Daniel R Montello

SPATIAL COGNITION AND ARCHITECTURAL SPACE

RESEARCH PERSPECTIVES

Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello Standfirst to come: Daniel R Montello

Cognition is knowledge and knowing in sentient beings, including humans, nonhuman animals and intelligent computational machines such as robots.[1] Core components of cognition include mental structures and processes involved in thinking, imagining, perception, learning, memory, linguistic and nonlinguistic communication, reasoning and problem-solving. Cognition is also deeply intertwined with affect (emotion) and behaviour, because what we feel and do depends in sometimes complex ways on what we believe, and vice versa. Cognitive structures and processes include both those of which we are consciously aware and those, perhaps more substantial, of which we are not conscious.

St Vitus Cathedral, Prague, 1929
The vertical expanse, elegant lines and subdued lighting from above in the St Vitus Cathedral inspire spiritual feelings.

Cognition always occurs in the contexts of places, both real and imagined. Furthermore, cognition is very often specifically focused on aspects of space, place and environment. Without question, therefore, cognitive structures and processes are deeply relevant to how people perceive and imagine architectural spaces, how they remember them, talk about and make pictorial representations of them, make behavioural decisions about and within them, and experience aesthetics and other emotional responses to them. Likewise, and just as fundamentally, the processes of architectural design involve the cognition of architects and other stakeholders.

Researchers from several disciplines study spatial cognition, including cognitive and environmental psychologists, behavioural geographers, cartographers, architects and planners, linguists, anthropologists, biologists and computer scientists. They address a diverse array of topics, including how spatial beliefs are acquired and develop over time; how such beliefs are mentally organised and used to reason; how people navigate and stay oriented; how people use language and graphical symbols to communicate with each other about space; and how aspects of spatial beliefs and reasoning are similar or different among individuals or groups of people.

Like other physical environments, architecture influences human cognition, experience and behaviour by allowing, facilitating, requiring, impeding or preventing various perceptions, thoughts, emotions and acts.

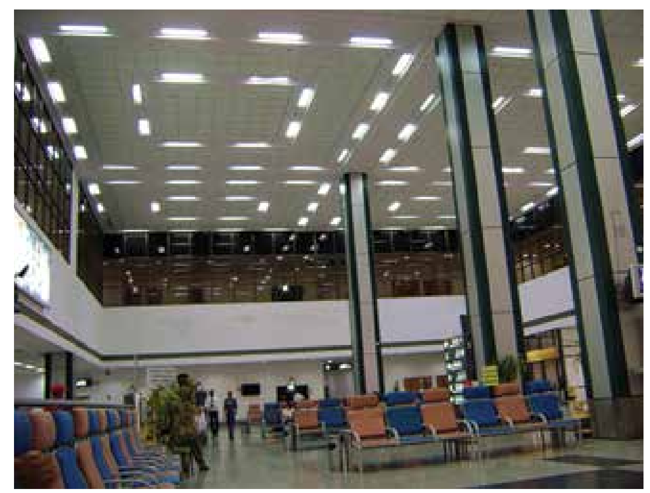
***top:* Members Lounge, Golfclub Schloss Egmating, Egmating, Germany, 1988**

***bottom:* Waiting Lounge, Sardar Vallabhbhai Patel International Airport, Ahmedabad, India, 2008**

Properties of architectural spaces can facilitate or impede sociability. The Golfclub Members Lounge has low ceilings, articulated subspaces and furniture arrangements that facilitate social intimacy. In contrast, the spatial dimensions and arrangement of the Waiting Lounge at Terminal 1 of the Sardar Vallabhbhai Patel International Airport has the opposite effect.

Environmental Cognition

Like other physical environments, architecture influences human cognition, experience and behaviour by allowing, facilitating, requiring, impeding or preventing various perceptions, thoughts, emotions and acts. Architecture does this physically, as when walls block movement, sight or sound. It does this mentally, as when visual patterns stimulate aesthetic responses or invite exploration. And it does this socioculturally, through implied rules and norms, as when entrances and walkways appear publicly inviting or privately restrictive, even when they are equally accessible in a physical sense. We can identify the cognitive mechanisms of these influences in greater detail. Architectural design affects *sensory access* – what can be seen and heard; attention –what is looked at and listened to; memorability – what is remembered about a building; knowledge – how one reasons and makes decisions; behavioural affordance – where one walks, sits and so on; affect – what one feels, including one's mood, comfort level, stress and fear, and aesthetics; and sociality – with whom one interacts socially, as a function of factors such as pedestrian flows, noise levels, social distances and body postures.



Physical attributes of architectural spaces include the shapes and sizes of their exteriors and interiors, the number and locations and appearance of their entrances and exits, their degree of articulation into chambers and pathways, the topological and metric patterns of their chambers and pathways, their number of floors above or below ground, their lighting (intensity, wavelengths, spatial pattern), the visual and tactile qualities of their surfaces (textures, colours, surface reflectivity), their temperature and humidity, the stability and smoothness of their floor surfaces, and more. All of these can influence people's cognition; the specific ways they do so depend on the nature of human perceptual and cognitive systems.

Researchers have proposed that the legibility of architectural spaces derives from three attributes of such spaces[2] (of course, non-building factors such as familiarity and spatial ability also matter):[3] (1) differentiation of appearance, (2) visual access, and (3) layout complexity. The concept of 'legibility' comes from Kevin Lynch's seminal work *The Image of the City* (1960)[4] and refers to the ease with which parts of an urban landscape can be recognised and organised into a coherent pattern. Lynch's urban principles have been applied to individual buildings, wilderness environments, web pages and more. Legibility determines the imageability of a place – how readily it evokes clear mental images – which in turn influences how easily people can maintain orientation while travelling through a place (architects usually refer to oriented and planful travel as wayfinding). However, the three attributes have implications for human experience and cognition that go well beyond orientation and route choice during wayfinding. They influence the ease of learning the layout of a space, how accurately it is remembered, one's sense of privacy and territorial control in the space, and aesthetic and emotional responses to spaces, including feelings of beauty, fear or boredom.

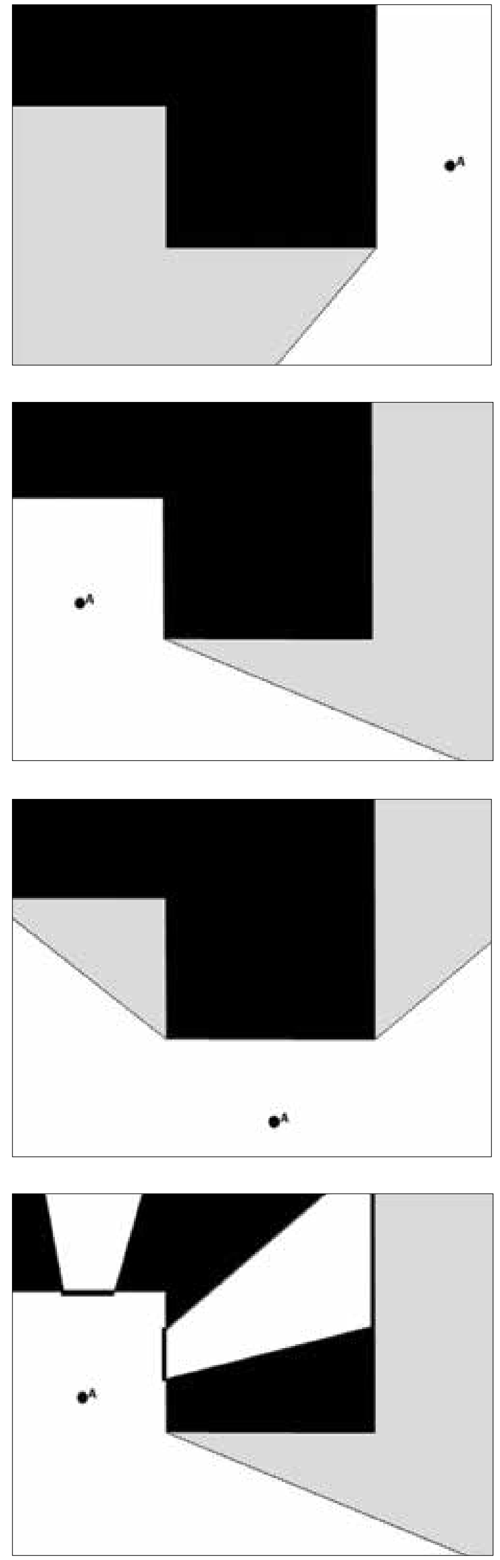
Legibility determines the imageability of a place – how readily it evokes clear mental images – which in turn influences how easily people can maintain orientation while travelling through a place (architects usually refer to oriented and planful travel as wayfinding).

Differentiation of Appearance

Differentiation of appearance refers to the fact that buildings differ in the degree to which their parts are homogeneous or heterogeneous in appearance, with respect to size, shape, colour, architectural style and so on. Generally, people find differentiated environments easier to comprehend and wayfind in because the differentiated parts are more distinct and memorable – differentiation creates better landmarks. This can go too far, however, and become chaotic and disorienting. Differentiation is a subjective variable, to a degree; what we notice in a building depends in part on our expectations, interests, training and state of mind.

Visual Access

Visual access is the degree to which different parts of the building exterior or interior can be seen from various locations. It also concerns the locations from which people can see particular parts of buildings, including the entrance, destinations and other potentially key landmarks or structural features. People have a greater sense of comprehension and can maintain their spatial orientation more easily when visual access is high. Greater visual access will decrease mystery and uncertainty. In a complex or unfamiliar environment, this will tend to reduce excessive stress, while in a simple or familiar environment, it will tend to reduce moderate stress to boredom. Control over visual access influences one's sense of privacy. Of course, visual access is more informative of, or from, some locations than others.



Visual access can be systematically studied, in both interior and exterior spaces, with the help of isovist analysis. An isovist is the collected spatial extent of all views, or vistas, from a single vantage spot. They are usually assessed as two-dimensional vistas that direct in 360 degrees around a vantage point, but both of these isovist characteristics can be modified (three-dimensional vistas, for instance, or vistas focused on the forward field-of-view). For the purpose of relating them to psychological variables, it might be relevant to analyse many different physical properties of isovists, such as total size, symmetry, maximum length and so on, but so far only a little work has systematically tested these properties. Manipulating isovists might be especially important in constricted spaces, such as prisons and outer space stations.

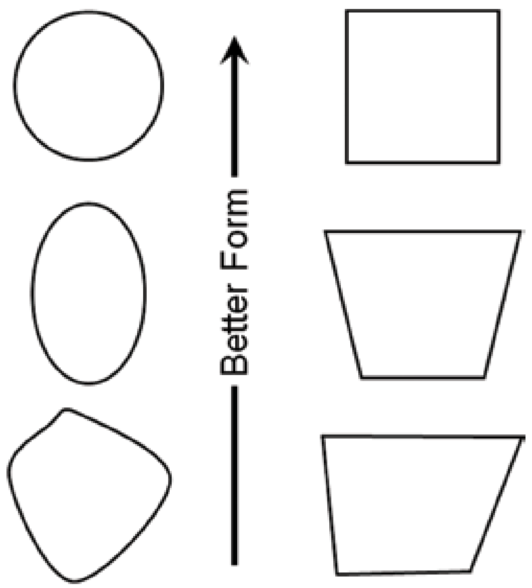
Layout Complexity

Layout complexity is probably the richest yet most poorly understood architectural attribute to consider from a cognitive perspective. There are various formal approaches to quantifying shape or network complexity, such as information theory, but these tend to ignore the fact that what constitutes a 'complex layout' cognitively depends not only on the objective layout of a building, but on the nature of human cognition in general and the cognitive characteristics of individual people specifically. This is like differentiation, but even more profoundly so. More articulated spaces, broken up into more different chambers and pathways, are generally more complex, though the way the different parts are organised is critical. Certain geometric patterns of pathways influence cognitive complexity; for example, oblique turns are more complex than straight paths and orthogonal turns. A promising analytic approach to studying topological aspects of layout complexity (those derived only from patterns of connectivity) is provided by space syntax analysis.[5]

Hospital in the Rock, Budapest, 1940s
opposite: The irregularly winding and descending corridor in the Hospital in the Rock (a secret emergency hospital and nuclear bunker) triggers fear, suspense and mystery.

Two-dimensional isovists from various viewpoints within a building
left: In each panel, white areas are visible from point A, grey areas are nonvisible from point A, and black areas are exterior to the building. Windows in the lower right panel give visual access to the exterior.

When people believe a layout follows a good form, they can readily comprehend it, even to the extent that they will mistakenly distort their understanding of the layout shape towards the good form.



An interesting aspect of layout complexity concerns the possible role of the overall shape of a layout of chambers and pathways. People find certain layouts less complex if they are close in shape to what might be called 'good form' (what the Gestalt perceptual psychologists referred to as *Prägnanz*). Curved hallways are complex, but less so if they fit within a symmetric radial pattern, as long as people grasp the radial logic. A square is better form than a rhombus; a circle is better form than a lopsided oval. When people believe a layout follows a good form, they can readily comprehend it, even to the extent that they will mistakenly distort their understanding of the layout shape towards the good form.

Limits to Understanding Architecture Through Cognitive Science

Two concerns that may be expressed about applying cognitive research to architecture are that it risks courting 'architectural determinism',[6] and that it is not very effective.[7] These two concerns are linked, and ironically so, because the more force one of them has, the less the other one has. Architectural spaces clearly do not strictly determine the cognitive (and emotional, behavioural) responses of people experiencing the spaces. But they do have likely (probabilistic) influences on human responses with sufficient strength and regularity to warrant their scientific analysis. Of course, there are many other important influences on human responses, including those derived from a person's past experiences or cultural milieu. It is challenging for the study of architectural cognition to understand the role of context (of various kinds) in providing a frame through which people make sense of the meaning of architectural structures.

Furthermore, people differ in their genetic makeup, language, physical size and mobility, educational backgrounds, preference for verbal or pictorial or numerical information, and much more. Effectively studying architectural cognition requires taking some account of this complexity. Even if this complexity were thoroughly accounted for, however, we should expect only limited success in applying cognitive research to understanding and improving architecture. After all, architecture has for centuries largely been a craft/practitioner discipline and will undoubtedly remain so to a substantial degree, at least with respect to design elements that speak directly to the experience of users (as opposed to various accounting and engineering issues). But when even imperfect scientific understanding has modest implications for so many people in so many places for so many hours, its considerable value becomes obvious.

Minoru Yamasaki, Pruitt-Igoe urban housing estate, St Louis, Missouri, 1954
above: The uniformity, spacing and high-rise isolation of buildings in the Pruitt-Igoe public housing complex infamously provoked a sense of anonymity and lack of territorial control among its residents that promoted public criminal behaviour.

***Prägnanz* (or good form) of layout shapes**
right: Good form of layout shape increases from the bottom to the top, demonstrating that the degree of good form influences layout legibility and memorability.

Garden labyrinth, Château de Villandry, Villandry, France, 17th century
A variety of factors, only some of which have been systematically researched, influence the cognitive complexity of architectural layouts. The builders of labyrinths like this one from the gardens of the Chaâteau de Villandry understood many of these factors implicitly.

Notes

1. Daniel R Montello, 'Cognitive Science', in Karen K Kemp (ed), *Encyclopedia of Geographic Information Science*, Sage Publications (Thousand Oaks, CA and London), 2008, pp 40–3.
2. Tommy Gärling, Anders Böök and Erik Lindberg, 'Spatial Orientation and Wayfinding in the Designed Environment: A Conceptual Analysis and Some Suggestions for Post Occupancy Evaluation', *Journal of Architectural Planning Resources*, 3 (1), 1986, pp 55–64.
3. Laura A Carlson, Christoph Hölscher, Thomas F Shipley and Ruth Conroy Dalton, 'Getting Lost in Buildings', *Current Directions in Psychological Science*, 19 (5), 2010, pp 284–9.
4. Kevin Lynch, *The Image of the City*, MIT Press (Cambridge, MA), 1960.
5. Craig Zimring and Ruth Conroy Dalton, 'Linking Objective Measures of Space to Cognition and Action', *Environment and Behavior*, 35 (1), 2003, pp 3–16.
6. Karen A Franck, 'Exorcising the Ghost of Physical Determinism', *Environment and Behavior*, 16 (4), 1984, pp 411–35.
7. Duncan Philip, 'Essay: The Practical Failure of Architectural Psychology', *Journal of Environmental Psychology*, 16, 1996, pp 277–84.