (second) induction-line runs at a fairly large angle with the test-line, the test-line is perceived as more perpendicular to the induction-line than it really is (Fig. 24 a). If on the contrary the induction-line runs at a small angle to the test-line, the perception of the test-line is 'pushed around' in the direction of the induction-line (Bouma and Andriessen 1970).

2.4. Application

A great number of visual design-problems can be tackled with the help of the laws and experiments described above. If an architect wants a long façade in a street to appear shorter (because it would otherwise appear to be 'out of scale'), he can divide it according to the principle of Fig. 19 in parts of unequal height; if the dividing line is accentuated by a pilaster or a drain, the building will be perceived in two parts. The contrast between the parts can be enhanced by differences in fenestration, color and texture of materials, etc. Conversely, a number of different façades can be unified in an alteration job by raising them all to the same height and covering them with the same material. The first operation brings them under the law of continuity and of simplicity of overall form, the second enlarges the redundancy of the surface, and both increase the possibility of seeing these façades (according to the law of Prägnanz) as one single indivisible whole.

Such operations are easier to perform on rectangles than on circles (Fig. 25). Some shapes have so much internal coherence (through redundancy) that it is very hard to subordinate them to a larger configuration; they remain visible as distinctly separate forms. Such forms can be called 'hard Gestalts'. A circle is in this sense 'harder' than an equilateral triangle, and a square is 'harder' than the average rectangle. Often the only way to subordinate them is to use the law of continuity, by continuing one of their contours (Figs. 20, 21, 25).

A hard Gestalt which has a common contour with some other form of a different color or shade gives rise to a figure-ground effect (Fig. 26). One form seems to be located before the other, because the second form is completed too (see also Fig. 22). This effect
Fig. 24. The experiments of Bouma and Andriessen. The (long) induction-line influences the perceived direction of the short test-line, as is shown by subject's errors in situating the dot.

Fig. 25. A 'hard Gestalt', such as a circle, is difficult to integrate with other forms. Two circles remain two circles and do not change into some other, more complex, unified form (see also Fig. 19). A rectangle is but loosely attached to the circle and becomes more of a part only when its side is a tangent to the circumference of the circle (law of continuity). A rounded end at the rectangle enhances the relation between the two parts; it uses the law of equality for increasing visual redundancy.

Fig. 26. Simplicity of form makes us see the figures at the left as 'in front' or 'on top' of each other. Indenting the forms that appear to be behind (middle column) reduces the depth-effect; breaking the contours of both forms brings them in the same plane, because then each form is at the same time 'in front of' and 'behind' the other.

can be countered by breaking the contour; both forms are then perceived as lying 'on top' as well as 'below' each other (Ratoosh 1939, Ittelson 1952, Chapinis and McCleary 1953).

Configurations which nearly, but not entirely satisfy a certain Gestalt-law will produce ambiguous perceptions. Such ambiguous forms are difficult to decode, because perception vacillates between two 'readings'. Figure 27 shows some examples of ambiguous forms. The angle that the line connecting the two vertices makes with the nearly-continuous horizontal sides is evidently the decisive factor in Fig. 27 a. The configuration of points of the upper part of Fig. 27 c belongs mathematically to the same type as the lower part of 27 c: the distances alternate between short and long. However, because the regular spacing (middle row) is far more redundant, there is a tendency of the visual system to opt for that alternative, which produces the ambiguity.

Repetitive series of equal forms are called rhythms in architecture, just as in music. We can distinguish between three types of rhythms: regular, increasing and irregular ones (Fig. 28). Regular rhythms may consist of the repetition of a single element at regular intervals, or of a group of elements; the criterion for regularity is the instant recognition of the group that is repeated. The recognition of the redundancy of repetitive groups is harder than that of single repeated elements, which makes a larger number of repetitions necessary (Fig. 29). If the number of repeated groups is too small, ambiguity will be the result (Fig. 41). Increasing (or decreasing) rhythms depend on the redundancy in the
Fig. 27. Ambiguous figures. Each figure of the top row lies between the two below it. a) Top: the two sides do not line up, yet seem to do so, because of the law of continuity. Middle: lining up; bottom: unambiguously not lining up. b) The dot seems to be nearly in the center. c) The series of dots consists of pairs so spaced that it could be a continuous series with equal intervals. In each of these three ambiguous figures the ambiguity arises from being very close to a simpler form, which is preferred in perception because of its greater redundancy.

Fig. 28. Rhythms: regular, increasing and irregular.

Fig. 29. Three repetitions are sufficient if the repetitive element consists of a single line only. Repetitions of groups (middle) contain more information; to make decoding still relatively easy, additional redundancy is desirable, which is obtained by repeating the group more than three times.

Fig. 30. The tendency to increase redundancy is so much a part of the visual system that even entirely irregular rhythms look as if they had some regularity.
reduction of sizes or distances: the proportion between two succeeding sizes or distances is constant (Figs. 29, 41). Irregular rhythms are generally the hardest to design, for the tendency of the visual system is to enlarge redundancy, which means that regularities will be perceived even where there are none (Fig. 30).

An arbitrary collection of irregular figures on a ground (Fig. 31) has but little coherence. Such a configuration does not only contain a great number of curves, vertices, sizes and directions, but in addition do the distances of sides and vertices to each other and to the edges of the ground vary continuously. Such a configuration, as far as contours and location on the ground are concerned, seems to go in the direction of the informational maximum that was described in section 2.2.

The large amount of information makes the decoding of such a configuration virtually impossible; it seems completely accidental and meaningless for the visual system (Moles 1971). The shapes seem to 'float' in the space of the ground. Increasing the redundancy enlarges the readability and hence the meaningfulness. This may be obtained by reducing the number of shapes and/or the number of types of shapes; by lining them up parallel to the edges of the ground (two vertices and a side at equal distances to the edge of the ground = redundant), by reducing the number of dimensions, and finally by applying the law of continuity (Fig. 32).

The last operation in particular has the effect of changing the left-over space of the ground between the figures into a figure of sorts too (Fig. 33). A characteristic difference between an arbitrary collection of figures on a ground (such as in Fig. 31), which seem to be completely disconnected, and a 'tight composition' is that in the latter, figure and ground are, up to a point, reversible. The figure can be seen as ground and the ground as figure, because both have a certain amount of redundancy, which is indispensable for the perception of some form as a figure.

Reversibility is of course far simpler to obtain with rectangles in an upright position on a rectangular ground than with triangles on a rectangular ground (Fig. 34). Each point on a single edge of the rectangle has an equal distance to the parallel edge of the ground, which increases the redundancy of the ground. A triangle may 'float' more in the space of the ground.

The various experiments with directions allow the explanation of some other aspects of the perception of forms. The special sensitivity of the visual system for directions ex-
plains why deviating directions in architectural design are so conspicuous.

Inclining lines or edges can be subdivided in markedly oblique and ambiguously oblique ones (Fig. 35). The experimentally demonstrated tendency of the human visual system to perceive nearly horizontal lines as still more horizontal and nearly vertical lines as still closer to the vertical, reduces an already small angle still further. The ambiguity can be reduced by the addition of a truly horizontal line (Fig. 35 c), for now the degree of deviation from the horizontal can be read off from the differences in distance. (These differences are of course the same in inches in Fig. 35 b, but percentually they are there much more insignificant).

Yet another ambiguity can arise with small angles of inclination near a vertex. The oblique line of Fig. 36 a seems to have been accidentally dislocated, from the rectangular vertex; it 'ought' to have started in that vertex, as Fig. 36 c does. Fig. 36 c is clearly more redundant than Fig. 36 a, because it has only one vertex, where Fig. 36 a has two. Because the two vertices are so close to each other (see Fig. 36 b), the visual system tends to interpret Fig. 36 a as an inaccurate form of Fig. 36 c. With a larger angle, or the abutting to another side (Figs. 36 d and e), the ambiguity disappears, because the intersection with the second side moves too far away to be interpreted as accidental.

**Fig. 33.** Reversible figure. It can be seen as two black shapes on a white ground, but also as a white loop on a black ground.

**Fig. 34.** A black square on a white ground can still be seen – up to a point – as a reversible figure: a white ring around a black patch. The triangle (second from the left) does not allow such an interpretation, because the distances of every side and vertex to the nearest edge of the ground vary. The coherence between triangle and ground can be enlarged by increasing the redundancy with the help of the Gestalt-laws: drawing one side parallel to an edge of the ground; coincidence between vertices of figure and ground; having two or three vertices of the triangle on the edges of the rectangular ground. The last two operations produce simpler forms in the (white) areas of the ground visible next to the figure.

**Fig. 35.** The experiments of Bouma and Andriessen showed that an oblique line which is nearly perpendicular to another is perceived as still more perpendicular. This makes the middle figure ambiguous. A horizontal line immediately below it shows the degree of inclination as a series of increasing heights or distances, which removes the ambiguity.

**Fig. 36.** Corners and ambiguity. a is more ambiguous than d, notwithstanding the greater distance between the vertex of the right angle and the point of intersection of the oblique line; b and e show why this happens.
Fig. 37. Housing often uses equal forms.

Fig. 38. Rhythm through equality and proximity, just as in Fig. 16.
Fig. 39. Equal windows at equal intervals, which makes this block appear to be one long building. The subdivision in separate dwellings is visible only in the first floor and the chimneys.

Fig. 40. Here the subdivision in separate row-houses is made visible by a repetition of groups, each of which corresponds to one unit.
Fig. 41. Façades decorated with a repeating group of 5 posts, each group consisting of a rhythm of increasing intervals. The side elevation shows only two of such groups, which makes them hard to recognize as repetitive groups. See also Figs. 28 and 29.

Fig. 42. The law of continuity. Lining up the side of the small window with the corner of the masonry above 'connects' the window visually with the corner. It produces a reversible façade, comparable to Fig. 33.
Fig. 43. The windows in this façade are all different, sills or heads correspond but rarely, so very little redundancy occurs. This causes the windows to 'float' in the façade. See Fig. 32.

Fig. 44. Counter-example to Fig. 43: many equal dimensions and corresponding sills and heads (law of continuity). The upper floor is a reversible figure: the concrete wall-panels can be seen as an 'H' on its side. The masonry of Fig. 43 cannot be perceived as an independent form.
Fig. 45. 'Give a book': poster around the beginning of December by Gerard Wernars for the Dutch Booksellers' Association, showing the Dutch Saint Nicholas (his feast is on December 5) whispering the slogan in the ear of Santa Claus. All forms have a simple contour; many sides of the figures are parallel to the edges of the poster, many elements are repeated (oblique lines, rounded corners, eyes and ball on the cap of Santa Claus). The left-over areas of the ground between the figures are also of a simple form, which produces a certain degree of reversibility. The coats of both gentlemen end exactly in the corners of the ground.
Fig. 46. Simplicity of overall form in the combination of radiator and headlights in a Renault 4.

Fig. 47. The very small gradient of the roof makes this elevation resemble a rectangle. The predilection of our visual system for horizontals and simple rectangles creates an ambiguity.
3. Space perception

3.1. Equivalent configurations and the optical array

The last chapter described a set of psychological tendencies in form-perception, relevant to the perception of the built environment. The psychologists of the Gestalt-school were interested in finding general principles and used therefore simple, flat test-figures primarily. As a consequence, our first group of applications focused on flat forms too, such as posters and facades.

But the built environment is three- rather than two-dimensional; can the ‘laws’ of form-perception be applied to three-dimensional forms as well? I believe they can; but that also involves the principles of space-perception in general. A discussion of these principles is therefore necessary, before we proceed with further applications.

The perception of space seems self-evident. We simply see ‘what is out there’; movement and touch usually confirm our visual perception. Usually, but not always; sometimes we see depth where there is none, or perceive depth incorrectly (Figs. 57, 59). A clever draftsman may create an illusion of depth with some cues, contradict them with others, and leave us with an insoluble spatial paradox (Fig. 58). These ‘misperceptions’ show: 1) that space-perception depends on a whole set of cues rather than a single one; 2) that these cues are differently weighted (for otherwise we would not see a ‘dwarf’ in Fig. 57 or depth in Fig. 58). The cues will be enumerated in the next section and their contribution to space-perception will be discussed there.

An adequate explanation of space-perception should cover both the majority of cases in which visual perception is right, and the exceptional situations in which it goes wrong. One way of constructing such an explanation would be to relate space-perception to experience. We have no experience with distorted rooms as shown in Fig. 57, or with the shapes of Fig. 59, whereas we do have experience with rectangular rooms, three-pronged forks and right angles. Already in the cradle we start to accumulate spatial experience in grasping for rattles and curtains. Through trial and error we integrate the experience of movements with visual images; space-perception might hinge on the redundancy of the cues. But Walk and Gibson (1961) have shown in a famous experiment that this view is probably erroneous; spatial vision is more likely to be innate than learned (fig. 48).

For a long time, spatial vision was believed to be due primarily to our having two eyes (Pastore 1971). The differences between the two retinal images provided the information from which spatial perception was constructed. However, closing one eye makes the world look flatter, but it does not obliterate depth perception. People with only one eye are allowed to drive cars. Wearing an eye-patch is only a minor impediment, which does not make you bump into everything. Photographs, paintings or prints (Fig. 56) may create a truly impressive illusion of depth, which would be impossible if the illusion depended on binocular vision alone. We will start our discussion of the cues for depth perception with monocular ones, which are more powerful and general than the binocular. Also, the consideration of movement will be postponed for the moment.

The concentration on monocular stationary cues makes it possible to use the camera-analogue: they are projected on the retina in the same way as the outside world is reproduced on a photographic film in a camera. Fig. 49 shows that a great many different forms produce exactly the same set of light-rays, which is called the optical array for that set. A single retinal image corresponds to a particular array in monocular stationary perception. The different forms which produce the same optical array are all equivalent configurations for that optical array. The illusion of depth in a photograph or a realistic painting is the result of equivalent configurations (Fig. 50).

A ray in the optical array (e.g. OP, in Fig. 49) is completely determined by the optical
Fig. 48. The visual cliff. Babies from 6-14 months old were put on the far end of the table in this photograph. The mothers stood at the side from which the photograph was taken, and called out to the babies, so that they would crawl over the heavy plateglass window covering the deep side. Practically all of them refused to cross the abyss. There was no evidence that this apprehension of height was learned from experience with falling. This experiment of Walk and Gibson (1961) shows that depth perception is fully developed by the time a baby can crawl, and that it is not based only, or primarily on experience.

center of the (stationary) eye and a point on one of the equivalent configurations. Which point is actually represented by this ray (P₁, P₂, P₃ or P₄) cannot be perceived by the eye, because it cannot measure the distance along the ray. The whole length of a single ray of light is projected as a point on the retina. Or, in other words, a ray of light is determined by 0 and two coordinates in any one of the equivalent configurations, but it represents a point (or line, such as P₁–P₂) in three-dimensional space. The indeterminate third coordinate is the distance along the ray (0P₁, 0P₂ or 0P₃) (Ittelson 1960)
The indeterminate distance of the point along the ray of light is familiar to us all, not only from photographs, but also from observations in nature. Binocular vision or movements makes no difference to our view of the starry sky. Therefore all stars look as points of light radiating from an immense celestial sphere around us, an illusion reinforced by the apparent turning movements of that sphere during the course of the night. And that was indeed the way in which the stars were perceived in Antiquity, as equidistant lights on a sphere. From astronomy we know that such stars as Bellatrix and Betelgeuse in Orion are 50 lightyears apart, yet they continue to look equidistant. The planetarium uses the equivalent configuration of a sphere with lights for a deceptively realistic imitation of the starlit sky.
Fig. 49. An optical array of equivalent configurations. All these figures produce the same retinal image, and the eye cannot determine which of them is the origin of this image, because it cannot estimate the distance of a point on a light-ray. $P_2$ may just as well be the origin of the light-ray $OP$ as $P_1$, $P_3$ or $P_4$.

Fig. 50. Equivalent configurations allow the construction of perspective drawings with a convincing effect of depth. Brook Taylor's engraving of 1719 shows the principle of perspective drawing. Dürer's woodcut shows a simple device for its practical execution. The eye of the draughtsman is fixed by the vertical rod. His perspective view of the woman is subdivided by a grid of threads; he transfers the details which he sees in a square to the corresponding square on his paper.
3.2. Cues for depth perception

Though the stars in the sky are an extreme case, there are other situations in which it is difficult or impossible to guess distances. Look at the mountain on the left in Fig. 54. We know that it has volume and depth, but that is because of our familiarity with mountains. The uniform black of that mountain provides no information for a three-dimensional perception; a cardboard cut-out in a diorama would produce a very similar retinal image. The same holds for the mountain ranges behind it.

But what does provide a clue for depth perception in that photograph is the fact that we see a series of adjacent irregular forms, each of its own distinct color. The optical array of that scene is not uniform throughout, but falls apart in a set of different arrays, corresponding to different objects – here to mountains – in space.

A second cue is overlay. The black mountain on the right is in full view, whereas the grey mountains are partly invisible; they disappear behind it. A car that obscures part of a building stands in front of it; if the building obscures a part of the car, then that must be behind it (Figs. 40 & 46). Escher used overlay to contradict the cues from perspective in Fig. 58. The tendency to perceive simple forms (2.2.5) combined with overlay leads to the perception of figures in different planes in the left-hand part of Fig. 26. A special case of overlay is the perception of figure and ground (Fig. 13); the ground ‘disappears’ behind the figure, or the figure stands ‘before’ the ground. The baby of Fig. 48 is perceived on top of the checkerboard table.

Another type of cue is size. The (visual) angle of the optical array of an object becomes progressively smaller as the distance between the eye and the object increases (Fig. 51). Note that a correct estimate of the distance of an object involves a knowledge of its size. The height of the mountains of Fig. 54 is unknown; therefore the farthest range may be either very high and very far away, or nearer and lower. This cue can be overridden by others. The girls in the Fig. 57 give the correct cue to the perception of the room, yet we cannot help but see either one as a giant or the other as a dwarf.

Some experiments have been conducted on this cue. In one experiment, subjects were shown two inflated rubber balloons at equal distances from the eye, sparsely lit, in a dark room. The balloons were invisibly connected by a tube, and a pump inflated one while deflating the other. The inflated balloon was perceived as advancing toward the eye, the deflated one as receding (Ames 1946, Ittelson 1952). Similarly, two points of light of different brightness at equal distances from the eye in a dark room are perceived as two equally bright points at different distances (Ittelson and Kilpatrick 1952). These experiments show that perception opts for constant size rather than for constant distance, if other cues are eliminated. Size-constancy may be the fruit of our experience; our everyday world is filled with objects of fixed sizes at varying distances. This hypothesis is supported by another experiment by Ittelson (1951b). He mounted playing cards of normal design but of abnormal sizes at various distances, and eliminated all other cues for space perception. One cue he could not eliminate: the accommodation of the eye to bring the card in focus (in monocular perception). But that was overridden by the size-judgment.

The varying angle of the optical array of objects of the same size is the cause of perspective. As the visual angle of the sleepers diminishes with increasing distance (Fig. 53), the rails seem to approach each other and to meet on the horizon. The receding surfaces of a lawn, a brick pavement or wall, a carpet or a gravelled path provide the same cue.

An entirely different set of cues is given by atmospheric conditions. The mountain ranges in the center of figure 54 are seen as farther away because they are lighter in tone; our vision of them is obscured by the rising haze of daybreak. This cue is called aerial

![Fig. 51. The angle of vision subtended by a form decreases with increasing distance to the eye.](image)
The reduction in apparent size of the pebbles is a cue for the perception of depth. The atmosphere absorbs some of the light, particularly in a haze or a fog. That is why objects on the horizon are usually hazier and more bluish in color than trees or buildings nearby. In exceptionally dry areas, such as the Arizona desert, this cue is missing and consequently everything looks much nearer than it really is.

In a fog, adequate spatial perception is also hindered by the lack of shade; everything looks gray. Handbooks of photography always advise amateur photographers to take their pictures with side-light. Photographs taken with the sun straight behind the camera (or against the light, see Fig. 54) look very flat. Snapshots with a flash light mounted on the camera gives similar flat results. The depth-effect of a photograph is partly dependent on the plastic, three-dimensional appearance of objects which is produced by a contrast between light and shade. Light and shade are therefore also cues of spatial perception.

All the above cues are used in monocular perception from a fixed point of view of an immobile environment. They apply just as much to our environment as to a good color photo of it. With the exception of color, they hold also for the photographs in this book, and cause their illusion of depth.

The next cue cannot be transmitted by a photograph. Through my window I can see a parking lot, an apartment building behind it and a wood in the far distance. If I move my head, the window will shift in the appropriate direction in my retinal image, the cars on the parking lot will shift less and the apartment building will shift hardly at all respective to the wood. The amount of shift is a cue for the distance of each object: this is the movement parallax.

All the above cues can be effective in a monocularly perceived fixed environment. Sometimes objects in the environment are themselves moving: a branch in the wind, a pedestrian, a car, etc. Such movements again tell us something about the spatial position of these objects respective to their surroundings, primarily because the moving object stands out as a figure from the immobile ground.

All the above cues hold good for monocular vision. Binocular vision produces more data about the space around us. The optical arrays of the same scene are different for our two eyes: you can see different sides of a letter, a ruler or a matchbox held just before your
Fig. 53. The sleepers below the rails are all equal, but subtend a smaller angle with increasing distance, which is why the rails run to the vanishing point on the horizon: the principle of linear perspective.

Fig. 54. Aerial perspective, caused by the absorption of light in the atmosphere, makes near objects stand out more clearly than distant ones. It is of course particularly noticeable in a haze or a fog.
nose with each eye. The same shift in objects that occurs in the movement parallax, operates also in the images of our two eyes, of course. The different optical arrays are combined in a single perception, and the differences between the retinal images are cues to the structure of space. These differences are used in a stereoscope for obtaining photographs with a stronger depth-effect.

Finally, two physiological cues contribute to our knowledge of space. The annular muscle around the lens of the eye must be contracted to get the object in focus (accommodation). We aim the visual axes of both eyes at objects at which we are looking; this is very visible when we squint at something right in front of our noses (convergence). Muscular innervations are combined with retinal images in the perception of a stable world (see section 1.3); therefore the muscular innervations for accommodation and convergence can also be used for space perception.

Research has shown that these last two cues are not very reliable, easily overridden and of comparatively minor importance (Ittelson 1960). Accommodation and convergence are dependent rather than independent variables; we adjust our accommodation and convergence to the apparent distance instead of estimating the apparent distance from accommodation and convergence (Ittelson and Ames 1950). As the lens hardens around 45 years of age, accommodation drops out and people have to wear reading-glasses, with hardly any loss of depth perception. Accommodation and convergence are only effective over very short distances, in the immediate vicinity of our bodies. Linschoten has pointed out that stereoscopic vision too is primarily effective over distances between 30 and 100 cm from the eyes; i.e. over the distance which is within reach of our hands; the same distance in which accommodation and convergence are most pronounced. Stereoscopic vision, convergence and accommodation allow us to guide and control minute movements of our hands, e.g. in threading a needle, repairing a watch or setting a jewel. They are therefore of great value to man-the-maker, but of comparatively little importance in the perception of the built environment (Linschoten 1950).

3.3. The simplest of all equivalent configurations

In static monocular vision it is impossible to determine the distance of objects with certainty, because of the principle of equivalent configurations. Binocular vision is ineffective for perception at a distance. On the other hand, correct spatial perception is facilitated by many cues. Many visual phenomena can be explained with the help of equivalent configurations and these cues.

Why do we usually perceive only one of these equivalent configurations, which, moreover, if we try to verify our perception by touching the objects with our hands, nearly always turns out to be correct? How can a human subject estimate the length of a rod of 1.80 m at a distance of 700 m with an average error of only 14% (Gibson 1950)? And why, if perception is usually true, is it not always so?

In the perception of a stable world, information from quite different sources is welded into an indivisible whole. Part of that information consists of shifting retinal images, another part of muscular innervations. In the same way space perception consists of the integration of a variety of visual data into a single percept. Each different cue provides some information about the spatial structure of our environment; and in general all the cues add up. The three-dimensional 'normal' equivalent configuration is the simplest of all configurations. All the cues, including those by touch, are 'right' for it, usually, and they are moreover redundant. Even in the photograph of Fig. 54, which provides so little information, all the cues point in the same direction: the mountains in the center are overlaid, lighter (aerial perspective) and smaller than the ones on the sides. Only in the psychological laboratory are cues seen in isolation (e.g. the balloons of varying sizes of the Ames experiment). The overlay of the figures on the left side of figure 26 is similar to such a test situation, because it occurs in 'abstract' figures. Usually we know far more about the overlaying and the overlaid forms (e.g. see Fig. 46); then perception is redundant in that sense too.

Space perception can therefore be interpreted as 'an educated guess', involving previous knowledge, and based on all the cues available (Ames 1946, Ittelson 1950). This combina-
Fig. 55. Two- or three-dimensional? Each vertical pair may be interpreted as two views of the same object. The bottom row is perceived as three-dimensional, the top row as two-dimensional, because this is the simplest of the equivalent configurations in each case.

The hypothesis that space perception is no more than a guess can be supported with the study of Fig. 55. These figures can be interpreted as pictures of the same set of objects, seen under different angles. The top row, however, seems to consist of flat figures, and the bottom row of three-dimensional objects. Only with an effort can we see the top row as three-dimensional and the bottom row as flat. The figures of the bottom row are more regular and symmetrical, i.e. more redundant when perceived three-dimensionally. The top row with its bi-axial symmetry is already very redundant as a flat form, which is why it is seen in two dimensions only (Kopfermann 1930, Metzger 1936, Hochberg and Brooks 1960).

The multitude of possible cues for depth perception and their redundancy allow the creation of convincing equivalent configurations. All monocular static cues are used since the Renaissance to create pictures with a 'deceptive' depth-effect (Fig. 56). By setting off some cues against others, 'impossible' spatial situations may be depicted too (Figs. 57, 58, 59). If the stronger cues are used for enhancing the 'false' depth-effect and the weaker ones for contradicting it, perception will inevitably follow the royal road towards a mistaken space-construction. These illusory spaces enhance the constructive character of space perception. (Neisser 1967) We do not really see what is 'out there', but construct an equivalent configuration based on the information provided by the cues, which is simpler than the flat pattern. If we are fed 'wrong' (Fig. 57) or contradictory cues, the construction will be wrong too.

The photograph depends, just as the perspective drawing, on equivalent configurations of monocular static cues. Movement (3.2.5) is added in films and television. The absence of movement-parallax (3.2.4) and sometimes of stereoscopic vision (3.2.6) puts a limit to the deceptiveness of the three-dimensional effect; it is nearly always evident that we are dealing with a representation and not with reality itself. Besides, an equivalent configuration is only really equivalent if the eye of the beholder is in exactly the same position to the photograph as the lens of the camera to the negative when it was taken. In any other position the optical arrays do not coincide. (Fig. 60). Exact coincidence is of course exceptional in practice, and that again makes it easy to distinguish a photograph or a film from reality (Pirenne 1970).

Overdetermination of spatial perception and perceptual reduction causes us to see 'things as they really are' and not their perspective images. People keep their sizes as they walk away, and rails do not intersect on the horizon, but remain parallel. We understand a
Fig. 56. This engraving by Piranesi of the cisterns at Castel Gandolfo of 1764 uses all the cues for static monocular space perception to create a convincing illusion of depth: position in space, overlay, perspective, aerial perspective and light and shade.

Fig. 57. Conflicting cues. The distorted room of Ames has been carefully constructed to appear as rectangular: the distant corner, in which the diminutive figure stands, has been proportionately enlarged so as to be equal in height in the retinal image as the near corner (Eastern Daily Press, Norwich).
Fig. 58. 'Belvedere', a lithograph by M.C. Escher of 1958. The power of cues for space perception such as perspective and light and shade is so strong, that they can be set in conflict with overlay (Escher-stichting Haags Gemeentemuseum).
Fig. 59. More impossible figures, based on the power of perspective. No three-dimensional object can correspond as an equivalent configuration to the figure on the left. It uses closure and continuity to connect two different (and possible) objects, i.e. a three-pronged fork on the left and a U-shape on the right, in a single ‘impossible’ 3-D form. The device is similar to the use of columns in Fig. 58.

little better now why so many pictures make no use of perspective (Fig. 4,5). The picture is made after the threedimensional form. The perspective drawing is an equivalent configuration, which is just as artificial and as difficult to construct as a psychological test-picture.

A large building cannot be completely seen ‘at a glance’ from close quarters. Yet we can get a complete – and usually correct – perception by looking along its sides, its height, etc. A single scheme of the form of a building is apparently constructed from the different perceptions. This shows again that our separate perceptions are not forgotten, but stored in our memory. If we walk around the building, we have to make an even heavier demand on memory, because when at the back of the building we must remember our perceptions of the front. Otherwise, it would be impossible to obtain a total image without plans and elevations. With complex buildings this is difficult indeed – and sometimes impossible – but with a house or a shed it is easy. For reading books, watching films or listening to music we use our memories, for otherwise it would be impossible to remember the previous adventures of heroes or to recognize the variations on a musical theme. Detective stories, the musical development of themes, or reasoning or argumentation would become impossible without memory. For visual perception, memory is just as indispensable (Vernon 1937, Arnheim 1956, Gombrich 1960, Mackworth 1963, Sanders 1967).

Inside buildings we also need perceptual schemes. The livingroom too cannot be perceived at a glance; we have to look around. Even less can we ‘see’ the spatial arrangement of our own house, with the locations of the staircase, the bathroom, the attic etc. And yet we carry a scheme of this spatial arrangement in our heads, as is evident when we descend or ascend the stairs in pitch darkness, find the doors of bedrooms, the bathroom, etc. The scheme is more topological than metric: we know there is a linen-cupboard in the hall, but not exactly where; we have to feel with our feet for the first step of the stairs.

We dispose of spatial schemes not only for our own houses, but also for our neighbourhood and for the city in which we live; and often in a more rudimentary form for cities which we have visited several times. Some groups of subjects were asked to sketch the city-centres of some cities well-known to them. The schemes showed a good correspondence to reality in the relative location of streets and landmarks, but the proportions were strongly distorted (Lynch 1960, de Jonge 1962, Stea 1969). Again, apparently, a topological and not a metric scheme is used. This result agrees with the experiments of Piaget, who found that the topological spatial relations are developed by the infant before the metric ones (Piaget and Inhelder 1956).
Fig. 60. If the distance of the eye to the photograph is proportionately very different from that of the lens to the original negative, the photograph loses its illusionary effect of depth. This photograph could only be seen in depth at an extremely short distance from the page, because it has been taken with a very wide angle. That causes the distortion of the spherical lamp and the round table on the right.

Fig. 61. The same scene in a more normal projection.
3.4. Application: architecture and the cues

In general, the various cues for space perception are of more importance to draughtsmen and painters than to architects. A draughtsman may try to create an illusionary space perception with the position of objects, overlay, size, perspective and light and shade. The architect does not need such an illusion, for the building is really three-dimensional and will in most cases be correctly perceived as such. Many architects today would reject the idea of spatial illusions, because they go against the doctrine of 'honesty' in architecture, a doctrine which arose in the 19th and 20th centuries as a reaction to eclectic architecture.

Some of the cues for space perception cannot be influenced by architects. Aerial perspective involves distances which are generally too great, and stereoscopic vision, convergence and accommodation involve distances which are too small to be manipulated in architectural design. The other cues have been used for centuries — consciously or unconsciously — in the perception and design of buildings. Repetitive floor-patterns, such as coloured tiles, define the positions of pieces of furniture and of people in space. Rows of freestanding columns or pillars show overlay over the walls behind them; rectangular rooms show a clear perspective, and these cues together with light and shade facilitate a correct spatial perception. But misperceptions of space occur in a number of buildings, intentional or not, and they can often be traced to a manipulation of cues. the interior pilasters, capitals, bases and entablatures of St. Peter in Rome have been detailed, in accordance with classical precepts, in proportion to the vast dimensions of the nave. Boullée (1953) has criticized this interior already in the 18th century for appearing much smaller than it is in reality. He ascribes this false impression to the huge dimensions of the details. After seeing a great many classical columns and entablatures, we have formed for ourselves an idea of the 'normal' range of sizes of such details. As a result, the interior of St. Peter's is judged by its details, and the details are estimated by our idea of their normal size. Consequently the interior is scaled down. Boullée's analysis parallels the experiment of Ittelson (1951-b) on playing cards.

Fig. 62. Le Corbusier used light and shade to create the illusion of a hovering roof and deep-set windows to accentuate the thickness of the wall below.
Perspective has been used to create an illusion of depth where none or very little of it existed: for instance in Bramante's apsis of the Sta. Maria presso San Satiro in Milan, in Palladio's Teatro Olimpico in Vicenza, and in Borromini’s perspective gallery in the interior courtyard of the Palazzo Spada in Rome. Related to these examples is the use of mirrors in narrow spaces, particularly in bars, coffeeshops and restaurants, to double the space optically. The most famous example is Adolf Loos' Carinthian Bar in Vienna.

Light and shade have been used many times to create spatial illusions in Baroque cupolas. Heavy cornices shielded the windows in the lower zone of the cupola from view. The contrast between the shadows on the cornice and the apparently miraculously lit cupola above it, sometimes enhanced by an illusionistic painting of a sky with angels and clouds, created the impression of a view of an unlimited expanse above the spectator. There are famous examples of this in Borromini’s S. Carlo alle Quattro Fontane in Rome and the Dôme des Invalides in Paris.

A modern variant of this trick is found in Le Corbusier’s chapel in Ronchamp. An apparently massive roof seems to hover above an equally heavy wall (both are in reality skeleton-constructions) because a narrow strip of windows has been made between the top of the wall and the ceiling (Fig. 62). The other windows in this heavy wall have splayed jambs and sills and have been varied in seize and in their position in the wall. Therefore, not every window becomes visible at the same time if one walks along this wall. Le Corbusier has used the cue of movement-parallax to create an interesting effect in lighting and to accentuate the apparent thickness of his wall.

The example of the wall at Ronchamp draws our attention to a more general aspect of modern architecture. Many recent buildings have plain smooth facades. Such surfaces show no play of light and shade in the sun, and change far less in movement-parallax than heavily moulded facades (Fig. 66). Two major cues for space-perception are lacking in such surfaces; this makes a correct perception of distance and location in space more difficult. The lack of these cues contributes to the abstract, irrealistic appearance of such buildings.

3.5. Application of the Gestalt-laws to buildings

The laws of figure-and-ground and of Prägnanz, as well as the detailed Gestalt-laws derived from the latter, have been demonstrated with flat, abstract figures. Parallels in music show that the underlying principles — sharpening of contrasts in figure-and-ground and reduction of information in the law of Prägnanz — are of a very general nature. Therefore, they probably hold not only for flat figures, but for space as well.

Where a flat figure has a contour as a boundary, a three-dimensional object has a surface. This surface may be perceived as continuous, just as the flat contour, in accordance with the law of continuity (2.2.4). An entrance which juts out in front of this continuous surface, or a loggia which is out out in it, are not perceived as interruptions of the surface; the facade seems to run over the opening or behind the block.

But the continuity of the facade can be broken by the combination of a hole and a projecting mass (Fig. 65). Only in this last example is a plastic relationship obtained between facade and entrance block; in Fig. 63 this block appears 'stuck to the surface of the facade' rather than as a part of it.

Whether a facade is seen as a continuous surface depends on its surface-treatment. A smooth facade looks far more continuous than one with heavy mouldings and strongly projecting members (Fig. 66). The ‘attaching’ of projections, such as balconies or staircases, is far easier with such heavily moulded facades, because the perception of a single plane surface has been made impossible.

A flat, smooth facade is a hard Gestalt (see section 2.4); its simplicity as a surface makes it an absolute form, comparable to the straight line or the circle (Fig. 25). That is why such facades look so impenetrable, even if they are completely made of glass (Fig. 66). More heavily moulded facades are less ‘closed’, more ‘accessible’, more ‘open’ and ‘softer’, because of a lack of continuity (Fig. 67, 68, 69).

The law of simplicity of form can also be applied to buildings. Many new buildings are simple rectangular blocks (Fig. 83). Such blocks are never perceived as an addition of
single flats, but always as a block with a repetitive pattern of windows on its facades. They, too, are hard Gestalts. Because of closure (Fig. 70-71), projecting of recessed balconies change but little in this perception, as long as the corners are left intact.

The human visual system tends to divide the perception of a building in chunks, which are at the same time as large and as possible (laws of Prägnanz, 2.2.1, and of simplicity of form, 2.2.5). This causes prismatic masses which abut against each other, or which penetrate each other, to be seen as separate blocks rather than as a single mass (Fig. 72-a and -b). The visual cohesion between such masses can be increased by using the law of continuity (Fig. 72-c).

3.6. Application to space

People, furniture, machines and buildings are 'located in space'. Space is the background for objects, just as the paper of this page is the background for the text. The ground in flat figures is less tangible than the figure on it (Rubin 1915, see section 2.1); similarly space is less tangible than the objects it contains. Space is 'what remains between the objects'. Space is only known through the objects; for instance: the space of the living-rooms through the walls, the floor and the ceiling. Our image of an empty space is derived from its material boundaries.

Some authors have pointed out that there are different kinds of space (Russell 1948, Beth 1950, Bollnow 1963, Prak 1968). In the context of this book we have to distinguish between at least four different kinds:

3.6.1. Visual space: the space we see, for instance, of the room in which we are now reading.

3.6.2. Conceptual space: this same room as we think of it when we close our eyes or when we go to another room. The space which an architect can 'see' mentally from a plan and a section is also a conceptual space.

3.6.3. Behavioural space: space in which we can move around. A hole sawn in the floor of a room forces us to walk around it; behavioural space is more restricted than before, but visual and conceptual space remain unaffected. A room divided in the middle by a pane of plate-glass has practically the same visual space as an undivided room, but a completely different behavioural space (Prak 1968).

3.6.4. Physical space: the continuum to which the laws of physics apply. Physical space for instance contains the air of the room in which we are sitting now. If we open a window, we connect this body of air with the atmosphere outside. The visual space of our room has changed but little, but the physical space has changed a great deal, because it may become cold and draughty in our room.

The first two kinds are particularly important for our subject. The image of the room in which we are sitting now is more conceptual than visual in character, because we can only see a part of it at the same time. But this conceptual space is continuously supported and corrected by the perceptions of visual space. A conceptual space entirely constructed from memory or from drawings has to do without such support and corrections, and is therefore more indefinite. (Conceptual spaces correspond to the schemes described in section 3.3).

The formation of an image of a conceptual space is often quite easy for rooms in a building. Many rooms have a simple rectangular shape. The law of the simplicity of form applies to conceptual spaces, and helps us in forming simple – and usually adequate – spatial schemes (but see Fig. 57). But the formation of an adequate scheme meets with more difficulties in complex interior spaces, such as staircases, where the conceptual space is the counterpart of the treads and risers of the stairs, and the walls and the ceiling.

Still greater difficulties for the formation of a conceptual space arise outside, in the streets of a city. Bounding surfaces, such as walls or ceilings, which can help us in a room, are often missing here. Only where we can find sufficient support in buildings or trees for the formation of a conceptual space, can it arise at all. Such a conceptual space is subject again to the Gestalt-laws of perception. If the form is simple (2.2.5), the bounding surfaces continuous (2.2.4) and sufficiently close to each other (2.2.2), it is possible to form an image of space which can be described and remembered. Bounding surfaces for
Fig. 63. An entrance block which seems stuck on the facade. The law of continuity causes us to perceive the facade as running on behind the entrance.

Fig. 64. Because the law of good continuation, the facade seems scarcely interrupted by the hole.
Fig. 65. Only with a combination of projection and recession can the continuity of the plane of the facade be interrupted.

Fig. 66. The smooth facade on the left is far more 'impenetrable', even though it contains so much glass, than the one with projections and recessions on the right. A smooth surface is a 'hard Gestalt'. 
Fig. 67. Continuity, repetition, and particularly the predominance of the plane of the facade makes this a hard, reflecting and impenetrable surface.

Fig. 68. In this block of flats the continuity of the facade has been broken up by much larger openings, in combination with projecting parts in the balconies, set at alternating points. The lower story has been recessed. Because the law of continuity cannot operate here, the facade is far more accessible and 'soft' than the one of Fig. 67.
Fig. 69. Balconies in the same plane, set close to each other, form a continuous surface, to which the law of continuity applies. Setting the fronts of the balconies at an angle prevents the perception of such a closed, continuous plane.
Fig. 70. The projecting balcony and its wooden railing proclaim the designer's intention to create a 'soft' facade. Yet the building looks hard, because its total shape is a simple box. As we have seen in flat figures, the overall perception is determined in particular by the angles and edges.

Fig. 71. Breaking up the corners is particularly effective in counteracting a box-like appearance.
exterior spaces are few and far between in modern suburbs, partly because of the theory of open planning (C.I.A.M. 1931) (Fig. 73, 74, 75, 76). The lack of possibilities for the formation of a conceptual space may be one of the reasons behind the complaint that modern suburbia is more a place to go through than to stay in. Old cities, with their narrow streets and enclosed squares on the other hand facilitate the formation of spatial concepts. (Fig. 73, 74).

Adequate space-perception is often hampered by modern building practice. An experiment of Gibson has shown that the localization of objects in space depends on the possibility of relating them to a background, particularly to some kind of patterned floorsurface (Gibson 1950). With many large modern buildings we have only the cue of overlay at our disposal (Fig. 77). They simply rise, one behind the other, 'somewhere' in space. Intervening masses often prevent the perception of a connecting ground, and the size of the buildings prevents a simultaneous vision of front- and side-elevations, which might supply a perspective cue. From the cue of overlay we can see that one building stands behind another, but not how far behind (Fig. 79, 80). The lack of cues makes the formation of visual and conceptual space almost impossible. Curved streets give much information about the location of buildings in space; this is one of the visually attractive aspects of such streets (Fig. 78).
Fig. 73. The architecture of the old Berner Kramgasse allows the formation of a conceptual space, because it is enclosed at the end by a tower, and overhead by the roof overhangs. (Corners were sufficient for the perception of a rectangle in Fig. 18)

Fig. 74. The Meent in Rotterdam has approximately the same width and height as the Berner Kramgasse, but lacks the overhanging roofs and the tower, so its conceptual space is far more indefinite.
Modern open planning creates no enclosed spaces, in the sense of the Berner Kramgasse. In this suburb in the Hague it is impossible to form definite images of conceptual space, because the blocks have been simply placed side by side.

This view in Ommoord, Rotterdam, shows again the impossibility of getting an image of a conceptual space, because the boundaries are lacking and the buildings are of very different heights (so there is 'no ceiling', perceived as the continuous surface over the tops of the buildings, see Figs. 73 and 74).
Fig. 77. Buildings one behind the other. For an estimate of distances we have to rely on overlay alone. Important cues for depth perception, such as a connecting ground, are missing.

Fig. 78. The Oppert in Rotterdam. The tower of the St. Lawrence church is clearly related to its surroundings by the elevation of the street; its curved wall gives the necessary cues of perspective and grain to make an adequate localization and estimate of size possible.
Fig. 79. The mountains on the background of the Maria Theresienstrasse in Innsbruck appear at an undefined distance.

Fig. 80. ... until we look from a higher viewpoint and see the hills between them and the city, with their cottages and roads. The connecting ground is a cue to their distance.
4. Coherence, contrast and complexity

4.1. The need for variety

The preceding chapters described how the ever-shifting mosaic of colored points of light on the retina is changed into the stable and usually reliable perception of our environment. We use the redundancy of spatial cues for an estimate of distances, sizes, solids and voids. We use redundancies in form, such as repetition, texture and uniform color, or continuity and simplicity of bounding surfaces for the perception of objects. Sometimes we see one object when there are really two, sometimes we see two when there is one, dependent on the visual cues, our previously acquired knowledge and the tendencies of human form-perception.

The Gestalt laws demonstrate that the efficient use of redundancies is build into our perceptual system. It has the advantage of freeing perception — as far as possible — for the detection of change and novelty, i.e. for picking up information. It has some drawbacks too. Repetitive tasks are uncongenial to us and we soon get bored by them. Jobs which consist of the same routine day after day, such as many operations on a conveyor belt, inspecting dials in a power station, punching cards for a computer, or typing paper after paper of written material often get so boring that we make mistakes. The power station attendant misses a crucial change in a dial, the typist skips several lines, the driver may miss a vital sign or even drop off to sleep, etc.

But the advantages are beneficial on the whole. Being tuned in on information rather than on redundancy, we can react adequately to the unexpected. Our orientation on information and the future course of events has led to our exploration of the world, the construction of tools and finally our technological dominance over parts of nature. Kaplan (1972 a and b) has speculated that this orientation is a biological product of evolution. Aboriginal man, without the advantages of overpowering strength, great speed, claws or a hard shell, had to survive by his wits. Those who could not adequately forecast what would happen next from what they saw now were soon killed or starved.

Indispensable as this characteristic might be for aboriginal man, it would never have survived the centuries if it had not been or become an integral part of our psychological constitution. Without an inborn urge to explore and discover in every new-born baby, there would have been no new generations of scientists, explorers, astronauts and inventors. Earlier psychological theories assumed that men and animals interacted with their environment mainly to satisfy their primary biological drives, such as hunger and sex (Hull 1943). The modes of satisfaction which the individual sought received but little attention. This has changed recently; curiosity, play and exploratory behavior are nowadays valid and promising areas of research in psychology. Some authors believe that the need to stimulate the organism by a variety of experiences and exposure to information is just as much a primary drive as hunger or thirst (Hebb 1949, Berlyne 1960, Lindsley 1961, Fiske and Maddi 1961, Schultz 1965, Dember 1966).

This need for variety makes the baby explore his box and the toddler investigate the kitchen drawers. Experience with the consequences of this need alerts mothers when for a long time no sound is coming from the children in the den. The need for variety makes us change our dresses, our work-routines and our menus. Recreation is sought in activities far removed from the routines of daily work. The bank employee will spend his weekend in the garden or hiking through the woods, the farmer will stay indoors. Sports, hobbies and the adventures portrayed on TV all provide outlets for the need for variety. This need is the cause of curiosity and ‘useless’ scientific research, of tourism, hiking and mountaineering, of watching horror-films and reading detective stories. And even the most famous paintings, poems or pieces of music lose their interest after a while for somebody
who has seen or heard them too often. They have become too redundant (Moles 1971).

As all other biological functions, the need for variety must be allowed to develop and to seek outlets in order to become a properly functioning part of our personality. Muscles, too, have to be used and trained if they are to work well; otherwise, they atrophy and we become stiff and clumsy. Some experiments described in the next section show that perception also needs practice to become — or remain — efficient. By partial satisfaction of his need for variety, the individual not only enriches his life, but also keeps that same need functioning, which increases his possibilities of adaptation to new situations.

The theory of a need for variety can obviously be applied to the built environment. Indeed, many buildings have been praised for their 'variety' and 'liveliness' or condemned for their 'monotonous' appearance. How this theory can be integrated with the other aspects of perception, in particular with the Gestalt principles outlined in the previous two chapters, will be discussed in section 4.3.

This discussion will be preceded by a description of some experiments, relevant to the postulated need for variety. For the argument in this section is based on nothing more than rather simple observations of events in everyday life. With equal facility we could have argued that modern man hankers after rest, routine and habit rather than after variety. If this need really exists, it should be possible to show some experimental evidence for it.

4.2. Little and much information

The need for variety is more difficult to demonstrate than the need for food or sexual contacts, for the last two needs are directed at objects, whereas the need for variety is directed at a relation between objects or settings. The 'proofs' for the existence of such a need are therefore indirect.

We will start with the experiments on the lack of variety. At the MacGill University in Montreal, students were asked to volunteer for an experiment with an environment having a very low informational content. Each of the 22 students who volunteered had to lie for 24 hours a day on a bed in a small, electrically lit cubicule. He had to put on translucent goggles, thick gloves and cardboard cuffs over his lower arms (to prevent touching). His head lay in a U-shaped foam-rubber pillow, to prevent the penetration of sound; the cubicule was partially sound-proofed. The subject maintained contact with the outside world, for eating and going to the bathroom, by means of microphones. He could neither hear nor touch and saw only diffused light (Bexton, Heron and Scott 1954).

Most subjects fell asleep. After they had slept their fill, they started to sing, to whistle and to talk in themselves, to beat the cuffs together and to touch the wall with them. They became very restless and fidgeted continually. The experimenter asked them to solve small arithmetical problems and to make a word out of a string of letters (anagram) or as many new words as possible from an existing word. These tasks were executed at a significantly lower level of competence than those of a control group. Subjects complained that they could no longer concentrate. Most subjects started to have hallucinations of geometrical forms and fantastic scenes (e.g. a procession of squirrels with rucksacks on in the snow). Although they were paid twice as much as they could earn elsewhere, most subjects could not hold out for more than two or three days; the lack of variety became unbearable.

After this, a series of similar experiments were held, in which techniques and tests were varied (Solomon, Kubzansky a.o. 1961, Schultz 1965, Zubek 1969). The results were also similar. According to Schultz we have to distinguish between perceptual deprivation, in which the organism receives stimuli which it cannot code or decode and sensory deprivation in which there is a complete — or nearly complete — lack of stimulation. A subject in the condition of sensory deprivation may for instance sit in pitch darkness, with plugged ears. The subjects of Bexton, Heron and Scott saw white light through their goggles, but no forms; hence perceptual rather than sensory deprivation was the condition in this experiment. Sensory deprivation is easier to endure and produces fewer disturbances than perceptual deprivation, according to Schultz.

A set of animal experiments used similar techniques of deprivation over prolonged
periods, to study the effect over time. Riesen raised chimpanzees in conditions of (visual) sensory or perceptual deprivation, i.e. some completely in darkness, some with a translucent mask (as the subjects of Bexton) and some in darkness, but with lights turned on during one and a half hour a day (Riesen 1950). Treatment was stopped after seven and sixteen months. The chimpanzee which had had one and a half hour light a day behaved as a normal seven month old chimp. The animals which were raised for sixteen months in complete darkness did not react to toys or their bottles, unless they touched their bodies; nor did they react to objects which moved in the direction of their faces. One animal learned to react normally after considerable time, another never learned it at all. The chimpanzee with the translucent mask needed less time to adapt visually than an animal that was raised for the same length of time in complete darkness. Finally a normally raised chimpanzee of seven months was kept in complete darkness till the age of twenty-four monts. When he returned into the light he could no longer use his eyesight; he did not recognize his bottle (as he did at the age of seven months), he no longer looked at objects or people, did not close his eyes in direct sunlight, etc. Riesen's conclusion is that

Fig. 81. The apparatus of Held and Hein: both kittens have the same visual experiences. If the strapped-on kitten walks around its brother in the gondola is pulled along too; when the active kitten turns then the other one does too. But the active kitten acquires a combination of visual and motor experiences; the passive kitten only gets the visual impressions. Later reactions show that the active kitten can — and the passive kitten cannot — react adequately to its environment. Movement and visual stimulation are both necessary for adaptation to our environment (Figure from Richard Held — Plasticity in sensory-motor systems, Sc. American Nov. ’65, Copyright Scientific American Inc. All rights reserved).
the visual system must be used to become or remain useful for the organism and that a lack of stimuli puts it out of action. Light alone is insufficient; it is also necessary to perceive forms.

Held and Hein have shown that a combination of visual stimuli and motor-activity are necessary for developing adequate adaptive behaviour. Five sets of new-born kittens, each set consisting of two kittens from the same litter, were used as test animals. They were raised in total darkness. Visual experience was gained only in the experimental condition. The experiment was conducted in a vertically striped circular cage with a rotating bar in the middle (Fig. 81). One kitten was strapped to the end of the bar; it could run in the cage and turn around. The second kitten sat in a gondola at the other end of the rotating bar; it was pulled and turned around by the first kitten. The first kitten experienced a combination of motor-activity and visual stimuli; the second had only visual stimuli (quite similar to the stimuli of its freely moving brother or sister). Afterwards only the first kitten showed adequate reactions to its environment: it braced itself when pushed to the edge of a table, it avoided a glass-covered ‘visual cliff’ (Fig. 48) and it blinked its eyes when a hand was moved towards its head (Held and Hein 1963).

The conclusions which can be drawn from these experiments have important consequences in various fields. The experiments show that adaptive behaviour and adequate visual perception must be learned. Riesen’s chimpanzees could not learn to perceive in their visually deprived condition. If interaction between motor-activity and visual stimuli is absent a kitten does not learn to move or blink adequately.

The need for variety produces interaction between the organism and its environment, partly in exploratory behavior. Such interaction is not only useful for keeping on the alert for information, but necessary for the development of the various faculties of the organism; it is kept on the move and by moving it goes on learning.

Dember (1966) has drawn attention to the dramatic consequences of an arrested development in a highly redundant environment. Spitz (1945) had written about the conditions of infants hospitalized for a considerable period. These babies lay in their cots, surrounded by white sheets and curtains, with a white ceiling above them, without toys and even without a patterned wallpaper to look at. Contact with adults was minimal. Many of these children became listless and apathetic; their physical and intellectual development was retarded and an abnormally high proportion of them died. Spitz argued that lack of maternal care and love was the cause of their apathy and arrested development, and this was certainly the main reason. Dember drew attention to the correspondence between the conditions of these children and of the subjects of Bexton, Heron and Scott. The arrested development could have been aggravated by the partial perceptual deprivation, from which these babies – in contradistinction to the Canadian students – could not escape after three days.

An entirely different kind of ‘proof’ for the existence of a need for variety is given by experiments which offer a choice between two objects or settings which differ in information content, or in which an organism can manipulate the amount of information in its environment.

Monkeys were able to open a peephole in their blinded cage, which allowed them a brief look at the adjoining room. They kept on opening the hole for hours on end. The frequency increased with the interest of the visual stimuli: an empty room gave the lowest frequency, food produced a higher rate of response, a running toy train yet more and another monkey the highest (Butler 1954, Butler and Harlow 1954). Rats in a maze could choose between two different paths to a foodbox: one with a regular alternation between right turns and left turns and one in which the sequence of turns was changed after every session. Normal rats preferred the second path, even when it was longer than the first (Krechevsky 1937). For another experiment with rats a maze was built on a plan in the form of a number 8. The walls of each of the two loops of this maze were treated differently: one loop plain, the other striped, or one loop with horizontal and the other one with vertical stripes. (Running along a vertically striped pattern gives rise to a greater variety of visual stimuli than a horizontally striped one). The rats could be spotted in the maze through a translucent floor. They showed a marked preference for the more complex wall-treatment (Dember, Earl and Paradise 1957).

Berlyne studied the simplicity and complexity of figures. He distinguished between
various aspects of this dimension and showed adult subjects pairs of slides, which differed in complexity in one aspect: in the number of elements, in their regular or irregular positions on the ground, in their similarity, or in the regularity of their contour (Fig. 82). Fixation times on each slide of a pair during the first 10 seconds of exposure were noted; they were always significantly longer for the more complex slide (Berlyne 1958a). Babies too looked longer at a chessboard pattern than at a plain square, or at figures with long contours than at figures with short contours (Fantz 1958, Berlyne 1958b).

The experiments of Berlyne show the relation between complexity and the Gestalt-laws. The simpler figures stay closer to the Gestalt-laws and they contain less information than the complex patterns. They are more redundant: a regular pattern of elements is based on equal distances and satisfies — just as the equality of elements — the law of similarity. A figure with a broken contour is more complex than a figure with a closed contour (laws of simplicity of form and continuity). Regular discontinuities in a contour are simpler than irregular ones (law of similarity). The simpler figure is more ‘ordered’, the complex figure more ‘chaotic’; the simpler figure is more redundant, the complex one is richer in information.

Berlyne’s test figures show that in particular the law of similarity is of fundamental importance to his results. Complex figures have nearly always distinguishable parts, such as the points of a star, the sides of a polygon or the stripes of a hatching.

According to the law of Pragnanz and the law of similarity these parts are perceived as similar as possible. On this similarity depends the perceived simplicity or complexity of the figure. Equal parts (distances, sides, angles, lengths, etc.) reduce complexity, contrasting parts increase it. Contrast between parts of a figure is evidently one of the most important factors which contributes to its perceived complexity. Another factor is the number of parts or elements.

But an unequivocal preference for complex figures is not shown in the experiments of Berlyne and Fantz. The longer fixation times of the complex figures could be due to a longer processing in the visual system, which the greater amount of information required. Subjects might have taken a longer look at the complex figures, because they did not ‘understand’ them as quickly as the simple figures and not because they preferred them.
Such a question can be resolved by measuring preferences rather than fixation times. Preference for figures is difficult to test. Subjects are inclined to attach some kind of meaning to a figure, even to an abstract geometrical pattern; the preference for one pattern over another may be influenced by this meaning. Forms with a very large information content are difficult or impossible to decode and will therefore not be preferred (Moles 1971); there is probably an upper limit to a (supposed) preference for complexity. People differ in visual interest and visual experience. Abstract forms contain less information for architects and graphic designers, who are used to them, than for the layman. It seems probable that everyone has his own preferred level of complexity (Dember and Earl 1957). Experiments have demonstrated the existence of such a personal level and that, if this is taken into account, together with the meaning of forms, most people prefer somewhat complex figures to very simple figures (Dember, Earl and Paradise 1957, Munsinger and Kessen 1964, Dorfman and McKenna 1966, van Wegen 1970-a).

By definition unknown figures contain more information than familiar ones. As a consequence of the need for variety, unknown figures would have to be preferred over familiar ones and also receive more attention. Fantz (1964) showed 10 pairs of pictures to babies aged from 2 to 6 months. The pictures consisted of photographs or advertisements cut from magazines. In the successive presentation of pairs to a single subject, one picture always remained the same (although it was shifted from right to left), whereas the other picture was a different one at each presentation. Every subject got a different picture as a constant stimulus. Fixation times on each of the two pictures of a pair in every presentation were measured. Fixation on the constant picture decreased gradually during the series of presentations and did so faster with older babies than with younger infants.

Artists, architects among them, manipulate forms daily. Forms which are new to the layman are familiar to them. As prior experience enters into the concepts of information and redundancy, what is ‘information’ to a layman is often ‘redundancy’ for an artist or an architect. Novelty and variety are not absolute, but relative to previously acquired knowledge. Complex forms that baffle the layman, are disentangled and ‘understood’ by the expert with ease. Consequently the preferred level of visual complexity of artists and architects lies above that of the average man, as several experiments have shown (Barron 1953, MacKinnon 1961, 1962).

The need for variety and information is not unlimited. As we saw in Section 2.4, the new must be understood in the framework of the known; and our sensory and mental faculties set definite limits to the amount of information we can handle in a given period. That much was evident already from film and T.V., where we see separate images as an indivisible whole. It is also demonstrated in the experiments of Kalsbeek (1967) who set his subjects two separate tasks, thereby increasing the amount of information they had to handle. Their heartbeat started to show a rhythm similar to that under a condition of physical effort, some subjects became slightly aggressive. The preferred level of figural complexity lies only a little above the level to which one is accustomed, according to Berlyne (1960) and Dember (1966). The need for variety pushes the preferred level upward, but the limited capacities of the organism in handling information keep it down. This theory of a small increment could help to explain the aversion of the public for very modern works of art or music. As the public has so little knowledge of what goes on in the world of the avant-garde, nearly everything in such works is new to them, and therefore, far exceeds their capacity for handling it. (Moles 1971).

4.3. Application: coherence, contrast and complexity

As both complexity and the Gestalt laws of form-perception relate to the concepts of information and redundancy, it must be possible to integrate them in a single theory of perception.

Buildings of a simple prismatic shape with flat facades and a repetitive window pattern (Fig. 83) are less complex than buildings in a broken irregular form with projections on their facades and a less repetitive window pattern (Fig. 84). The first follow the laws of
Fig. 83. A simple box-like building: a hard Gestalt of minimal complexity.

Fig. 84. An apartment building for senior citizens in Delft, of a complex, broken form.
simplicity of form, of continuity and similarity more closely than the last and are therefore more redundant.

The opposite of 'complexity' is 'simplicity'. Following the Gestalt laws produces simplicity, going against them creates complexity. Architects do both in designing buildings. They try to create 'interesting', 'varied', i.e. complex forms with contrasts, using different forms (e.g. rectangles versus curves), different dimensions (e.g. high versus low, wide versus narrow) and different materials (e.g. concrete, brick, wood, steel). But the Gestalt laws operate as much on complex buildings as they do on simple ones. The effect of using a great many contrasting forms is that they are reduced in perception to a disjointed collection of simpler parts, each of which follows by itself the Gestalt laws (Fig. 85, 86, 91). The contrasts reduce the formal coherence in the design.

Coherence in design is obtained by following the opposite procedure, using similar forms, dimensions and materials. Architects try to strike a balance between the two, usually offsetting contrasts in some aspects such as proportions, by coherence in others, such as type of forms used (all rectangles for instance; see Fig. 96). Coherence is considered desirable, because it shows the building to be 'all of one piece' or 'a single building'.

Contrasts and coherence can be made in the following aspects of forms: types of forms (e.g. rectangular, curved); directions (parallel, oblique, at right angles); dimensions; surface treatment (textures and colors). In combination with the Gestalt laws we get the following table:

<table>
<thead>
<tr>
<th>COHERENCE</th>
<th>CONTRAST</th>
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<tbody>
<tr>
<td>Similarity</td>
<td>dissimilarity (of types of forms, directions, dimensions and surface treatment)</td>
</tr>
<tr>
<td>Continuity</td>
<td>discontinuity</td>
</tr>
<tr>
<td>Simplicity of form</td>
<td>complexity of form</td>
</tr>
<tr>
<td>Proximity</td>
<td>(distance)</td>
</tr>
</tbody>
</table>

Fig. 85. The roof of this church contrasts with the rectangular block below. Due to the law of Prägnanz we see this roof, not as an integral part of the total form, but as a detachable element, casually put on top of the finished building.
Fig. 86. The cohesion between these complex forms has to be brought about by employing a single material on the exterior, i.e. concrete.

'Distance' is the opposite of 'proximity', but is not effective as a contrast-category, as it leads to the perception of independent forms.

The theory can be applied to groups of buildings as much as to a single one. The visual coherence of a group of houses is increased if they are built at short distances (proximity), in alignment (continuity), with the same heights of gutters and the same or a similar slope of roofs (continuity and similarity), of the same bricks or painted in the same color (similarity of surface treatment). All these operations increase the visual redundancy and thereby automatically reduce the complexity of the group. Dutch architects and town planners often try to increase the visual coherence between a group of custom-built houses (Fig. 87), because they think pronounced individualism to be anti-social, and because the character and visual coherence of the suburb is valued above the possibilities of the individual designer. Needless to say, the client often aims at the opposite effect: his custom-built house is to him a form which expresses his identity and status (Figs. 87, 88, 109; see sections 5.3 and 5.4).

American developers build sets of houses which, for economy of construction, are often the same in a single development. To cater for the individualistic wishes of their prospective clients, they disguise these houses as individual, custom-built units, by adding dormer windows to one, a porch to another, and by painting them in different colors.

If there is a need for variety, why is then complexity of form in the built environment not always increased to the maximum? One reason is the desire of clients and architects to make the building stand out as a single unit, which requires coherence rather than complexity. Another is that with increasing complexity forms become more difficult to decode; they are 'harder to understand' (Moles 1971). And finally, according to the theories of Berlyne (1960) and Dember (1966), the preferred level of complexity of architects lies only a little above the complexity to which they are accustomed. The architects cannot accept a very high level of complexity as satisfactory, because they, too, have to understand the degree of complexity of a design within the frame of reference to which they are accustomed.
Fig. 87. Group of houses in Voorschoten, Holland. Townplanning regulations obliged the owners and their architects to build sloping roofs and low gutters, which results in a greater coherence than that of Fig. 88.

Fig. 88. This is the result if there are no such regulations. Coherence between the houses diminishes; similarities are accidental.
The preferred level of complexity is thus based on past experience, and changes over time, as I have tried to show in an earlier book (Prak 1968). The eclectic architects of the last century (e.g. A.W. Pugin, G.W. Street, E.E. Viollet-le-Duc, Ch. Garnier, G.B. Post, J. Renwick) had a much higher preferred level of complexity than the next generations, in which such men as Voysey, Berlage, Richardson, and Sullivan urged the adoption of simpler forms, i.e. a lowering of the level of complexity (see also figs. 89 and 94). This ‘return to simplicity’ was based on a dissatisfaction with the ‘make-believe’ of eclectic architecture, i.e. on the meaning of forms, and not on their complexity by itself (Summerson 1971, Pevsner 1938).

The functionalists (e.g. W. Gropius, L. Mies van der Rohe, Le Corbusier) were interested primarily in the usefulness of buildings and the development of a new building technology and continued the trend towards greater simplicity in the years 1925-1940. An ‘International Style’ of great simplicity was the result. After 1945 this style gained worldwide renown and influence. As a reaction to its ‘monotony’ several architects (P. Rudolph, L. Kahn, R. Venturi, A.E. van Eyck, E. Saarinen) intentionally stepped up the level of complexity after 1955. At the same time, a new interest arose in the complex eclectic architecture of the 19th century.

Many architects believe that contrasts are effective on memory images also (Cullen 1961). A room of a certain height would appear higher if it were entered from a low room than when it were entered from a room with the same height. The following experiment was performed to test this view. Rooms were built on the same plan (22′ x 14′), but with different heights (7′ and 16′-8″). Subjects estimated the heights of the rooms after direct entry and after entry from the room with a contrasting height. Responses were made with a movable platform which could be hoisted along a mast to the true height, with an adjustable model (to the scale of 1 : 12.5) and verbally. The results did not confirm the architect’s view on the effectiveness of contrasts on memory-images, for they showed no differences in responses between subjects who entered directly and subjects who entered through a contrasting room (Steffen 1968). It may also be that the effect was too small for the measuring instruments, or that it was not specific enough to be measured.

The need for variety can be demonstrated not only with abstract figures, but also with pictures of buildings. A comparison between slides of two bungalows of similar size and price-range showed a clear-cut preference for the more complex form, with subjects volunteering specifically that complexity was a reason for their preference (Steffen 1969). Kuiper (1972) asked 5 psychologists to arrange 5 series of 5 photographs of street-views in order of complexity. Four of these series were offered to 60 subjects, who were asked to arrange them in order to preference, supposing they had to walk to work everyday along such a set of streets. The correlation between the rank-orders of preference and complexity was 0.71.

Most of the complaints about the lack of variety in modern architecture, particularly in suburbs and in office buildings, are made by architects (e.g. Kiemele 1967). Though such feelings are not restricted to architects (Department of the Environment 1972), they turn up but rarely in research reports on consumer opinions about the built environment, and then usually only marginally (Weeber 1971, Den Draak 1971, Centrale Directie 1964). Apparently the supposed visual simplicity of modern buildings is not bothering lay people as much as it does architects, or it is not perceived at all.

The differences in opinion between architects and laymen about the complexity (or ‘monotony’) of new suburbs agree with the theory of the preceding section. For laymen ought to prefer a lower level of complexity than architects, because they are less experienced in handling abstract forms.

In judging the relatively low level of complexity of many modern office buildings or suburbs, we ought to avoid the pitfalls of extremism on both sides. Some architects have linked the experiments on perceptual deprivation directly to the criticism on modern architecture. People suffer from perceptual deprivation if the built environment does not offer them enough variety (Noble 1963; criticism in: Manning 1965). Such a connection seems much too direct; no matter how dull or redundant such buildings may be, they offer infinitely more information than the cubicles in the experiments of Bexton, Heron and Scott.
Fig. 89. Shops and houses in Rotterdam. A visually ‘rich’ (i.e. complex) street facade, caused by the differences between shopping windows and between houses.

Fig. 90. Shops and offices in Rotterdam. Less contrasts and much more coherence (i.e. more redundancy). Visually ‘poorer’ than the street of Fig. 89.
These experiments demonstrate the existence of a need for variety in human beings in general, with the help of extreme conditions. Nobody will get hallucinations from the similarity between the houses of Levittown or the apartments in Stuyvesant town. But a negative opinion about the level of complexity of such environments may be caused by the need for variety, which was demonstrated in the experiments.

As such criticism of the built environment is uttered primarily by architects and professional critics, whose perception has been satiated with forms and formal experiments to a far greater degree than lay people, perhaps we can dismiss their opinions as professional prejudice? Not entirely. Little is known about the way in which people acquire opinions about the built environment; it is certainly a complex process (see chapter 5). It could be that the layman is prevented from giving a negative opinion about modern architecture, because he thinks that as a progressive modern citizen he has to like it. An exploratory questionnaire by Wentholt (1968) produced answers which pointed in this direction. Kuiper's research showed that laypeople had a preference for more complex street-views. Additional research could be done on the question whether the preference for complexity is related to knowledge about the function of the building. Is a dull apartment building disliked more than a dull office building? (see chapter 5).

The criticism of architects of monotonous buildings is thrown in relief when it is compared to Moles' (1971) criticism of light music. According to Moles, light music is so easily enjoyed because it has such a low information-content. We catch on to it because of its many redundant elements: a simple melody, a few chords, many repetitions. But these same elements start to bore us after we have heard the same piece a few times over. 'Difficult' music contains much more information, which is why we can listen to it many times, because we extract new information from every repeated performance. In the same way a 'dull building', which we see every day, could start to bore us because its information-content is soon exhausted (Figs. 89, 90, 91 and 92).

The need for variety bears upon all aspects of our surroundings. It concerns social contacts, physical and psychological events, and the possibility of manipulating our environment. In the overall pattern of interactions between man and his surroundings, the built environment probably plays only a modest rôle in the background (Prak 1970, Gans 1968, Michelson 1970). In a perceptually rich environment we hardly notice the architecture (Fig. 93.). But the built environment does form the backdrop for the dramas or comedies of life. The doors in this backdrop determine the exits and entrances of the players, which allow the performance of some plays whilst preventing that of others. The growth of cities and the ubiquitous motorcar have promoted a functional division of territory. Suburbs became dormitories, the city centre turned into an exclusive business district. This functional division is the result of economic pressures and not - as some innocent amateurs seem to think (Mitscherlich 1965, Berndt 1968) - of the ideals of functionalist architects. This functional division in particular has lowered the information-content. We miss the calm and silence as a contrast to the hustle and bustle in our city centres; on the other hand in the suburbs everything is too quiet. A 'rich' environment is first of all rich in its functions. Contrasting forms of buildings can add to the total information-content, but it can never replace functional variety. This does not make the importance of contrasting forms negligible. In particular moving parts, such as trees, plants and water, can add to the complexity, because the visual system is built for the detection of changes in the environment.

Variety in the built environment is also of practical use. Lynch (1960) and de Jonge (1962) have shown that the image ('cognitive map') of a city is based on a set of characteristic points and boundaries, such as a conspicuous church, a traffic intersection, a canal or a railroad track. These objects contrast with the interminable stretches of houses, in which they lie or stand; in other words, they are locations where new information is supplied. It is very difficult to form a cognitive map of Jersey city, in which such characteristic points and boundaries are missing (Lynch 1960). Such a cognitive map is necessary for orientation; without it, it is hard to find one's way (Goodey 1971). For an efficient use of our vast urbanized areas, contrasts are indispensable.
Fig. 91. A row of buildings in Windsor, England, very rich in contrasts. Heights, widths, forms, colours and materials of the facades, the patterns and subdivisions of windows, all are different. There is therefore a maximum of information and a minimum of redundancy, which can be expressed in such epithets as: 'lively, varied, interesting' etc. But it remains a coherent street facade, through continuity (all buildings are aligned) and proximity (no room between two adjoining buildings).

Fig. 92. The facade of the Rotterdam Concert Hall, 'rich' in material (marble), but 'poor' in forms. The facade has a very great redundancy and low information-content, because of its rows of equal subdivisions and the simple rectangular overall shape. It can be described with such adjectives as: 'dull, monotonous, boring, uninteresting', etc.
Fig. 93. Suburban shopping street in Rotterdam. Often we do not notice the architecture at all; probably it penetrates much less into the consciousness of ordinary human beings than most architects suspect. This environment has a very high information-content but this is not due to the (inconspicuous) architecture.

Fig. 94. The Westzeedijk in Rotterdam. Most modern buildings, with their taut, rectangular forms are much more redundant than 19th century houses with their gables, balconies, window-niches, and variety in colouring. The modern buildings are more coherent and monotonous, the 19th century buildings are richer in contrasts and more interesting. The differences in information-content between the two have certainly influenced the recent changes in appreciation for 19th century architecture.
Fig. 95. Three window-patterns of increasing complexity. At the top the simplest and most coherent, at the bottom the most complex.
Fig. 96. Middle class row-houses in Rotterdam with complex facades. Contrasts are: the 'open' part with the large windows and the balcony versus the 'closed' part with the front-door; the differences in heights between that door and the window next to it and the very low window on the top floor. Coherence is attained with the simple rectangular forms of 'open' and 'closed' parts, correspondence between the upper edge of the front door and the window to its left, and the position of the low window on the top floor to the edge of the brick wall.

Fig. 97. Middle-class row-houses in Voorschoten, with much simpler facades than in Fig. 96. Contrasts: the differences between the openings. Cohesion: equal and equally spaced windows on the upper floor, similar window pane dimensions.
Fig. 98. Apartments near San Francisco. Cohesion between building and landscape through parallelism of contours.

Fig. 99. School at Engelberg, Switzerland. Contrast between building and landscape; the slopes of the hills and mountains are not repeated in the building.
Fig. 100. Apartments in Biel, Switzerland. The tower contrasts in heights and plan with the other buildings. Cohesion is obtained by the repetition of the oblique balconies and the window forms.

Fig. 101. Contrast of directions in Rijswijk, Holland. Because both apartment-buildings are 'hard' Gestalts, there is no cohesion, just as in Fig. 99.
Fig. 102. Shops in Rotterdam. The street beyond the Ter Meulen department store runs at an oblique angle. To relate the department store to this street, the architect has set a part of the facade perpendicular to it. But he used the same materials and the same heights for this oblique part, thereby guaranteeing its cohesion with the rest of the building.

Fig. 103. ... in contrast to the treatment of the oblique corner of Ahrend. This corner too has been set at an angle, parallel and perpendicular to the side-street. But here materials and heights are different, which makes this corner look as if it belonged to another building.
Fig. 104. Elevator machine room and roof-exit on a home senior for citizens in Delft, coherent with the rest of the building through continuation of the surface of the facade (law of continuity) and repetition of loggias (law of similarity).

Fig. 105. Cohesion between two buildings in Rotterdam, obtained by letting the height of the block to the left of ‘Mobil’ correspond to the height of part of the older building at the corner. The law of continuity was used to get a formal coherence.
Fig. 106. Coherence between tower and church through continuity of the surface of the brick, repetition of the curves of this brick wall in the top of the tower and at the edge of the church and the exclusive use of one material.

Fig. 107. In contrast to Fig. 106 there is little coherence between this staircase tower and the office building, because the different forms abut with an abrupt break (no continuity) and tower and offices have been built from contrasting materials. The oblique endings of the tower repeat the bevelling below the windows, but this repetition went unnoticed through the difference in size.
Fig. 108. The projecting parts of this rheumatic clinic in Rotterdam contrast in materials and colour with the main block. The upper edge of the windows of these parts does not correspond to the lower edge of the main block. The flush facades and the simplicity of form of this main block cause the different parts of this building to be perceived as separate elements.
5. Form and meaning

5.1. Visual perception as part of interaction

The visual perception of the built environment is no aimless pastime, occurring for its own sake, but a purposeful activity. It forms a part of the continuous process of interaction between man and his environment. We look out for certain buildings and doorplates to find an address; we try to find the entrance, the staircase or the canteen in a building. It follows from this, and from the open, dynamic and purposeful character of visual perception, that such perception will both be influenced by and exert an influence upon the meaning of forms.

Less is known about the meaning of forms in perception than about other aspects. In most psychological experiments an effort is made to eliminate the influence of meaning, e.g. by presenting abstract nonsense figures. This is done to keep the variables of the experiment under control, because meaning might influence reactions in an uncontrolled way. Because of the lack of knowledge in this area, this last chapter is more speculative than the others.

It is useful to distinguish between two aspects of meaning:

the denotative aspect, which refers to cognition, to things we know and recognize; e.g. a building is recognized as 'a school', 'a church', or 'a fire-station'. Part of the denotative aspect may be symbolic. E.g., many U.S. State Capital buildings are reduced copies of the Capital in Washington; the seat of State government is symbolized by a reference to the well-known symbol of the Federal government (Prak 1968). The denotative aspects of the meaning of a form furnish answers to such questions as: 'What is it?' and 'What does it represent?'

the connotative aspect, which refers to the emotional overtones, the way in which form (and meaning) are subjectively experienced. E.g., some people may consider a building to be an 'ugly school', another 'a pretty house', or 'a dull office-building'. The connotative aspect supplies answers to questions such as 'how much do I like it?'.

The two aspects are, of course, interdependent. An interior that is evaluated as 'cozy' as a living-room would be thought to be 'too homely' if it were used as an office. One's appreciation for a certain church building depends in part on how one thinks about and what one expects from the church as an institution.

5.2. The denotative aspect

For efficient handling of his environment, man must be able to recognize the objects it contains. In his mental development from infancy to adulthood he learns to recognize and deal with shoes, pencils, cars, telephones, doors, taps, plugs, switches, etc. A child construes the concept 'house' first and foremost from living in a house; visits to other dwellings enlarge this concept to a category. Stereotypical images of 'the school', 'the hospital', 'the gas-station', arise in a similar way. Recognition of houses, schools, hospitals, etc. is based on these stereotypes.

Different societies create different forms of dwellings and of religious and educational buildings. The word 'home' does not make a New Yorker think of an igloo or a corral, nor does it make an Eskimo think of an apartment. Rural Americans will have other stereotypes than city dwellers; the poor will have other stereotypes than the rich. The (partly indefinite) form of the stereotype arises from the life-history of the individual, within the subculture of the group to which he belongs, and that again within the larger cultural setting of his society and his time. The influence of the subculture on the
formation of stereotypes can partly explain the resistance to innovation and the adverse comments on certain modern buildings, as well as the predilection of large groups of the population for ‘Colonial’ or ‘Spanish’ architecture.

Many architectural forms, such as towers and columns, or materials such as marble or glass, have been used to transmit a symbolic meaning. Smooth, stuccoed facades in an asymmetrical form and with large panes of glass symbolized the ‘open society of the future’ and the ‘dematerialization’ of the building for the avant-garde architects between 1925 and 1940 (van Loghem 1932, Prak 1968). These forms were used on a large scale by many architects after the second world war. They lost their symbolic meaning and became temporarily a part of ‘normal’ architectural fashion. The majority of the people have never understood the symbolism; they probably saw such forms as ‘architect’s whims’ in the thirties and as ‘modern architecture’ in the sixties.

5.3. The Connotative aspect

Everyday experience shows us that the built environment is not only used, but also evaluated. Protests against urban renewal and efforts to protect or restore old buildings demonstrate that the environment means much more to people than just shelter. People get attached to the spaces they use, which they show by personal treatment and by their reactions when these spaces are ‘occupied’ or ‘invaded’ by strangers. Research confirms these observations. Ambulant patients in hospitals often try to establish an exclusive right to use ‘their’ particular chair and table (Sommer, 1970, Esser, Chamberlain, Chapple and Klein 1965). Similarly, sailors forced to work together in pairs in fairly cramped quarters, soon appropriated their ‘own’ chairs, beds and sides of the table (Altman and Haythorn 1967).

This sense of personal involvement is strongest, of course with the home. Questions by Ekambi-Schmidt (1972) about desirable qualities in a house brought out its protective and private character. Respondents stressed it in particular for their own rooms, which for the adult couple would mean the parents’ bedroom. In this private room — and to a lesser degree in the whole house — man finds his own territory, to which he or she can withdraw from the outside world; it is the one space which he can call really entirely his own.

Many authors suppose that man needs such a private territory, just as the animals (Goffmann 1961, Stea 1965, Altman 1970). They believe that he owes his self assurance and his identity partly to such a territory. He takes possession of it by furnishing it with his personal belongings. E.g., many secretaries decorate ‘their’ corner in the office with calendars and picture postcards just as students and army-recruits turn an anonymous bunk in a dormitory into a private nook with pin-ups. An individual is ‘boss’ over such a territory, he can ‘throw others out’. Some boys build their own ‘houses’ in a garden or a tree, and withdraw to them for days; other children install themselves in a ‘secret’ place in an attic for daydreaming.

The relation between identity and territoriality shows up in two research findings. Ekambi-Schmidt asked her subjects about the first requirement of a house. The answer most frequently given was that the house had to reflect the personality of its inhabitants. A piece of research done by Dutch architectural students started from the premise that inhabitants would identify more with their homes if these could be clearly distinguished from other similar dwellings. The subjects lived in a 12-story apartment building, of which the door and window frames of the 2nd and 10th floor were painted blue, whereas the other floors had white frames. Questions about satisfaction or attachment to the dwelling brought out no significant differences between inhabitants of ‘blue’ and ‘white’ floors. A question about the attributes by which one might characterize a person (his car, books, profession, religion, etc.) did produce a significant difference: inhabitants of the ‘blue’ floors mentioned the home far more often in the first place than inhabitants of the ‘white’ floors (Bakker and Snelder 1971).

That connotative aspects of meaning influence perception was demonstrated in a series of experiments on size-perception. Lambert, Solomon and Watson (1949) made it possible for three to five year old children to obtain candy with a token. After this they
had to adjust the size of a circular patch of light to the size of the token. Comparison
with a control group showed that the ‘value’ of the token influenced the adjusted size.
Similar results were obtained in other experiments (Proshansky and Murphy 1942, Bruner

For the measurement of the connotative aspects of meaning, Osgood, Suci and Tannen-
baum (1957) developed the semantic differential. It consists of a list of paired opposite
adjectives (good-bad, optimistic-pessimistic, light-dark, warm-cold, beautiful-ugly, etc.).
The two adjectives of a pair are printed at the ends of a seven-part scale. Subjects are
asked to evaluate a word (or a color, a painting, a melody, etc.) by marking one of the
parts of this scale with a cross. Putting the cross in the middle means that both adjectives
are equally applicable; moving the cross towards one or the other end of the scale means
that the adjective at that end is more applicable than the other. There was a high
correlation across subjects, or, in other words, people agreed on the degree of optimism,
warmth and beauty to be accorded to a color-word such as ‘red’. In addition, these
statistical calculations showed that the adjectives tended to cluster in groups. One group
consisted of such adjectives as: ‘good, beautiful, sweet, clean, tasteful, valuable, friendly,
agreeable,’ etc. This group was called the evaluative factor in (connotative) meaning by
Osgood et al; they also found a potency factor and an activity factor.

Van Wegen (1970-b) studied the connotations of the words ‘wood’, ‘concrete’, ‘brick’,
and ‘glass’ with the semantic differential. The evaluative factor in particular showed up
clearly with all four words. The series of bipolar adjectives associated primarily with the
evaluative factor in these experiments were: beautiful-ugly, friendly-unfriendly, interesting-
dull, cozy-cheerless, colorful-colorless, varied-monotonous, natural-artificial, and pleasant-
unpleasant. Wood was always evaluated very positively (beautiful, friendly, interesting,
etc.) and concrete very negatively (ugly, unfriendly, dull, etc.). Brick and glass were
found to be in an intermediate position between these two extremes.

Prak and van Wegen (1974) were interested in the relations between denotative and
connotative aspects of meaning in architecture. A first group of 80 subjects guessed what
the functions might be of 17 slides of buildings; 11 of them turned out to be ambiguous
(different labels were given to the same slide). Three of these 11 slides were selected for
the actual experiment because the guessed functions would probably differ considerably
from each other in their evaluation, some functions seeming to be far more attractive
than others. E.g., one slide could represent ‘school’, ‘factory’, or ‘indoor swimming-pool’. After
this the three slides and the words naming the functions which were associated with
them, were evaluated by separate groups of subjects on an abbreviated evaluative seman-
tic-differential scale, consisting of the bipolar pairs beautiful-ugly, friendly-unfriendly,
interesting-dull, cozy-cheerless, varied-monotonous, pleasant-unpleasant. The exper-
imenters assumed that mentioning a certain building function, such as ‘swimming-pool’,
triggers a whole train of emotional associations and raises certain expectations about the
building which houses such a function. If the function is liked — as would be evident
from a positive evaluation of the word — and the building on the slide is liked less, or
even disliked, than the expectations would be thwarted. This led to the hypothesis that
the coupling of a positively evaluated function with a neutrally or negatively evaluated
slide would produce an even more negative judgment for the combination (and not an
average of the two). The three slides were then presented with the different functions as
labels to different groups of subjects (N=594). The results confirmed the hypothesis.

5.4. Application

The experiments of Lambert, Solomon, Watson and others have shown that perception is
probably affected by meaning. The last experiment of the preceding section demon-
strated some effects of meaning upon attitude. The purposive and practical nature of
human perception makes it seem probable that meaning is an overriding influence in
perception, particularly in the selective attention to what is perceived and remembered.
The evidence for this cited in the previous paragraphs is admittedly insufficient for such a
sweeping generalization; yet I believe this to be due more to the lack of an adequate
theory and an accompanying set of sensitive measuring instruments than to the absence
of this factor by itself. Impressive results have been obtained in the study of the mechanisms of the perception of form and space. The theory and measuring instruments for this kind of study have been developed in a period of over a century. Knowledge about the perception of form and space is a prerequisite to the study of meaning; but it would be a mistake to let the matter rest there. It was necessary for an adequate study of the tendencies of the visual system to eliminate meaning as far as possible from many experimental situations. Today our scope should be broadened and meaning must again be included, in my opinion. Otherwise we run the risk of studying perceptual processes which are easy to manipulate in a laboratory setting, but irrelevant to the larger issues in the outside world.

An environment is never perceived in isolation, but always in a context. The human being brings his whole mental equipment to bear on his interaction with the environment, of which perception is but a part. Nature and nurture determine his pattern of reactions. He can use a great variety of strategies for adapting his environment to his activities and his activities to his environment. He has learned social norms and adjusts his interaction to what he supposes to be the social norms of others. His status, work and satisfaction, his religious and political convictions influence his attitudes and his perceptions of schools, houses, factories, recreation areas, etc. In short, we have to do with the whole man and not with some easily detachable function which can be studied in isolation.

Let us take another look at the experiment with the ambiguous slides, mentioned in the last paragraphs of section 5.3. A building of a certain type, say a factory, has a position in the total range of all known building types, from sheds to city halls and churches. The attitude of a person towards various types of buildings is probably derived from his attitudes towards the activities which take place in these buildings. These attitudes towards activities in their turn are part of the system of norms and beliefs of an individual, and vary between individuals. For some people a factory is primarily a cause of environmental pollution, for others it is a sign of economic well-being.

Secondly, a single building is rated against a background of buildings of the same type. Twelve years of personal experience with schools, combined with the comments overheard from our parents and what we read about schools have gone into the building of our own stereotypical image of 'a school.' This stereotype causes us to expect something of a school for our own children. We compare that school with our stereotype and with other schools we know. If it falls short of it, we will be disappointed, and this disappointment will show up in our rating of the building. As schools differ in rich and poor districts, in urban and rural settings, the stereotypes, the expectations and the ratings will differ too. The degree of satisfaction with a building is therefore probably a dependent variable. To look for some kind of constant judgment in this area which architects could use for the design of each and every school is probably as hopeless as the search for the Philosopher’s Stone.

Although the practical deficiencies of modern buildings have usually born the brunt of the user’s criticism, the visual appearance has sometimes been commented upon too. The (British) Department of the Environment questioned tenants about their reactions to the general appearance of their dwellings and their surroundings (1972). ‘Large slab blocks were often said to be too massive and with their numerous similar windows seemed to have an institutional appearance; they were frequently described as prisons, barracks or concentration camps’ (p. 2). It may seem obvious to relate this reaction to the need for variety described in sections 4.1 and 4.2 of this book; but to let the matter rest there seems too simplistic to me. We gain a totally different perspective if we set such monotonous housing blocks against the background of the general category of ‘houses,’ a class which ranges from dilapidated substandard tenements to split-level ranch homes in shady suburbs. Then it becomes apparent that the blocks are much closer to the tenements than to the ranch house; in fact too close to them for comfort. The monotony has a meaning — it speaks of parsimony. It is evident that the tenants of such flats have been fobbed off with the barest minimum; and the tenants can see that too. That may well be the primary reason for their adverse criticism, outweighing the need for variety. It should be noted that criticism was more or less evenly divided over low and high rise projects, and not related to heights of buildings or distance between frontdoor and street. Most research has shown a preference for living on the ground level, and the single-family house (row
Fig. 109. Small custom-built houses of market-gardeners south of Bruxelles. If the client can build exactly as he pleases, unhampered by restrictions of code or town planning departments as regards form, a highly contrasting set of forms will result. The coherence between these houses is weaker than in Fig. 91 because they are not adjacent and not built in alignment, which is why they are perceived as separate blocks and not (as in Fig. 91) as parts of a continuous street.

Fig. 110. Size, overall shape and details still show that these allotment-garden houses were originally identical. The users 'personalized' them by changing them according to their fancy.
house, semi-detached or detached) has usually been the major choice. Yet in this study, which focused on appearance of the estate, it did not come out first.

Conversely, the favorable comments on some more varied housing projects which were collected by the Department of the Environment may not be due only, or primarily to their excellence in design per se. The visible effort to do more than the strictly necessary put these dwellings in a category entirely different from the the massive slab blocks. The evidence that the housing agency cares for the external appearance and is willing to spend money on it may completely overshadow the questions of quality of the design, visual complexity, etc. Of course such aspects influence the attitudes too, but they may well play a minor role. This argument, if it is correct, upsets a few cherished architectural beliefs. Architects have often argued that cost and materials mattered less than the quality of the design. But from the viewpoint of the tenant cost and materials matter a great deal, and are of more importance as signs of respect for him by the housing agency than the display of architectural virtuosity. Of course it cannot be denied that design exerts an influence on attitude too, but architects are prone to overrate it.

A similar line of reasoning can be applied to the durability of materials. They, too, are not taken at face-value, but interpreted. Many public housing estates have been constructed of practically indestructible materials, such as glazed brick and rough-shuttered concrete. Tenants are no fools; they can read such signs of mistrust in their behavior and correctly interpret them as tokens of disrespect and paternalism. Their very indestructibility is an inducement to vandalism. Once the first edges are chipped off, the first sheets of wired glass are broken, a downward spiral sets in. Because an elevator lobby looks shabby, litter is left lying around, more windows are broken, walls are smeared with paint, etc. The neglect in turn influences the attitude, which leads to more vandalism again (Ward 1973).

At the opposite end of the scale we find environments which are well cared for. They too are full of meaning. In Europe many public housing estates of the twenties and thirties have been lovingly repaired and maintained. Well-kept lawns and flower beds and tidy entrances are evidence of pride and care. Some tenants thought it worthwhile to invest their time and money in such an environment. This investment in its turn reinforces a positive attitude, which may lead again to new investments in time, money and effort. By the signs that it emits, such an environment activates a certain amount of social control and self-control. To throw litter in a derelict elevator lobby is 'normal'; on a well-kept entrance or lawn it would be an outrage.

The symptoms of personal care are, of course, most evident in environments which have been made by their owners or tenants themselves. Personal manipulation of the environment has an important effect on the man who practices it. As he changes the environment to suit his own needs, he becomes more involved in it; it becomes more his own environment. The act of change of reconstruction is also an act of appropriation, as Habraken (1972) has pointed out. The desire to personalize one's home stands out clearly in owner-built houses which have not been hampered by restrictions on form (Fig. 109; compare Fig. 87). This variety and individuality in design may perhaps be interpreted as evidence for man's need to identify himself with his house. The findings of Ekambi-Schmidt and Bakker and Snelder lend some support to such an interpretation.

Many architects and town planners will probably look with disdain at the collection of houses shown in figure 109. They will think such a group 'incoherent' and 'messy', a 'sheer jumble of forms'. They would prefer to impose some kind of formal coherence, as shown for instance in Fig. 87. Architects set store by the aesthetic appearance of the built environment. They talk and write about 'spatial effect', 'visual drama', 'scale', etc. Research findings show that the users of buildings have an entirely different set of values. They criticize buildings primarily on practical points: they complain about leaking windows, lack of storage space and noises penetrating party walls. Users consider the built environment first of all as an instrument or a tool, comparable to telephone, typewriters, pencils or cars; an instrument that is a help or a hindrance in their activities. Architects on the other hand look upon the built environment more as an aesthetic setting in which they can display their design talents. The difference in values will induce an architect to sacrifice practicality to form in a case of conflict, whereas a user would probably take the opposite decision. Any architect who has designed custom-built residences can testify
Fig. 111. Would architects of concrete facades or interiors be aware of the distaste of laymen for exposed concrete?
from his own experience to such conflicts and such decisions, for the prospective owner of a custom-built house can intervene in the design process.

The attitude towards building materials is a case in point. In many recent buildings concrete is left exposed, both on the exterior and on the interior. Many architects have expressed their preference for exposed concrete; they feel that it ‘expresses’ the structural function of load-bearing walls and floors, and that it is ‘honest’ to leave it exposed. But the layman is not used to thinking in terms of honesty or strength of materials; he reacts directly to the dull grey color and the structure of the exposed surface.

Van Wegen’s experiment (1970b) with the words ‘wood, concrete, brick and glass’ shows that non-architects associate these materials probably with the constructions in which they usually occur. ‘Concrete’ is disliked, probably because it is associated with roads, dams and bridges. It should give architects pause to think about the use of a material that carries such connotations. The architect’s preference for exposed concrete is due to his training and to the fashionable influences of Le Corbusier and New Brutalism. It is a part of his professional system of norms and beliefs which he obviously cannot share with the layman. It seems likely that some of the negative connotations of the word ‘concrete’ will carry over to buildings executed in that material, no matter how well designed.

Psychological research on the way people judge each other has shown that a favorable or unfavorable judgment on some aspect of a person under review affects other aspects of the same person (Medley and Mitzel 1963, Cronbach 1964). E.g. if the same high-school student is taught English and History by the same teacher, and he does well on history, then the teacher will be inclined to view his performance on English more favorably also. Or a person who is considered to be ‘nice’ and ‘diligent’ will be judged more favorably on some quality which has nothing to do with it (e.g., ‘accuracy’) than an individual who is thought to be ‘impudent’ and ‘lazy’. It seems probable that this so-called halo-effect is the result of stereotype-formation in judgment and that it is applicable to the built environment as well.

Architects who like a building or a neighbourhood because it is ‘beautiful’ will be inclined to excuse its practical shortcomings. Research which showed this esthetic halo-effect for architects, did not show the same sensitivity to it by others (Kaplan, Kaplan and Deardorff 1974).

Several studies have given an experimental demonstration of the discrepancies between the attitudes of architects and users towards the built environment (Lansing and Marans 1969, Yancey 1972, Gadella et al 1973). Many architects believe that most — if not all — design decisions can better be left to them, because they know how people think and live (for they are ordinary humans themselves) and they are, in addition, experts in the use of space and the construction of buildings. These studies prove them to be mistaken. The ‘common sense’ of the architect is not the common sense of the user, simply because the one has been subjected to a professional training and the other has not. Let us, therefore, mistrust the intuition of architects and try to find out where people’s needs have been thwarted, by experimenting and theorizing. There is no intuitive shortcut to knowledge.
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B. Moosbrugger, Zürich: 100
N.L. Prak, Rotterdam: 11-44, 46, 47, 52-54, 63-72, 74, 76, 77, 83-97, 101-111
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W. Vandiver, New York: 48
V. Vasarély, Paris: 10
Verkehrsverein der Stadt Bern: 73
G. Wernars, Amsterdam: 45
This book bridges the gap between the psychology of perception and architectural design. It shows how psychological findings can be applied to architecture; how contrast or coherence can be increased or decreased, and why some buildings look complex and others simple. It discusses figural organization, the perception of directions and of space and the denotative and connotative meaning of forms. It is based on an information-processing approach to perception.

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