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TYPO-MORPHOLOGY AND ENVIRONMENTAL PERCEPTION OF URBAN SPACE

Abstract: *Urban morphologists intuitively understand and abstract patterns and elements of cities. Typo-morphology is an approach in urban morphology that classifies urban elements by their morphological characteristics. This paper discusses how the urban form affects different perceptual modalities. Vision is the dominant sense in humans, and the predominant focus in architecture and urban design. Visual perception is enhanced when supported by related auditory cues and vice versa. Sounds provide an important link to reality, are enriching and protective. We pay more attention to sources we can hear but not see, for example a car approaching from behind. Without sound, visual perception is less contrast and less informative. Urban design can be understood as the art of arranging urban elements, such as streets, buildings, sidewalks, urban furniture, vegetation etc. to meet human needs. It is important for urban designers to understand the urban form in the context of environmental perception and cognition related to the urban space for informed urban design.*

Keywords: *typo-morphology, morphological structure, environmental perception, design elements, urban design.*

Introduction

Urban design can be understood as the art of arranging urban elements, such as streets, buildings, land uses, sidewalks, urban furniture, vegetation, etc. in urban space (Taylor, 1999; Marshall, 2016). This urban design practice can be derived from urban morphology. Typo-morphology is an approach in urban morphology that classifies urban elements by their morphological characteristics, such as typical buildings, streets, or plots etc. and how they are arranged, as well as their variations and mutations over time (see Moudon, 1992; 1994; Kropf, 2009). Typo-morphologists intuitively recognize and abstract urban elements and patterns (Marshall and Çalişkan, 2011, p.421; Marshall, 2015). They create morphological structures (e.g. Kropf, 2014; 2018), typologies of design elements and patterns and rules how to combine different architectural or urban elements into patterns (e.g. Alexander et al. 1977; Alexander, 1979; Sanders and Woodward, 2015).

Morphological structure describes urban elements as physical features of cities and their hierarchy on different scales, from architectural elements in a room, dwelling, building storey or building, to urban elements such as building façades, buildings, streets, routes, neighbourhoods and urban regions (Alexander, et al., 1977; Cataldi, 2017). Many morphologists have proposed morphological structures for urban analysis that consists of different urban elements (Conzen, 1960; Lynch, 1960; Cullen, 1961; 1967; Caniggia and Maffei, 2001 [1979]; Alexander, 1979; Kropf, 2014; 2018). Urban morphologists commonly agree upon three fundamental elements of urban form: building, plot (or lot) and street. The morphological studies are predominantly executed on four scales or resolutions of analysis: building/plot or lot, street/city block, city and region (Moudon, 1997, p.3).

Urban designers work predominantly with experiential qualities of cities and spaces between buildings in three dimensions (Southworth, 2016). The classifications in urban morphology do not always derive from knowledge about how humans perceive urban space or understand

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physical features of cities. Instead, they are based on architectural or urban design and development practices. This paper looks at different conceptualization of morphological structures and urban elements and research on environmental perception and cognition. It discusses urban elements of the morphological structure of cities in different perceptual modalities and symbolic representations. Many architects and urban designers advocate for operational urban morphology or morphologically informed urban design (Samuels, 1990; McGlynn and Samuels, 2000; Talen, 2014; Sanders and Baker, 2016). Physical form rather than land use and urban activities persists over time (Hall and Sanders, 2011, p.442). There is increased interest in form-based master planning (Duany & Plater-Zyberk, 1991; Duany & Talen, 2002; Talen, 2002; 2009; 2013; Walters, 2007). Understanding urban form and its design in a context of environmental perception and cognition related to urban space is important for urban designers, and for researchers of the impact of urban form on human behaviour. Urban elements influence human behaviour through the sensory modalities, like vision, hearing and touch, as well as how cities are conceived and represented mentally.

Literature review

Urban designers and morphologists focus on the physical form of cities. The urban elements are their common interface or framework. Designers often use a palate of urban elements to create three-dimensional urban spaces, whereas urban morphologists study and classify urban elements by their characteristics. The literature review furthermore looks at works of anthropologists and environmental psychologists, architects, urban designers and planners that worked with wayfinding, orientation and experience of urban space.

Typo-morphology, urban elements and their arrangement

Typo-morphology is an approach in urban morphology that seeks to understand cities and their evolution through classifying urban elements into types. Aldo Rossi refers to types as archetypes (the Platonic forms in mind). In contrast to the Italians, English speakers (Marshall, 2005) prefer patterns. The differences between types and patterns are subtle. Patterns tend to be less metaphysical and practically applicable to solve urban design problems. Gianfranco Caniggia, one of the pioneers of typo-morphological approach, argues that cities grow incrementally with many elements being juxtaposed. An understanding of the formation and transformation of cities needs analysis of the mutation of the elements through both time and space (Moudon, 1994, p.292).

Architectural styles, building, street and neighbourhood types are social constructs. Society creates them to simplify communication and promote values (Franck 1994, p.345; see also the prototype theory in cognitive psychology, e.g., Rosch and Mervis, 1975). A type is a characteristic exemplar of a place, the essence or the original place that makes it possible for us to understand its image and class (Franck and Schneekloth, 1994). Similar as to a concept in linguistic terms, a type packs much information into one icon: a set of architectural or environmental attributes; a set of rules for construction and for organization of space; a set of behaviours and defined roles that take place within it; and a set of qualities it should exhibit (Schön 1988, Robinson, 1994). The spatial practices of any society both structure and are structured by the activity of creating and classifying types (Franck and Schneekloth, 1994). Like cognitive schemas (Anderson, 2015), types structure knowledge. Without types of some kind we could not know or act; we would have no way of recognizing similarities or patterns of differences, or of creating such patterns. We would have no way of structuring space or practices in space. Spatial structures and our ideas about them constitute a form of knowledge, a way of knowing the world. Types are not static. They change over time and vary considerably between cultures and between different groups within the same cultures. Even though the typologies vary across cultures, the activity of creating types lives within all societies (Schneekloth and Franck, 1994). Types emerge in one of two ways: relatively unconsciously, as a human response to the need to order objects for functioning in daily life and more or less consciously, in response to the

need to professionally describe and analyse an object for a specific reason. Type is what people ordinarily use and represents a way of understanding architecture or cities as sets of generalized, identifiable objects. The second kind of type represents the professional attempt to make distinctions and clarify relationships. In the first approach, type represents a point of convergence of objects (house, apartment). In the second, type delineates and differentiates between objects, defining boundary conditions (single-family, multifamily housing). These two ways of creation types relate to two different ways of understanding: nonprofessional, associational understanding from accumulated direct experience, and professional, critical, analytical or organized understanding. These two perspectives generate different, but complementary and often overlapping sets of categories (Robinson, 1994). This complies with general knowledge in cognitive psychology informing us that novices tend to categorise objects based on surface features, whereas experts tend to categorise them based on their meaning and function (Anderson, 2015).

Christopher Alexander's pattern language is an example of the typo-morphological approach. Alexander (1979, p.519) argues that each building, neighbourhood and town has a particular morphological character marked by patterns underlying it: patterns of events determined by culture and physical spaces where human activities happen. The patterns of events always interlock with certain geometric patterns in the space. The physical patterns precondition pattern of events to happen. A set of underlying elements and relationships between elements characterizes an urban pattern: $X = r(A, B, C, \dots)$ where X is type and r shows relationships between elements A, B, C, \dots . Each pattern is connected to certain larger patterns that come above it in the language; and to certain smaller patterns or elements. In the pattern language, the elements are patterns and patterns are elements depending on the scale. In addition, there are rules, embedded in the patterns that describe the way that patterns are created and how they are arranged with respect to other patterns. Even though there are theoretically millions of combinations between elements, the number of generic patterns is rather small. The rules only allow combining certain elements in a pattern. Few hundred patterns define cities like London or Paris (Alexander, 1979).

While Christopher Alexander presents the pattern language as unique expression of local culture and specific cities, many morphologists have worked on generic morphological structures that reoccur in different typo-morphological traditions. The Italian architects, the followers of Severio Muratori and Gianfranco Caniggia, discuss building typologies through establishment of procedural typologies (*tipologia processuale*; Moudon, 1994, p.292). Procedural typologies include typological processes. Typological process is progressive transformation of the idea of a building in its relationship with the route. Caniggia describes two major urban elements in interplay: the route (or street) and the building. The city block is an aggregate defined by the character of the route and aligned lots and buildings. These processes happen progressively from architectural scale (the building), urban scale (block or aggregation of blocks in a matrix) to regional scale (arrangement of settlements along regional poles and matrix routes, axes). Typological processes include typologies of buildings on lots, routes, blocks and a hierarchy of poles and routes (Caniggia and Maffei, 2001).

Similarly, M.P.G. Conzen differentiates urban elements: street layout, lots and their aggregation in blocks and buildings (Conzen, 1960), and land utilization (Birkhamshaw & Whitehand, 2012). The urban landscapes/townscapes/cityscapes are historical layers of urban elements (types of streets, lots and buildings). Cities experience cycles of intensive development, building booms followed by slumps. Technological revolutions, new planning paradigm, social and economic transformations, etc. trigger building booms in unpredictable fashion (Whitehand, 1987). Burgage cycles effect locations periodically. Every generation tenants reshapes buildings within the constraints of their lots and streets (Conzen, 1960).

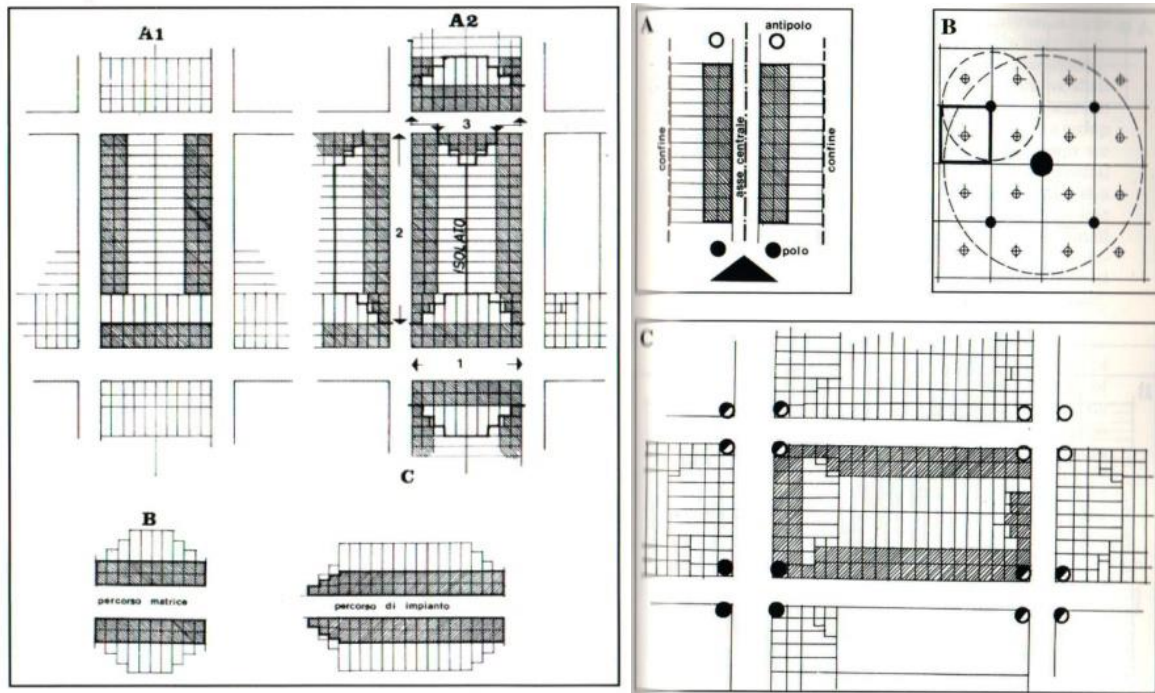


Figure 4. Interaction between building and route and the modularity chart based on poles and axes (Caniggia and Maffei, 2001, p.163)

The difference between the two approaches is in the perspective. As a geographer, Conzen looks at the city from above. The city block is a block of buildings. The lot defines the building. Caniggia is an architect. The analysis of urban form proceeds from the small to the large elements of the urban environment (Moudon, 1994, p.292). He stands on the street and looks at the architectural object or project. This defines the two principal perspectives in urban morphology: 1) observing the city from above, or 2) from within.

Two approaches in urban design have worked with symbols and urban elements to combine these perspectives. The aim is to understand urban experience and experiential qualities of urban environments. Kevin Lynch (1960) conceptualized five urban elements: paths, edges, nodes, districts and landmarks. These elements belong to the city from within, but they are represented on maps as symbols. Imageability according to Lynch defines the strength of the urban element to produce a strong or weak sensory mental image. The main streets are usually major paths because of the number of stores, many signs, many people, etc. and evoke strong images. People orient themselves by pedestrians moving along major paths and landmarks. They create mental maps of major and minor paths in respect to edges (impermeable transportation infrastructures, waterfronts, etc.) and landmarks. Gordon Cullen (1961) analyses sequence of images (serial visions) along pedestrian paths. He also represents the elements in each image with symbols on a map. The focus of the serial vision is the path, but it is defined by surrounding buildings and landmarks (what pedestrians see at the viewpoints). In contrast to Lynch, who focuses on imageability of these urban elements that pedestrian sees, Cullen (19697) looks at their character, scales and complexity.

The combination of the Conzenian and Muratorian typo-morphological traditions with Kevin Lynch's urban elements and Gordon Cullen's indicators produces a generic morphological structure (Figure 3).

Kropf (2014) fuses the Conzenian and Muratorian typo-morphological traditions and opens the discussions on a generic morphological structure. His review of the works of Conzen (1960) and Caniggia and Maffei (2001) includes a reconciliation between the two perspectives. Kropf embeds street space (Caniggia's block) in the morphological hierarchy of street, lot and building,

that expands to urban block and urban tissue (a morphological district). This morphological structure does not consider edges. Secondly, it does not consider symbolic representations on larger scales developed. With a regional view from the top, the three dimensional urban space of urban designers becomes centres/centroids (poles in Italian school of urban morphology) of activity and foci of transportation. This requires a topological understanding of relationships between neighbourhoods/urban areas (Figure 4). In the end, the generic morphological structure does not relate to environmental perception. There is no discussion about change in representations with the change in scale.

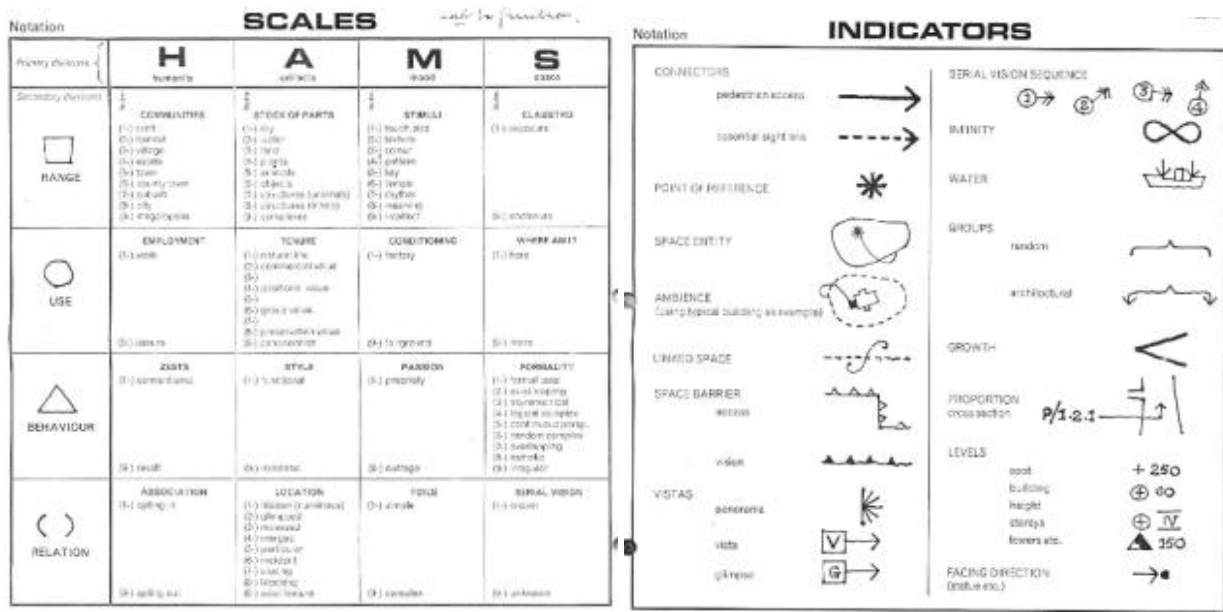


Figure 5. Symbolic representation of visually perceivable urban elements on a plan: Kevin Lynch's urban elements on the left and Gordon Cullen's scales and indicators on the right

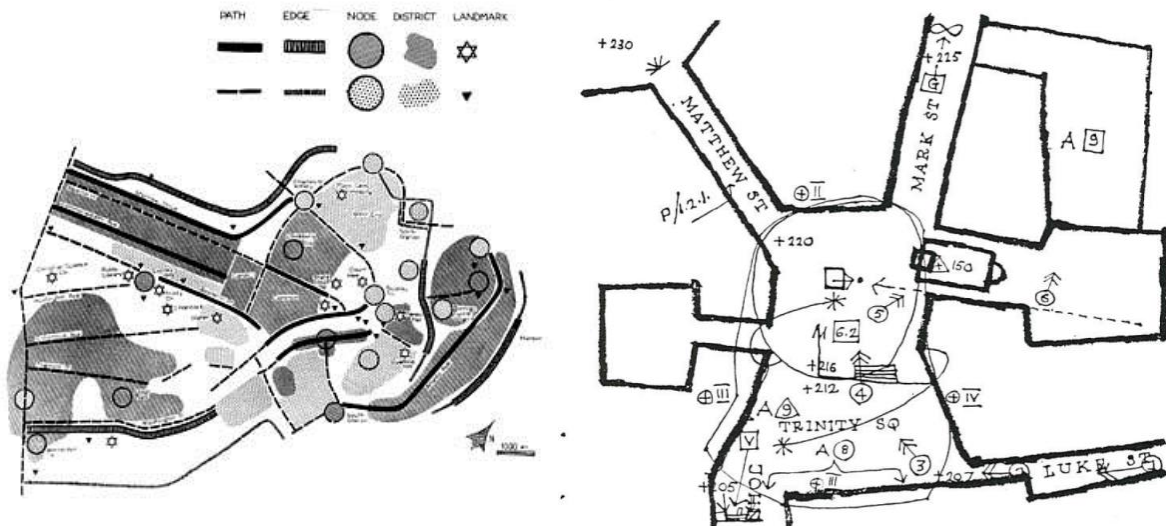


Figure 6. Generic morphological structure (modified from Kropf, 2014; 2018, to include Lynch's edges such as building façade and Cannigia's city block frontages/pertinent strip)

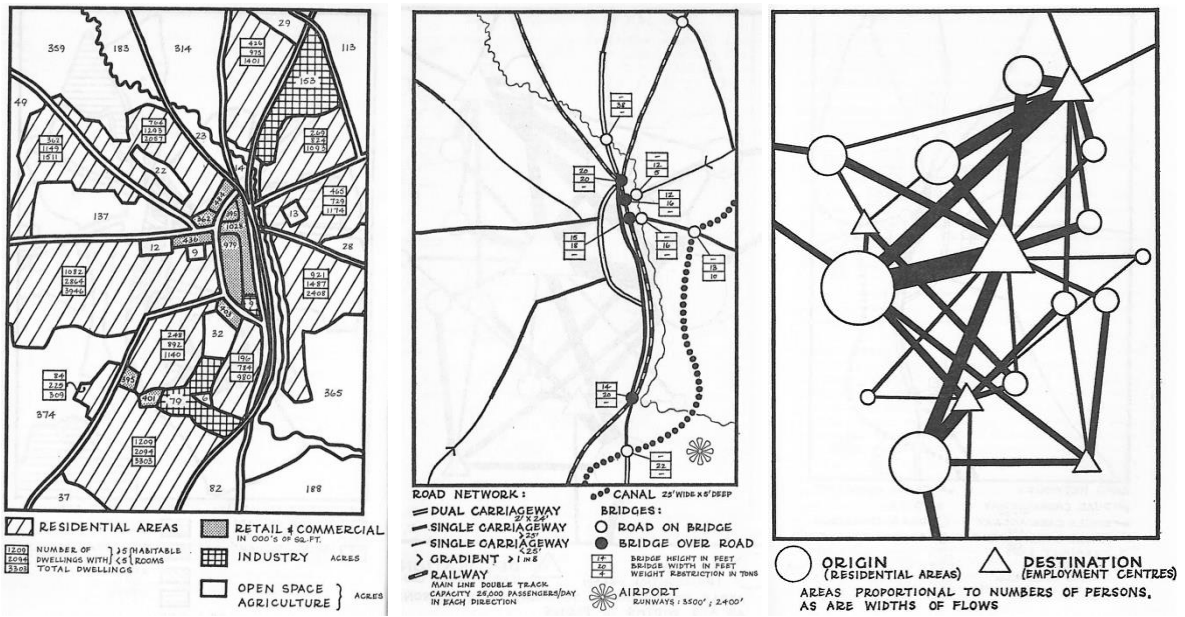


Figure 7. Symbolic representation of McLaughlin's urban system of elements

In the end, there is a more detailed urban design approach that focuses (like in the Muratorian typo-morphological tradition) on street spaces and the city block-street frontages (Figure 5). This symbolic representation shows elevations of building façades and interactions of neighbours and their perceived home territories (Appleyard, 1981)

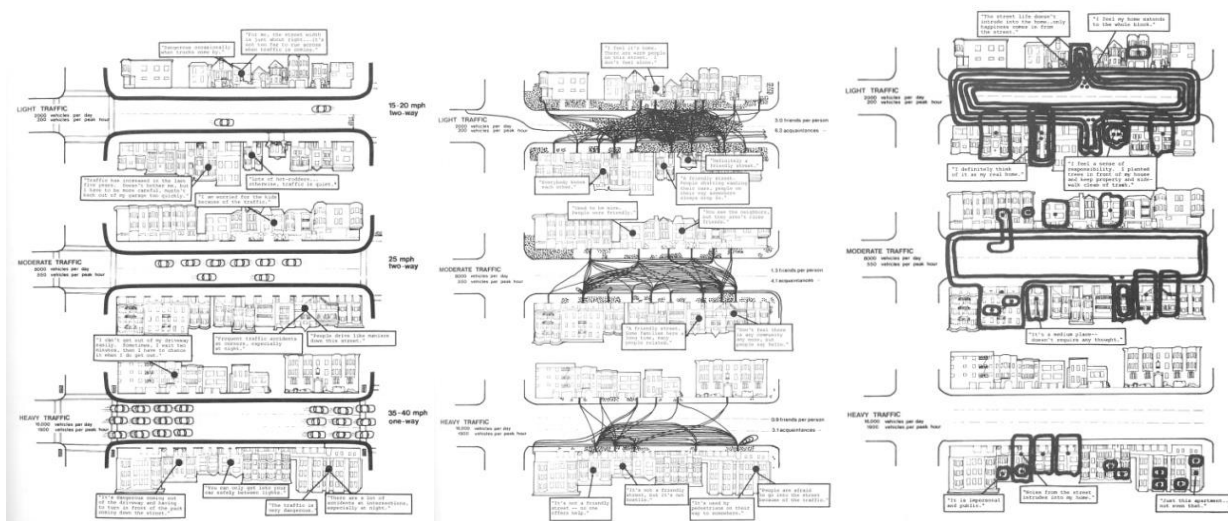


Figure 8. Symbolic representation of street spaces, interactions of neighbours over streets with high, medium and low volume of traffic and their perceived home territories (Appleyard, 1981)

Environmental perception

We recognize urban elements (benches, bus stops, subway exits, kiosks, sidewalks, etc.) as types. We match new impressions with previous experiences and interpret urban space in terms of affordances (subway exits lead to the underground train, robbers may hide in the unlighted and obscure park, the kiosk provides for newspapers, etc.). Affordances show what the urban environments offer to the observer either for good or ill (Gibson, 1986, pp.127). Environmental

perception includes interpreting sensory information from the physical and social surroundings, and the emotional responses they provoke.

The visual field is the area within the fields of view of both eyes. It is clear in the centre (foveal vision) and vague in the periphery (Figure 5; Gibson, 1986, p.206). The space within clear visual acuity is roughly 100–200 m. Similarly, it is possible to understand speech roughly within 20–30 m. These fields are referred to as spaces of visual and auditory acuity (Hall, 1967; Gehl, 1987; Figure 6).

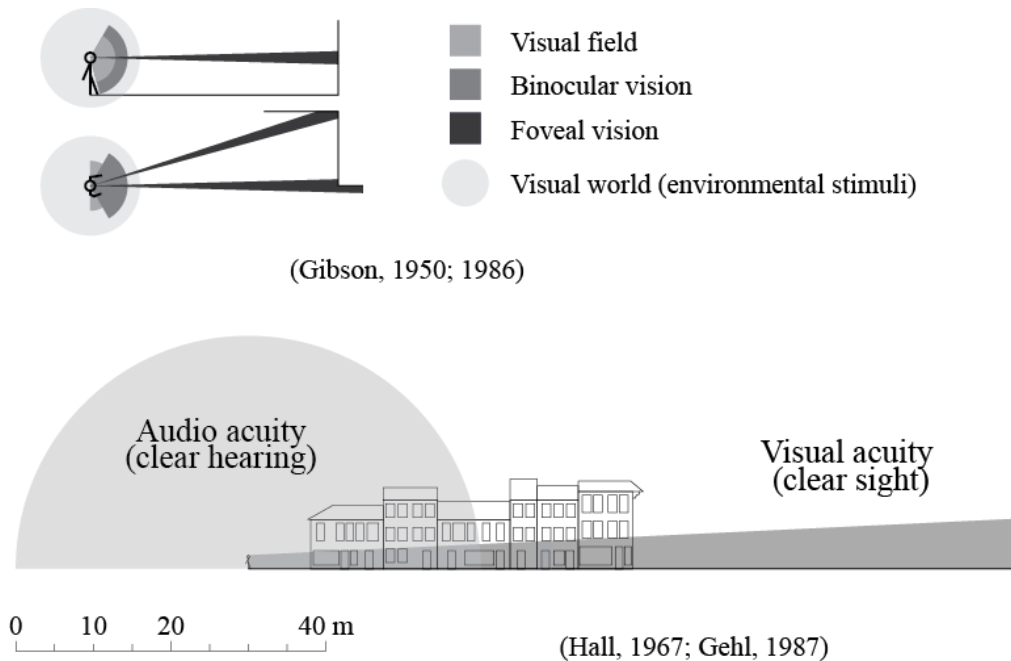
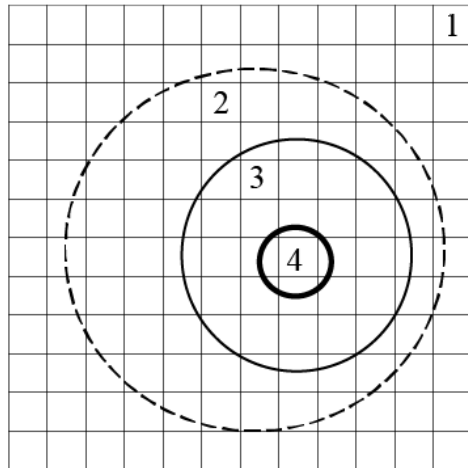
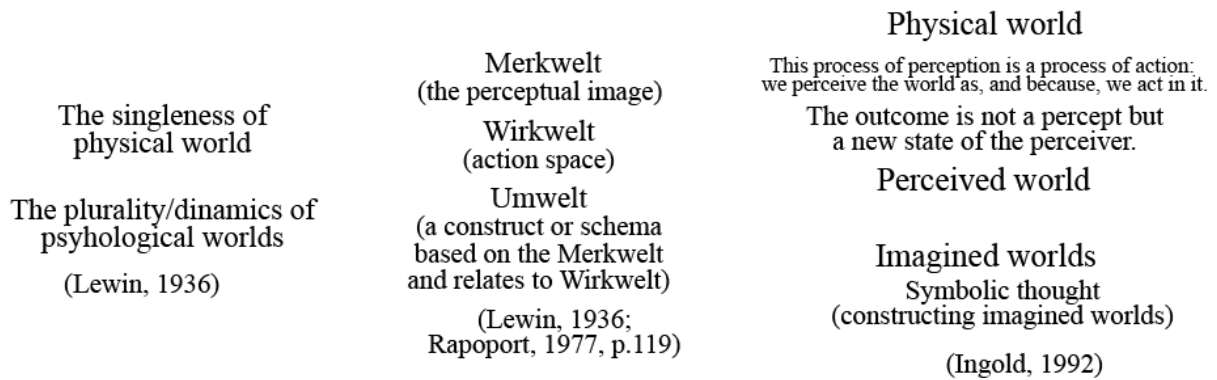


Figure 9. Human perception and environmental stimuli

We learn about cities by walking between destinations, perceiving the environment and creating a mental symbolic representation, or a cognitive map, of it. Environmental perception is a process of apprehending and responding to environmental stimuli. It is influenced by a mix of attitudes, motivations and values that affect actions. Perceived environment is the product of this process (Rapoport, 1977, p.25-30). It links to concepts such as life space (Lewin, 1935) and Umwelt (von Uexküll, 2010 [1934]). Life space is a totality of possible events, an overlay of movement space and accessible or inaccessible regions. The events depend on the state of the person and the environment (Lewin, 1935, p.12-4). Similarly, Umwelt or environment world include a perceptual world or space (Markwelt) and action space (Wirkwelt). Environmental perception includes nested layers as bubbles of space that tangle sensing and responding to stimuli (Figure 5). The operational environment defines the bubble where people move and work. Perceptual environment is the space of which people are conscious directly and to which they give symbolic meaning. In the behavioural environment, people are not only aware but it also elicits some behavioural response (Rapoport, 1977, p.13).

We are centred in layers of environments (Figure 7). This includes a movement space; an operational environment. We perceive a portion of this environment. We can act in an even smaller portion of the perceived environment. There are perceived worlds (of images, sounds, scents and textures) and imaginary worlds (physical maps, symbolic maps, cognitive maps, topological diagrams, etc.) Behaviour is more closely related to cognitive than to physical maps (Rapoport, 1977, p.122).



1. Physical environment
2. Operational environment
(environment within which people move and work and which affects them)
3. Perceived environment
(environment of which people are conscious directly and to which they give symbolic meaning)
4. Behavioural environment
(environment of which people are not only aware but which also elicits some behavioral response)

(Rapoport, 1977, p.13)

Figure 10. Conceptual model of perceived environment

Furthermore, according to David Canter there are two types of environmental behaviour. Dogs tend to defend a territory, for example a plot of land. This is represented by a continuous usually three-dimensional space between edges (fences, geographic features, etc.). Cats tend to take tours and cross edges. This is more a route type of environmental perception. Humans do both tours and experience three-dimensional space between edges (plots and neighbourhood borders). This creates several types of neighbourhoods. Neighbourhoods in close proximity are three-dimensional space, whereas wayfinding or making tours produces mental maps of routes/paths and two-dimensional neighbourhoods (described as districts by Lynch, 1960). Neighbourhoods exist as: 1) 'neighbourhood centres' defined by more intensive acquaintances and social interaction; 2) 'districts' determined by homogeneity of social groups or/and morphological similarities (e.g. variations of one type of building); and 3) 'functional units', as wider areas with services needed for everyday life (Lee, 1973). All three different types of neighbourhoods overlay and coexist on maps (Canter, 1977; Ceccato and Snickars, 2000; Talen and Shah, 2007). These neighbourhood types (Figure 8) correspond to Kevin Lynch's districts, but they do not apply to morphological conceptualizations. Lee's neighbourhood centres correspond to behavioural environments, whereas functional units correspond to operational environments or movement spaces. Functional units apply locally (in terms of walking) and regionally (by driving or taking public transportation). These operational environments cannot be seen, but only cognized and represented as shapes.

Urban elements in perceptual space

We perceive the urban environment while on move. Central to perception of the city is the movement or kinesthetic sensation. The kinesthetic sense of motion is supported by the combined play of all the senses (Cullen, 1961; Taylor, 2003). Vision is normally the dominant sense in

humans, and the predominant focus in architecture and urban design. However, we also hear and smell, and experience the city through or tactile sense (e.g., temperature). The city often overwhelms or senses. Perception of urban space requires effort, due to a high degree of cognitive load. The brain can handle only limited amount of sensory information (Steffansdottir, 2014). Consequently, environmental perception is unconsciously selective, to reduce the complexity. Drivers neglect the city as they focus only on information that is relevant to them, such as passing cars and signs (Carr and Schissler, 1969). Cyclists often enter a state of tunnel vision (Spinney, 2006).

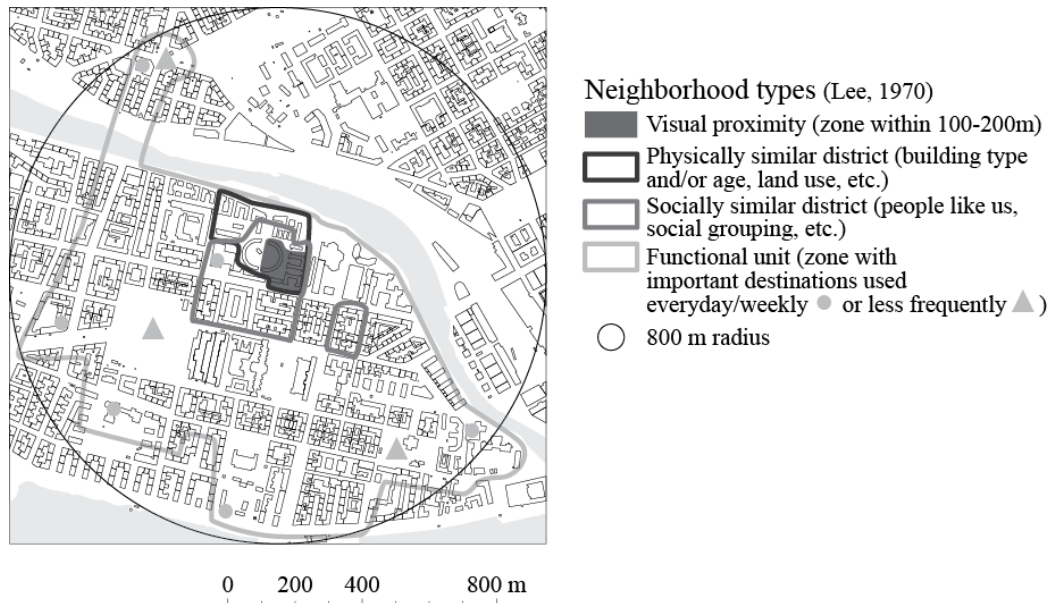


Figure 11. Neighbourhood types (Lee, 1970). Functional units correspond to operational environments. Functional units apply locally (in terms of walking) and regionally (by driving or taking public transportation)

To understand the effect of urban form on behaviour there is a need to discuss morphological structure and urban elements in relation to different perceptual modalities and cognitive maps.

The combination of vision and sound create different perceptual environments (perceptual worlds). Architects and urban designers such as Jan Gehl (1987), inspired by research on personal spaces (Hall, 1967; Sommar, 1969), have defined bubbles of spaces within the distance of hearing or sight. Visual perception is enhanced when supported by related auditory cues and vice versa. Sounds provide an important link to reality, are enriching and protective (Southworth, 1967). We pay more attention to sources we can hear but not see, for example a car approaching from behind. Without sound, visual perception is less contrastful and less informative. Audio-visual perception (things within roughly 30 m that we can see and hear) and visual perception (zone of visual acuity of 100 to 200m) are important for urban design. Visual perception works as an isovist; the set of all points visible from a given vantage point in space with respect to the obstacles and voids in the line of sight within a given environment (Benedikt, 1979).

Figure 9 shows the generic morphological structure important for urban design (adapted from Kropf, 2014) related to environmental perception and symbolic representations. The maximum scale of visual perception ends at a city block (as plot/lot series) and street layout level. It is impossible to see a hierarchy of routes or network of districts even from an airplane. However, it is possible to learn about them and to map them. The audio acuity exists in street spaces (as street sections). It is not always possible to understand speech along the entire city block frontage/pertinent strip, but it is possible to see. This creates different contexts for urban designers.

Urban (design) elements	Environmental perception		Symbolic representations		
	Audio acuity	Visual acuity	Accurate 3D models	Accurate 2D	Symbolic 2D
City/urban region	No	No		Plans of polygons and lines	Cartograms, symbolic maps
Urban neighbourhood (city block/city block series)	No	No	Perspectives, axonometric	Plans of polygons	Cartograms, symbolic maps
Networks of routes/street layout	No	No		Plans of lines	Cartograms, symbolic maps
City block (plot/lot series)	No	Yes	Perspectives, axonometric	Plans of polygons	
City block frontage/ pertinent strip	No	Yes		Elevations	Symbolic maps
Routes/street spaces	Yes	Yes			Cartograms, symbolic maps
Plot/lot	Yes	Yes		Plans of polygons	
Building	Yes	Yes	Perspectives, axonometric	Plans of polygons	
Open space	Yes	Yes			
Building façade (street level)	Yes	Yes		Elevations	Symbolic maps
Building façade (floors above or below street level)	Yes	Yes		Elevations	Symbolic maps

Figure 12. Morphological structure (adapted from Kropf, 2014) related to environmental perceptual and symbolic representations. Symbolic maps are shown on Figure 2, Cullen refers to symbols as indicators

Conclusion

This paper discusses generic morphological structure related to environmental perception. While geographers, architects and urban morphologists tend to create their structure and urban elements along their standpoints, environmental psychology offers possibility to understand morphological structure from a perspective of different perceptual modalities, mainly vision and sound. Creating symbolic representations according to established morphological structure of buildings, lots and streets however does not correspond to visual or auditory realities or perceptual spaces. This creates two polarities: production of plans of buildings, lots and streets and showing perspectives (photographs or sketches).

The argument is that we understand cities and operational environments in terms of types and we create symbols. It is impossible to see an urban region, but creating a symbology of elements (hierarchy of poles/places and routes) and drawing cartograms helps understand relationships (Figure 4). Symbolic representations belong to urban design and planning and cartography and not to psychology, but it is possible to learn from environmental psychology about perceptual modalities and ranges. Architects and urban designers work with experimental qualities of three-dimensional space. This space exists just in a range of visual acuity and incorporates a bubble of space with audio acuity. Many urban designers and planners have devised cartograms and symbols helps understand urban space, edges and relationships between streets and buildings, streets and lots, etc. and represent 3D elements on plans (Figure 2). It is very difficult to create a skewed 3D perspective by hand on paper, but it is not so difficult to create skewed perspective projections in digital 3D models and present them on a plan (Figure 10). This would also reveal architectural elements on the building façade such as entrances, storefronts, etc. (see Krier, 1983).

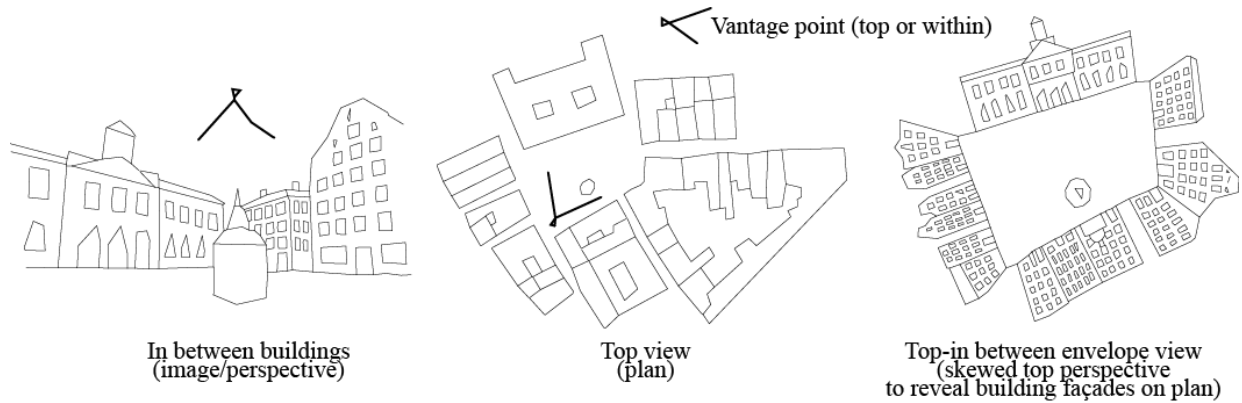


Figure 13. Typical perspectives and a skewed top perspective to show the interaction between building and street/route (visual impact)

Urban morphologists seldom work today with this three dimensional perspective (envelop view) of urban design. Future typo-morphological research could focus not only on patterns of buildings, lots and streets, but also on interactions between building façades (city block frontages/pertinent strips) and on street spaces. These urban spaces (envelop views allow symbolic representations) are behavioural environments with visual and auditory affordances. Furthermore, the cities are sequences of these behavioural environments (Cullen, 1960) refers to these kinematics as serial vision). The urban morphologists should consider kinesthetic sensation and motion that is crucial in experiencing cities today (Taylor, 2003).

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