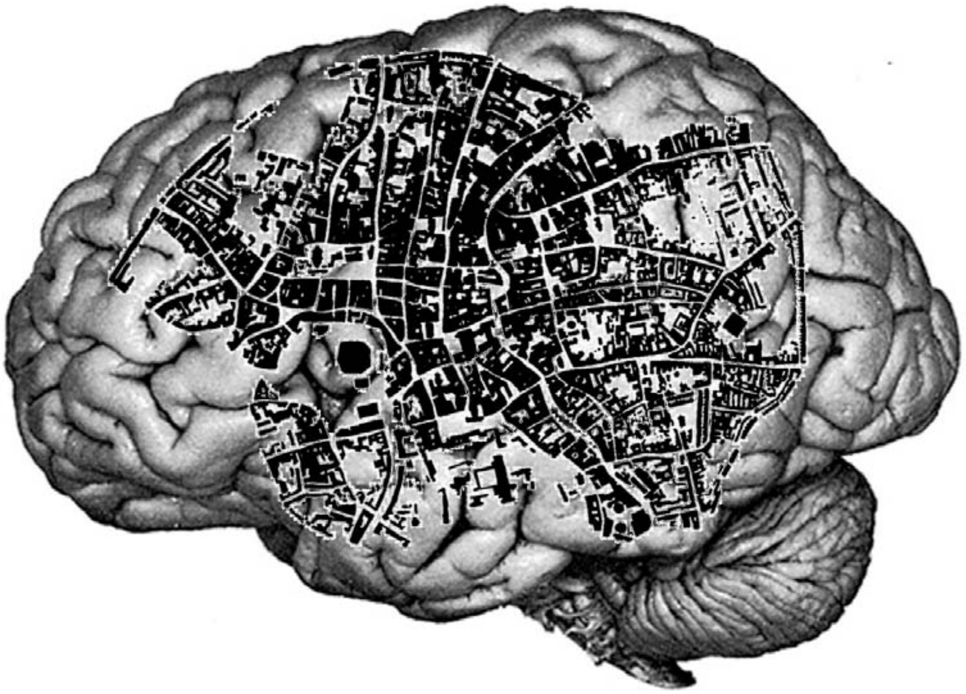

ABSTRACT

The justification for spatio-physical planning techniques based on patterns of streetscape morphology is elaborated in this paper. Local planning formats that encourage dynamic tensions between complexity and coherence are proposed elsewhere by the author.

Preferences are found to exhibit considerable constancy across people and cultures. To support survival, an animal must prefer environments, or spaces, that are suited to its purposes. In the built environment humans purposes are either specific and task oriented or aspecific and stimulation oriented. The former seeks environmental functionality (legibility and coherence) and the latter enjoys environmental animation (mystery and complexity). Cognitive processes that drive these behaviours derive from our evolved physiology. Our nervous system, composed in part by a homeostasis-seeking limbic system and information-hungry cerebral cortex, has adapted to succeed in our environment.

The visual system also exhibits complementarity – detecting change against stable backgrounds: too much randomness or coherence in a percept is equally dull. Urban character arises from the tension between the complex variability and coherence of perceived morphological components. Pattern and clarity is required in the streetscape as well as complexity and elusiveness. The tendencies of the mind and body should be the basis for local planning techniques through regulating low-resolution patterns of spatial morphology.

There is an increasing consensus that our perceptual tendencies and basic environmental preferences are shared (e.g. Kaplan 1988; Gibson 1950, 1977; Heath 1988; Berleant 1988). While there are undoubtedly individual, regional and cultural differences in opinion and taste, this rests on a prevailing hard-wired physiological foundation from a shared evolution. Tourism demand, cross-culturally, to experience particular (especially historic) built environments for their pleasure qualities provides anecdotal evidence of our shared aesthetic values. Tourists will frequent even rather 'ordinary' examples of towns and regions due to their spatial beauty – not just particular architectural monuments. We generally agree that historic cities and spaces are desirable and nowadays seek to conserve their character through planning laws. Meanwhile, 'the rest' (and most) of the built environment (i.e. streets and squares) are subjected to disjointed planning applications with no common spatial vision.

The historical concern for personal idiosyncrasies, or taste, by built form designers and regulators is misguided. While perceptions are not all the same, there are striking commonalities. Life experience leads to adaptive differences in judgement. Consequently, the greatest differences in preference occur between experts in a field (eg architects and artists - who manipulate forms daily), and everyone else (Berlyne 1960, Kaplan 1988: 53). Built-form professionals can not be 'impartial' judges of the aesthetics of proposed developments. Other than these people, there is a remarkable degree of preference constancy across people and cultures for different scenes (Nasar 1988a, 1988b; Prak 1977: 69).

E V O L U T I O N

The brain is the primary organ of perception and our instrument of judgement. It is a product of evolution directed toward survival within our surrounding ecosystem(s) and its components over millions of years. The brain's physiology was developed well before the arrival of *Homo sapiens*. According to Dawkins (1976), we are but a complicated gene-propagating device and our advanced brain gives us advantages to this end. For over 99% of human existence we have survived from hunting, and a hunter, predominantly, of big game. Besides being the major source of food on-the-hoof in Africa, where we travelled we have contributed to the demise of the largest species' first (eg the Woolly Mammoth, the Diprotodon of Australia, or the Moa of New Zealand (Flannery 1994). The danger involved in this food source, where our tools were only effective to around 30 metres, also influenced the growth of our perceptual system.

As an animal of limited speed or strength, humans have relied on intelligence and skill. The arboreal environment helped us develop excellent spatial vision and a grasping hand – but these needed to be combined with complicated analyses and plans to ensure survival. The requirement for planning and anticipation favoured the development of larger and more flexible information-handling capacity. Kaplan (1973) suggests that there are four types of knowledge required for our survival. We needed to know:

(1) where we were;
(2) what is likely to happen next;
(3) whether it will be good or bad, and;
(4) what to do (deciding responsive action).

The first point requires perception of the immediate stimulus array and implies memory schemas of preceding events. The latter points require a highly efficient predictive and decision making capability. The most efficient mechanism, or structure, that is able to meet these requirements is the neural network – a three-dimensional lattice of message sending/receiving devices. Linear, chainlike, hierarchical or treelike structures are not sufficient to utilise knowledge of a common object across a wide range of situations. Associations cannot be limited on the input or output side.

The nervous system is indeed composed of 15-20 billion electrically conducting neurons in a three-dimensional network. Each neuron has many connections, via axons, to other neurons. Messages, as electrical quanta, called the action potential, travel along the axons and stimulate the dendrites of target neuron(s) (Carlson 1998: 21). When the stimulation reaches a threshold, the neuron is switched from 'off' to 'on'. Attributes in the external environment that cause this neuronal switching *correspond* to those neuronal elements. The associative pattern of external attributes to neuronal elements is rich and unrestrained so that complex correspondences can occur.

At a higher level of complexity, collections of associated neurons imperfectly and flexibly correspond to objects (with multiple attributes) in the external environment. These are called representations and develop through experience with objects and situations – or learning. Representations are categorised in complex schemas, to manage the sheer quantity of environmental information, and stored as memories.

Active representations (present stimuli) can be rapidly linked with inactive representations (memories) to consider likely futures. The neural network properties of generic perceptions and associative networks provide the human organism with a highly efficient decision making capability. The same network associations that are necessary for short-range decision-making allow for the emergent capacity of long-range contemplative thought. When many possible representations are stored in the mind along with the relations between them, this is a cognitive map. Spatial cognitive maps are a special case of cognitive maps in general, and are intertwined with those other cognitive structures. They are an essential component in the adaptive process of spatial decision making and operability. Spatial cognitive maps have been defined as:

> "a construct which encompasses those cognitive processes which enable people to acquire, code, store, recall, and manipulate information about the nature of their spatial environment" (Downs and Stea 1973: xiv).

The human has been evolutionary selected for cerebral speed – one who is quick to perceive, decide and act. There must be a bias towards action and against internal rumination due to the danger of elaborate representations of a large number of possible futures. Thus, we tend toward oversimplification, generalisations and making decisions, and acting, on incomplete information. Pleasure and pain are treated like other sensory properties (Olds and Milner 1954) and give motivational coding to associated and derived representations (ie. possible events). Contrary to behaviourist rationality (eg Skinner 1980), where we would simply laze about when our primary drives are fulfilled, humans are intolerant of boredom. We are eager to learn, explore and act. Our evolutionary advantage has been the successful use of information derived from the environment and our ability to make decisions from this information. Environments that are not rich in information or possibilities, nor are homeostatically restorative, are perceived as lacking opportunity, interest or meaning.

Perception is derived from the information present in the environment. We focus on informational possibilities and opportunities. Gibson (1977) calls these possibilities *affordances:* what a percept (object, scene, creature…) has to offer the perceiver. We will be looking for affordances that increase our sense of comprehension and affordances for involvement – especially those that are rich in possibility. In evolutionary terms, animals, including humans, must be able to recognise and, importantly, prefer environments in which they will survive, and flourish. Environmental preferences must relate to functional appropriateness for survival success. It would not be efficient for animals to dwell in inappropriate environments for half of their life cycle, only to realise that an adjacent environment would have afforded a richer, easier and more productive life (eg in terms of offspring). Random or idiosyncratic environmental preference judgements would be disadvantageous in the evolution of a species. Preference judgements therefore need to be innate, rather than learned. Perception is linked to human purposes and purposes are linked to preference (Kaplan 1988a: 46). Perceptual preferences derive from human psychophysiology, which has been moulded, over time, by our environment interacting with our purposes (for information and restoration) in order to survive. We will prefer environments today that suit our inherited perceptual structure.

T H E N E R V O U S S Y S T E M

Dichotomies within dichotomies are present within the central nervous system. There is the somatic and autonomic nervous systems, dealing with information regarding the external and internal environments respectively. These systems have afferent and efferent nerves sending information to and from the central nervous system, respectively. The autonomic system is subdivided into the sympathetic and parasympathetic systems – the former used in situations needing energy and arousal, and the latter for de-arousal and preservation of energy. Dualities used in the visual system will be discussed below. Distinctions between the limbic system and the cerebral hemispheres will here be overviewed. The cerebral hemispheres themselves are a single unit with clear lateralisations.

The *telencephalon* is the largest and most important division of the brain. It includes most of the two symmetrical cerebral hemispheres that make up the cerebrum. The two hemispheres are mostly covered by a convoluted cerebral cortex (**Figure 1**) called the neocortex ('new cortex'). The convolutions triple the surface area of the 3mm thick grey matter (to 2.36squ.m.) upon which the surface of the body, including the retinas, are mapped (Carlson 1998). The neocortex works with complex memory schemas and may give rise place-attachment even in severely limited urban settings through repeated use and experience (ie memories).

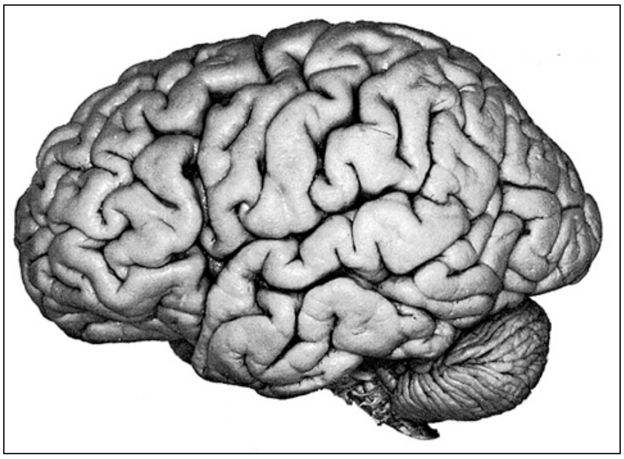

Figure 1 - The Cerebral Cortex of the Left Hemisphere

The two cerebral hemispheres cooperate and coordinate, through the corpus callosum joining them, but exhibit functional lateralisation (see **Table 1**). The left hemisphere predominates in the *analysis* of information – or dealing with specific informational elements. This ability makes the left hemisphere particularly good at recognising and controlling serial events and behaviours – such as talking, understanding speech, writing and reading. It is also good with mathematical ability and logical and rational deduction. In the built environment, it identifies functions and perhaps styles of buildings from logical memory schemas. It deals with verbal information (advertising, names and signs) and semantically sorts this information into related concepts. The left hemisphere enjoys details and intricacies of particular façades and scenes. It establishes a cognitive fix in space by using landmarks with verbal and sequential identification.

The right hemisphere specialises in *synthesis*. It is capable of simultaneous, as compared to linear, processing. Its forté is putting isolated elements together to perceive them as a whole. The ability to draw, especially three-dimensionally, read maps and construct complex objects from smaller parts, relies heavily on the right hemisphere. This hemisphere has a bias toward pattern and coherence. It is selective of abstracts such as shape, relative location, colour, texture, tone and rhythm. The shapes of buildings and spaces and their components (gables, windows, doors…) are of great significance. However, the right hemisphere is inarticulate and therefore communicates to consciousness non-linguistically.

HEMISPHERIC LATERALISATION	
Left Hemisphere dominance	**Right Hemisphere dominance**
Words	Faces
Letters	Emotional expression
Verbal memory	Non-verbal memory
All language skills	Spatial abilities
Arithmetic	Music
Complex movements	Movement in spatial patterns

Table 1 - Hemispheric Lateralisation (after Eysenck 2000: 86)

Conscious response to the urban field is a dialogue between the left and right cerebral hemispheres (Smith 1977). That is, between the response of verbal concepts and sequential issues (left), and the response to abstract information about space and form, especially elements contributing to pattern and unity (right).

The limbic cortex, also part of the telencephalon, sits around the edge (*limbus* meaning border) of the cerebral hemispheres, mostly in subcortical areas. It is the oldest and simplest form of cortex. The limbic system is a group of brain regions, including parts of the hypothalamus, involved in the regulation of 'motivated behaviours'. The hypothalamus in particular organises behaviour related to species survival ("the four F's") – fighting, feeding, fleeing and mating. The evolution of the system coincided with the development of emotion, though parts of it are also known to be involved with learning and memory (Carlson 1998: 74). The limbic system holds the raw material of conscious awareness and will seek a return to homeostasis once motivated behaviours have been executed (Smith 1977). A primitive complex optic nerve connects directly to the limbic system allowing rapid automatic reactions to external stimuli to occur. This system has a wider scanning capacity, with judgements related to a larger field of information, as well as a higher neuronal transmission rate than the cerebral cortex. Unconscious reactions therefore can occur up to seconds before one has 'time to think', or use the conscious part of the brain. Kaplan concurs that "preference judgements are often made so rapidly that they precede rather than follow conscious thought" (Kaplan 1988: 57). Experience of and reactions to the built environment is mostly subliminal and is therefore likely to be limbic-intensive.

The limbic processes would relate to the fundamental desire for 'refuge' (Appleton 1975), Kaplan's (1988) 'making sense' aspect of purpose (see below), or the 'orientation response' (Lozano 1988) in the built environment. Hall states that "man's feeling about being properly oriented in space runs deep. Such knowledge is ultimately linked to survival and sanity. To be disoriented in space is to be psychotic" (1966:105).

The limbic system will be content in environments offering safety, predictability and defensibility. As an organism under time pressure to respond in the natural world, efficient perception depends on the predictable recurrence of environmental properties (Kaplan 1973). This may be achieved through rhythms and patterns in the urban milieu. Personal security may be achieved through the enclosure of space, for protection, longer glimpses for orientation with direction and multiple entrances/exits for flight routes. The limbic system will prefer the presence of natural daylight and fresh air; the sight and sound of moving water; options for levels of activity and rest in a space; as well as enjoying the sights and smells of food and drink (Smith 1977: 32). These are some of the fundamental pleasures of life. One behavioural manifestation of limbic tendencies may be the ubiquitous enjoyment derived from sitting at the edge of a space overlooking the activity of people.

Smith (1977) provides a discussion of interactions simultaneously occurring between the limbic system and the cerebral hemispheres in the urban milieu:

> "the basis for rapport between the right cerebral hemisphere and the limbic system [is] in the matters of colour, pattern and rhythm. The limbic system reacts to primary hues of maximum saturation and brightness. The right hemisphere of the neocortex responds to colours further down the scale of chroma and brightness, the subtle, sophisticated colours. The limbic system responds to pattern for reasons associated with de-arousal and homeostasis, whereas the right hemisphere derives intrinsic satisfaction from the contemplation of pattern and coherence. The limbic brain responds very positively to simple serial rhythm (beat) or repeated simple pattern. The right hemisphere enjoys complex rhythm, especially when it contributes to a whole which is complex and elegant. At the same time a dialectic rhythm is established with the left cerebral hemisphere which analyses the mathematical system behind rhythm and pattern" (Smith 1977: 89).

The limbic system enjoys the rhythmic simplicity of life for the purposes of survival at the most fundamental level – to maintain homeostasis. The higher cortical areas enjoy the intricacy and complexity of environmental stimulation that is a by-product of our superior information-handling capabilities. The dichotomies of the nervous system are not always as clear-cut as presented, but can be considered 'fuzzy' (Kosko 1994) – a duality and complementarity as compared to binary systems. It is well known, for example, that left-handed people exhibit some reversal in hemispheric lateralisation.

Enjoyable spaces in the built environment satisfy the requirements of both the limbic system and the cerebral hemispheres. This can be achieved in the restrained complexity of an architected streetscape (eg Regent's Place, London), as well as amidst the patterning of rhythm and skyline of the urban high street.

PERCEPTION

Working within the complex array of processes in the nervous system is the visual process. Judgements of the built environment are overwhelmingly derived through this sense, as is much information about the world. Planning for the human scale needs to be related to the vagaries of the visual system. Amazingly, from tiny, distorted and inverted two-dimensional retinal images, the visual system produces a richly detailed and accurate three-dimensional perception of space and forms (Pinel 1997: 151). The eyes move at 50-150 oscillations/second over half an arc minute with selected images stored in short-term memory. This memory system compares and contrasts variables of the perceptual field (such as colour, size, movement, intensity) to discern objects. Visual perception is thereby based on the difference between what is known and what is new. It is based on comparison. Consequently, visual perception requires a level of redundancy, or familiarity. There must be a 'ground' against which a 'figure' can stand out. "Perceptions without redundancy are just as uninteresting as highly redundant ones" (Prak 1977: 17). Moving parts in the built environment, such as people, trees and water, add enjoyment because the visual system has evolved for the detection of change against a patterned background. Redundancies in form (e.g. repetition, texture, uniform colour, continuity, and simplicity of bounding surfaces) are used for the perception of objects.

The Gestalt-laws of form-perception firmly established that the mind has a level of attunement to pattern. The efficient use of redundancies and patterns frees our perceptual system to concentrate on new and different information (Koffka 1935). This ability is obviously necessary for survival in the natural world where there is an enormous amount of secondary background information to be accepted so we can focus on the primary stimulus. Four of the non-hierarchical Gestalt inclinations, relating to the perception of the built environment, are listed in **Table 2**.

♦ *Law of Prägnanz:* the visual system integrates separate visual stimuli into a (meaningful) whole. For spatially contiguous forms, perception organises visual stimuli in as large and as simple forms as possible. This is called *Simplicity of form*, where 'simple' may mean regular, symmetrical, minimal reentrant corners, etc.
♦ *Law of Proximity:* forms that are close together tend to be perceived as a coherent group. Grouping elements together is more efficient than seeing them as separate elements; hence this is an extension of *Prägnanz*.
♦ *Law of Equality:* Equalities and similarities, especially in patterns, are immediately recognised.
♦ *Law of Continuity:* A figure is continued as it starts – new information will not be added (e.g. a line continues as a line, a zigzag a zigzag, a plane a plane, etc.). Information is concentrated at changes in direction (e.g. angles) and therefore the effect of *closure* occurs even if only the angles of a form are given.

Table 2 - Gestalt Laws of form-perception

The Gestalt laws are often overlooked in modern building practices. Buildings with plain smooth façades show no play of light and shade and exhibit far less movement parallax than heavily moulded facades. Two major cues for space perception are thus missing. This makes the perception of distance and position more difficult and contributes to the abstract, irrealisitc effect of these buildings (Prak 1977: 46). The Gestalt law of continuity implies that a smooth facade will look more like one continuous surface than one with heavy mouldings and strongly projecting members. A flat smooth facade is a 'hard Gestalt': its simplicity as a surface makes it an absolute form, comparable to a straight line or circle. Consequently, smooth façades look impenetrable, even if made of glass.

Moulded façades seem more accessible, open and softer, because of this lack of continuity. Attaching projections, such as balconies and staircases, is also easier on a moulded façade because the perception of a single plane surface is not possible.

The *Law of Prägnanz* suggests that the human visual system divides a form (e.g. building or streetscape) into chunks that are at the same time as large and as simple as possible. Modern multistorey residential buildings are not perceived as combinations of flats, but always as rectangular blocks with repetitive patterns (eg of windows, doors, lines). These, too, are hard Gestalts. Because of the effect of *closure,* projecting balconies or features will change little in this perception as long as the corners are left intact. In the streetscape, closure is experienced when projecting eaves of approximately the same height give an impression of a street 'ceiling'. The visual system completes the shape that is implicated by the corners of the space (**Figure 2**). Where buildings are contiguous in a street, the laws of *Prägnanz* and *Proximity* imply that they will be perceived as a whole streetscape unit rather than a collection of individual objects. One unit is an easier percept to manage, ie is more redundant, than many smaller adjacent units. However, these sub-units can become the focus of attention at any time. The visual system will be further satiated when the percept contains internal complexity – preferably with articulated shapes, patterns and rhythms.

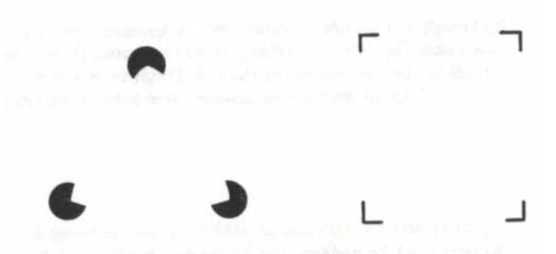

Figure 2: Closure

Too much redundancy, or predictability, is not desirable. Variety is achieved in form by opposing simplicity. It is akin to complexity. Complexity is achieved by creating contrasts in form, dimension, materials, scale and so on. Yet too much variety is perceived as disparate parts rather than of a whole design. A tension between coherence and contrast, pattern and variety, therefore must exist. Contrasts may be set up in one variable, such as materials, whilst coherence is maintained along other variables, such as forms or dimensions. Modern buildings of complex forms generally use a common material to indicate coherence. Where the form is simple, such as a house, diverse materials may be used. In the traditional inner urban area or high street, relative coherence is maintained in spatial dimensions (height, width, and rhythm), while diversity is present in the higher-resolution variables, such as materials, styles, fenestration, uses etc. This idea is in contrast to the recently prevailing architectural paradigm, published by Venturi (1966), of complexity and ambiguity in the urban scene. Both clarity and relative complexity are preferred in evaluations of residential and urban street scenes (Nasar 1988a, 1988b; Prak 1977: 69).

Environmental spaces need to possess a level of redundancy or pattern for interest to arise. Where a collection of buildings are disconnected in all variables (e.g. shape, placement, pattern, arrangement, materials…), a lack of perceptual interest will result. There is an inability to assimilate disparate elements. We could call the resultant space characterless, meaningless and incoherent. Toffler (1970) warns against 'future shock' in this manner – where too much change and information, without maintaining continuity and similarity temporally and spatially, will be psychologically damaging.

The perception of an environment will lead to the responses of either congruence or arousal (eg stress, reactance) – the latter will be followed by either successful or unsuccessful coping mechanisms by the organism (Bell *et. al.* 2001: 402). If there is constant arousal and unsuccessful coping, maladaptive and dysfunctional behaviour may result. In general terms, people who spend large amounts of time in environments that have either too much or too little information redundancy or coherence will experience repeated physiological arousal – this may be called stress. Where these people have mechanisms of coping or can experience 'restorative environments' (usually a piece of nature) – the environmental stress may be managed. However, constant over-arousal without adequate coping mechanisms tends to lead to antisocial or maladaptive behaviour.

Arrested development occurs in highly redundant environments (Dember 1966). Sensory deprivation, such as isolation torture, becomes unbearable after two or three days. However, perceptual deprivation, where information cannot be coded or decoded, is the hardest to endure and causes more severe mental disturbances (Schultz 1965). During the war, orphaned babies were left lying in hospital cots without toys or human interactions and immersed in a white environment (i.e. white sheets/ceilings/clothes/walls etc.) These babies became retarded, listless and an abnormally high number died (Spitz 1945). Chimpanzees do not learn to perceive in visually deprived conditions over extended periods, and actually unlearn adaptive behaviour when placed in deprived conditions (Riesen 1950). Rats and monkeys deliberately choose more complex and varied environmental stimulation even if it requires more work for their rewards (Dember *et. al.* 1957, Butler and Harlow 1954). Further, Held and Hein (1963) found that visual variety must be linked with physical interactivity to fully develop adaptive behaviour. Restricting the movement of one kitten in an environment led to maladaptive responses compared to the mobile twin kitten. A full life cannot be developed from the screen or through the car window.

While the connection between perceptual deprivation and psychological damage caused by dour modern environments can be overstated, it is demonstrable that there is a need for variety, pattern and interactivity for the fully adaptive development of humans (Prak 1977: 71). The most psychologically beneficial environment, i.e. that produces the greatest psychological well being, has a degree of complexity within a unified coherent pattern. This pattern and unity may be barely recognisable at the conscious level. Such environments also need to facilitate muscular interactivity (i.e. walking) to maximise behavioural adaptivity. Contrasting this is the environment with disconnected and repetitive forms, interspersed by distances requiring constant vehicle use (e.g. *La Ville Radiuse* by Le Corbusier).

Smith (1983) argues that the ideal 'amount' of tension between redundancy and information is the Pythagorean golden section (1.00 : 1.618). Georgian windows often possess the 'aesthetically perfect' rectangle (**Figure 3**). He argues that our mind will make slight adjustments even in highly complex scenes, such as the high street, in favour of the 40% to 60% split between complexity and coherence.

Figure 3 – 'golden mean' Pythagorean rectangles

Physical variety in the urban realm is useful and efficient. It is difficult to find one's way around where it all looks the same. Lynch (1960) demonstrated how differences in the environment help us create cognitive maps of urban regions. Such environments are said to have imageability in that we can create cognitive images and maps of them. This feature may be particularly important to children, who are developing cognitively through their interactions with their environment (Winkel 1978; Moore 1972).

P E R C E P T I O N   O F   S P A C E

It is at the third dimension that our ancestors thrived or perished. Given the evolutionary importance of space, especially from an arboreal heritage, it is not surprising that humans are highly effective at perceiving depth. To perceive spatial character we must be able to perceive, consciously or not, a space as a unit or 'thing'. The Gestalt laws, which have been derived through experiment on two-dimensional forms, can be applied to three-dimensional space when combined with the principles of space-perception (Prak 1977: 33; Ittleson 1960). The eye cannot estimate the distance to a point along a light ray reflected from an object, which is projected as a point onto the retina. Furthermore, many different objects can produce the same two-dimensional retinal image. Therefore, we have to use weighted perceptual cues to perceive depth. These are spelt our in **Table 3**.

Space-perception does not depend on binocular vision. Closing one eye does not make the world go flat, while paintings or photographs, which are monocular, could not illustrate depth if this were the case. Binocular disparity produces more visual data between the optical arrays of the same scene, similar to the effect of movement parallax (see **Table 2**). When all of the space cues are used, the perception of space is still an educated guess. Each cue in the visual world provides some information about its spatial structure. When we test these cues, through touch and movement, all the cues add up and usually agree with each other. Since the Renaissance, pictures have used depth-effects by setting some cues against others to create, sometimes illusionary, situations (e.g. **Figure 4**).

♦ *Colour*: helps distinguish between adjacent objects and objects against their background. Colour vision also makes it easy to make fine discrimination among objects (e.g. between ripe and unripe fruit).
♦ *Overlay* or *interposition*: where an overlapping object appears to be nearer than an overlapped object.
♦ *Size*: our discrimination of distances is dependent on the size of the retinal image provided by the object. The angle of the optical array (between the top and bottom of the object) decreases as distance increases and this difference causes perspective. Experiments have shown that perception prefers constant size over constant distance, which may be because our everyday experience of the world filled with objects of fixed sizes but at varying distances.
♦ *Light and Shade*: different combinations of shadow and highlight are reported with objects having different proportions and distances. Surfaces require differences in light and shade to contain depth. This is why photos are best taken side-lit, as front- or back-lit photos look flat due to reduced light tones.
♦ *Linear Perspective:* a constant distance between points subtends a smaller and smaller angle at the eye as the points recede from the subject.
♦ *Atmospheric Perspective*: over long distances, where the absorption effects of the atmosphere are relevant, objects usually look hazier and more bluish than those nearby.
♦ *Movement Parallax*: is due to the amount of shift difference in near objects to far objects. When moving one's head from left to right, objects in the distance will move little while objects nearby will move further in the retinal image.
♦ *Object Movement*: movement of one or more objects against an immobile ground.

Table 3 – Monocular cues for space perception

Edges are the most informative feature of any visual field because they define the extent and position of elements within the scene (Pinel 1997: 163). The strongest edges in the urban environment occur along the skyline, eaves and, vertically, between buildings and changing building lines. To perceive edges there needs to be contrasts between them. Contrast enhancement occurs through a process of lateral inhibition of retinal receptors (Eysenck 2000: 88). This process is strong for vertical edges and lines, but stronger still for spatial frequency (DeValois *et al* 1978). Periodic patterns of near vertical light and dark tones ('visual gratings') produce extreme sensitivity to deviations in some cells of the retina (Von der Heydt *et al* 1992). Some surfaces differ only in their texture (e.g. a pebble beach), and thus texture gradients are an important cue for the perception of distance and of survival significance. On the street wall, texture gradients are similarly important for the perception of distance with vertical distinctions between buildings. Visual gratings may be an efficient method to rapidly perceive and assimilate the vertical forms of primary interest (e.g. people, animals and trees). In light of this, built environments expressing vertical rhythm will resonate with the visual cortex most efficiently and allow the ready perception of depth, distance and variety. Arnheim (1977: 35) asserts that the overwhelming verticality of terrestrial forms leads us to associate this direction with life – detaching ourselves from the horizontality of the earth, and death. Again we see a natural justification for vertical pattern in the 'daily' built environment to support human action and perception.

Space is separate from form but is dependent upon it because it is known through its material boundaries. The image of the space around us, a room, street or district or region, is primarily *conceptual* and heavily dependent on memory. Conceptual space is continuously supported and/or corrected by the perceptions of visual space – the observed visual field at any time. By taking a large number of separate images and views and storing them, selectively, in short-term memory we create topological schemes of a space or structure. The work of Lynch (1960) confirmed the spatial, rather than metric, primacy of memory schemas for people in their neighbourhoods and cities. There was a good correspondence to reality in the relative location of streets and landmarks etc., but the proportions were strongly distorted.

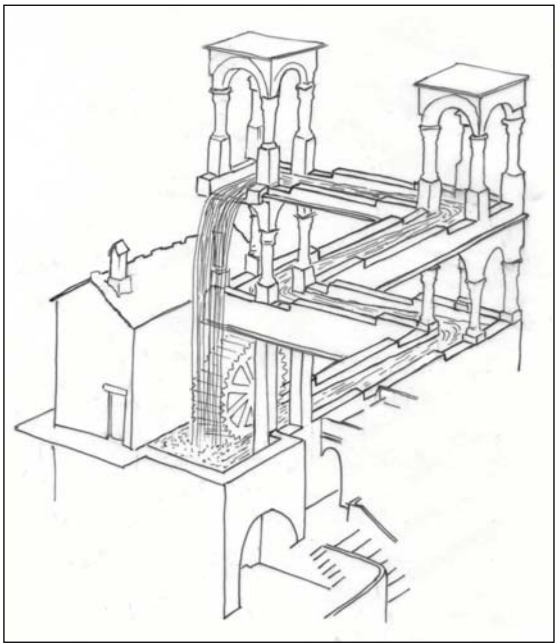

Figure 4: Escher's (1961) Waterfall illusion

In outdoor spaces the full range of bounding surfaces that help define space inside buildings are often missing. Space formation must be supported by the placement of forms – usually buildings, structures (eg walls) and vegetation. If the shape of a space is *simple*, the bounding surfaces are in alignment (*continuity*), the buildings have similar height eaves (*continuity* and *similarity*), and the objects are sufficiently close to each other (*proximity*), then conceptual spaces can be derived. Where these cues are missing, space becomes undefined and 'unconceivable'. Buildings become objects in space rather than objects defining space. Spatial cues are referred to in townscape analyses. For example, in a discussion of a typical market town streetscape, Tugnutt and Robertson state: "there are sufficient linkages in height, plot width and scale to help the group 'hang together', even though there are diverse elements such as style and material..." (1987: 48).

In cities with confined streets, attached buildings and enclosed squares, the formation of spatial concepts is more easily facilitated. The number of possibilities for the formation of conceptual space in 'open' built environments is greatly reduced. The localisation of objects in space, an inherent perceptual desire, depends on the possibility of relating them to a (redundant) background, particularly to some kind of patterned floorsurface (Gibson 1950). When many large and modern buildings are spread across a landscape only the cue of *overlay* is at our disposal. This cue reveals that one building stands behind another, but not how far behind. Intervening masses can prevent the perception of the connecting ground, and the often large building sizes prevents a simultaneous view of front- and side- elevations, which might supply some depth perspective. This lack of perceptual cues makes the formation of conceptual space, as well as distance and localisation, almost impossible - making them visually uncomfortable (Prak 1977: 53). Curved streets give much more information about the location of buildings and intervening objects in space; this is one of the perceptually attractive aspects of such streets.

P R E F E R E N C E

Parts of the built environment will be interpreted as supportive or inhibitory to our purposes depending on whether it fulfils our psychophysiological inclinations. These inclinations derive primarily from our biology and secondarily from cultural and individual learning. The greater part of our environmental requirements, in terms of the arrangement of space and form, are shared (Kaplan 1988; Gibson 1950, 1977; Heath 1988; Berleant 1988).

In the external environment, human purposes are not random and scattered but can be grouped into two types. One of these purposes is to 'make sense' of the environment and the other is for 'involvement' in the environment (Kaplan and Kaplan 1978; Kaplan 1988). Making sense refers to keeping one's bearings and understanding what is occurring in the immediate and wider environment. Involvement refers to stimulation: to learn and to decipher. Environments that support these purposes – that work in conjunction with a purpose for a successful conclusion – will be preferred. These purposes are commonly classified into two types of behavioural objective in the built environment (Heath 1988: 7; Bonnes and Secchiaroli 1995: 183). One behaviour type is *instrumental* (or *specific*). This involves doing a thing, getting to a place or achieving an aim. The built environment is here sought to efficiently facilitate one's present and specific aims. The other behaviour is *diversive* (or *aspecific*). The stroller, the tourist or window shopper seeking engagement, refreshment and stimulation from their setting typifies this. Ideally, urban environments will satisfy both behavioural objectives, allowing people to move easily from one behaviour mode to the other.

Environmental satisfaction may also be derived from the enjoyment of natural qualities. Such is our hard-wired affinity with nature that even rather mundane examples (e.g. grass and trees), or indirect experiences (e.g. view from a window) can have a restorative effect (Kuo and Sullivan 2001; Korpela *et al* 2001; Kaplan 2001). As Kuo and Sullivan (2001) found, a lack of nature in and around the home can lead to increased mental fatigue and aggressive behaviour. The aesthetic argument, based on economic theory of scarcity, that the 'unusualness' or novelty of a design or feature is proportionate to its value is incorrect. People's positive reaction to ordinary experiences of nature is an example of noneconomic value. Meanwhile, a unique statue or feature may not be valued at all.

Kaplan (1988a) provides a preference matrix (**Table 4**) based on the theory that people perceive information from their environment from the two-dimensional visual array as well as three-dimensional space. Within this array, three-dimensional variables provoke stronger preference ratings than the two-dimensional picture plane. While the visual array is important, "a substantial portion of the human response to landscape turns out to depend on the sort of space involved and the way the individual envisions moving in that space" (Kaplan 1988a: 54). The visual array relates to the two-dimensional 'picture plane' and just as a photo can have little or much to see, scenes can vary at this level of analysis. Complexity is the involvement component and maybe referred to as diversity or richness. Coherence relates to the making-sense component and indicates to the ability to organise the patterns of light and dark into a manageable number of information units, regions or areas. It is found that people store about five information units, or chunks, in a short term 'working memory' (Simon 1974; Baddeley and Hitch 1974), so scenes that can be divided into around five major units will aid comprehension.

Level of interpretation	Making Sense	Involvement
The visual array (2D)	Coherence	Complexity
Three-dimensional (3D) space	Legibility	Mystery

Table 4 – S. Kaplan's (1988: 51) Preference Matrix

In the third dimension, there is a strong preference for scenes that offer a sense of what has been termed 'mystery' implying the promise of new information if one could go further into the scene. "Mystery embodies the attraction of the bend in the road, the view partially obscured by foliage, the temptation to follow the path 'just a little farther'" (Kaplan 1988a: 50). Mystery evokes curiosity through suggestion, elusiveness and concealment. It implies opportunities and potential for information revelations. The wrapped gift is a prime example of our love of mystery. The perceiver ideally controls mystery so there is a connection between what is seen and what is hidden. One's rate and direction of action controls the rate at which new information is revealed. This is an ideal situation for a creature that is easily bored with the familiar, yet fearful of the strange. Cullen (1961) of the townscape school recognised mystery as a valued urban feature. Legibility relates to making sense and refuge, or safety (Appleton 1975), in three-dimensional space. Rather than the promise to learn, as with mystery, it is the promise to function – to be able to find one's way both there and, importantly, back again. It is similar to coherence in this manner, but involves the organisation of the ground plane rather than the picture plane. A highly legible scene is one that supports the ready production of a cognitive map. Legibility is aided by apparent depth and a well-defined space; smooth textures and distributed landmarks as well as easily perceived subareas or spatial regions. These analyses by humans are generally automatic and nonconscious processes – as expected for a far ranging spatially oriented species. Legibility has long been regarded as a valued spatial commodity in urban design texts (eg Bentley *et al* 1985; Cullen 1961; Lynch 1960; English Partnerships 2000).

C O N C L U S I O N

The human mind requires a balance of stimulation (novel information) and redundancy (pattern) in its environment in order to function adaptively and enjoy those environments. Parts of our brain look for homeostasis and environmental restoration, while other parts seek the stimulation of new, and/or potential, information to help us achieve our goals. The visual system detects change and novelty against stable backgrounds. The need for pattern in defined spatial units can be transcribed to the built environment. Spaces must firstly be created by built forms and within that space a level of coherence must exist that it can be perceived as a single perceptual unit in which we may function.

These patterns are of course provided by the morphological elements of the built fabric. In streets and squares, than can be analysed and extracted – certainly at low levels of resolution. This process, described elsewhere by the author, allows prescriptions of such low-resolution streetscape morphology to enhance the spatial cohesiveness of the said space over time.

However, it has been demonstrated, and is a common experience in the modern environment, that pattern and coherence do not suffice to make visual and spatial interest. In consonance must exist complexity and diversity of forms and spaces. Mystery, surprise and concealment are essential variables in the successful urban milieu. Planning cannot hope to regulate these variables – which arise from the vagaries of personality, politics and fashion. By indicating only the pattern within which such spontaneity is promoted, local planning can thereby promote humane environments that facilitate fully adaptive personal and social development.

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