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estudos semióticos

Lynch meets Moser: cognition, brain and environment*

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Abstract: The proposal of Cognition and the Built Environment (MØYSTAD, 2017) is that architecture is a basic mode of human cognition. The production as well as the use of our environment is a cognitive process in and of itself. Building human environment relates to and is informed by the prior built environment. One of Christopher Alexander's observations (1987) was that "building cities" actually means changing cities. Project by project. This insight carries implications for how we understand architecture, for how we understand the human brain and for how they interact. This paper will outline (1) the interaction between some spatial and morphological properties of the built environment on one hand, and (2) some of the recently discovered properties of the brain on the other, which seem to mirror similar properties of the external environment. Based on these two sets of properties I will then (3) make a brief discussion of some theories that seem to suggest an outline, not complete but still useful, of the cognitive relationship between (1) and (2).

Keywords: cognition; grid cells; affordance; umwelt; Kevin Lynch.

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1. Navigation properties of the city

The Image of the City (LYNCH, 1960) is the first modern attempt at formulating a proper theory of urban form. It is important first to underline that Kevin Lynch understands the city in a wider sense than as a collection of buildings and people. Already in the title of his first chapter he replaces the term 'city' with 'environment'.[1] By avoiding the administrative and institutional connotations of 'city', he opens his discussion to include man-made environment in general, urban and rural alike.

Lynch adopts an anthropological perspective on environment as a human living environment as if anticipating the later adoption of biological models into the analysis of the human life world (UEXKÜLL, 2010; GIBSON, 2015). So doing Lynch shifts the emphasis away from the modernistic object based focus of his contemporary architects and urban planners. Lynch's focus is people's need for an urban environment, which facilitates mobility, interaction and communication.

The historical city, as we know it from Mumford (1961), Reader (2004) and others, was a stable spatial structure of a manageable, or rather perceivable, size; hardly larger than what Lynch refers to as a "district" (LYNCH, 1960, p. 46 ff). It changed and developed on a pace that allowed its inhabitants to adapt and to remain familiar with it.[2] The historical city never challenged its inhabitant's ability to find their way around it. Almost 2000 years ago Rome and Xi'an were the only two cities in the world with 1 mill inhabitants. When Lisbon was struck by the earthquake in 1755, it was the world's 4th biggest city with 250 000 inhabitants.

Through the 18th century and the industrial revolution, however, cities began to grow as rural population migrated from the countryside to the industrial centres. We know the history, and after WW2 the cities had long grown beyond their familiar size, shape and legibility. The modern post-war cities challenged human perception and comprehension. *Metropolis* by Fritz Lang from 1927 paints the modern urban environment as alienating and dystopic, and in his films *Mon Oncle* (1958), *Playtime* (1967) and *Trafic* (1971) Jacques Tati pictures and the alien and absurd modern environment with a touch of tragicomedy.

Lynch points out the importance of being able to navigate and to understand one's environment. We have all, at some point, experienced the awkwardness of losing our orientation in a foreign environment. Suddenly an otherwise peaceful neighbourhood can turn uncanny when you get that sinking

[1] Chapter I in *The Image of the City* is called "The Image of the Environment" (LYNCH, 1960).

[2] For a discussion of how our capacity for orientation and understanding depends on a certain speed of change see Møystad (2017, p. 125-136) and Møystad (2015, 1998).

feeling of being lost. Equally we have all felt the relief of recognising a familiar landmark at the end of the street. Cognitive semiotics links 're-cognition' intrinsically to understanding, and to knowing (BRANDT, 1991; LACAN, 1966; MØYSTAD, 1994, 2017). Phenomenological theories of cognitive development (PIAGET, 1971; NORBERG-SCHULZ, 1965) based our sense of well-being on the legibility of our spatial experience, and Kevin Lynch founded his 'Image of the City' on the built environment's capacity to accommodate our navigation of it.

1.1 'IMAGE' and its ELEMENTS

By 'Image' Kevin Lynch does not mean image in the sense we know it from marketing, or branding. He neither aims at the simplistic architectural image-making of the 1980's post modernists like the Krier brothers or at Aldo Rossi who reduced the city to a collage of building typologies. Lynch took on the burden of going beyond the individual architectural object. He pursued the complexity embedded in his concept of the 'image' of the city. We will elaborate the concept, but first we need to frame it. Lynch pointed out that it is impossible to design urban form as such. Without actually adopting the term he implied that urban form, and its content or meaning, was emergent: "Only partial control can be exercised over its growth and form. There is no final result, only a continuous succession of phases. No wonder, then, that the art of shaping cities (...) is an art quite separate from architecture or music or literature" (LYNCH, 1960, p. 2).[3] In *A New Theory of Urban Design* Christopher Alexander echoes Lynch: "First, the whole grows piecemeal, bit by bit. Second, the whole is unpredictable." (ALEXANDER, 1987, p. 14).

Where does that leave us with respect to the 'image' of the city? Who creates that? Lynch defines the Image of the City as the result of an ongoing interaction and exchange between us and our environment. One could say that 'image' in Lynch' terminology would correspond to the interpretant, to borrow a term from C.S. Peirce (BUCHLER, 1955, p. 98 ff.), of the dynamic sign structure that mediates between the city dweller and his built environment. Lynch goes on to specify the 'image' in three elements: identity, structure (image) and meaning (LYNCH, 1960, p. 8). The triadic logic thus constituted by the three elements of the 'Image' corresponds to the elements 'Object', 'Interpretant' and 'Representamen' of the Peircean sign structure, and to its architectural equivalent 'Object of Architecture' – 'Field of Architecture' – 'Work of Architecture' (MØYSTAD, 2017, p. 52-53; MØYSTAD, 1994).

In terms of navigating a complex urban environment, Lynch argues that the production of images is a key to orientation. Therefore the 'imageability' of

[3] I do believe Lynch has used the term 'architecture' here in its narrowest modern sense as the builder of buildings. Period.

an environment is the quality that allows us to develop the images we need to interpret and navigate it and hence to interact meaningfully with it.

Let us keep in mind that the development of images is a two-way process. This process can be enhanced both by educating the user and by (re)shaping the environment.[4] The main point is however, that 'image' does not reside in us, nor in our environment. Image develops through the interaction between the subject and its environment. We will discuss the perspective of the user in the next section. Let us first look at what Lynch offers with respect to the environment.

First there is the surface on which we move; the landscape. The topography offers recognizable mountain ranges, summits, passes and valleys with rivers. The plains offer mild slopes, hills, lakes and level ground. Lynch relays examples of how a culture can develop specialized knowledge that enables its members to navigate territories where strangers would get lost. He mentions how Inuits are able to navigate snow-covered planes with little or no features visible to anyone but the expert. The knowledge that enabled the creation of 'Image' was passed from generation to generation, but only among the Inuit chiefs. Similarly the ruling caste among the Polynesians was the navigators (LYNCH, 1960, p. 123-139). Knowledge is power.

James Gibson lists typical terrain features and outlines how a surface affords certain movements to animals depending on its nature (GIBSON, 2015, p. 31 ff). Firm ground affords support for movement while a sump will prevent it. Level ground affords rest, as well as fast movement, while a steep slope can only be navigated with great care (GIBSON, 2015, p. 123 ff). We will return to Gibson in the section on affordances.

These are all existing or given properties of the natural landscape. Lynch, however, also mentions the ancient Chinese method of landscape analysis, geomancy, currently better known as *Feng Shui*. The first word a visitor in China learns after *Ni Hao* (hello) is usually *Shui*, meaning water. Summers can be hot in China, and dehydration is a problem. *Feng* means wind. In traditional Chinese culture *Feng Shui* was used to analyse a landscape with respect to its topographic formation and its flows of wind and water. The goal of the analysis was not to unveil the *Genius Loci*. The goal was quite pragmatically to find places where the natural conditions and microclimate were favourable for setting up a house, or a pavilion, or a temple. If the analysis showed that the available terrain could not provide the desired conditions, the analysis would suggest how to improve the landscape to achieve the desired quality (CLÉMENT; CLÉMENT; SHIN, 1987). *Feng Shui* is considered to be a bit of a pseudo-science, which it probably is; if one considers it a science in a conventional modern way. It is

[4] Lynch mentions the latest invention in the field of city navigation (1960): 'The Directomat'. Check an image search on Google!

however also a pragmatic, almost trivial method for interacting with landscape and with nature, which I believe one may say, has proven to be as valid as any contemporary Chinese urban planning based on modern scientific methods.[5] *Feng Shui* has, Lynch points out, two interesting features: "first, that it is an open ended analysis of the environment; new meanings, new poetry, further developments are always possible; second, it leads to the use and control of outside forms and their influences: (...)." (LYNCH, 1960, p. 139).

It is interesting to observe, with *Feng Shui* in mind, that in traditional Chinese culture a landscape is not considered complete, or perfect if it does not have at least one building in it. Traditional Chinese landscape painting demonstrates this point by always including a palace, a pavilion or at least a bridge. Let us return to the built environment.

Lynch studied the cases of Boston, Jersey City and Los Angeles, and he did so in the 1950ies. He would probably not recognise them today, no more than he would find a 'button store' or a 'Directomat' in them. He would, I am sure, still be able to identify the presence as well as the absence of the elements of their 'City Image'.

It would by far exceed the format of the present text to elaborate the content of these elements exhaustively. That would also be unnecessary as the interested reader can easily find these elaborations far better formulated by Lynch in his book. Here it will be sufficient to give a list and a brief outline of the elements that, according to Lynch, form the physical properties of the urban environment, the 'imageability', that afford us the possibility to develop an 'Image' and to navigate.

PATHS form the corridors through which we move in and through the urban fabric. They lead us to work and home again. They are streets, canals, walkways, bridges, tramlines and they form the most basic elements of our 'Image' of our city. Paths are also the channels through which we observe and locate most other elements. Paths form an underlying system in the urban fabric as well as being perceivable elements in their own right. They form the basic element of Gibson's 'Terrain Features' (GIBSON, 2015, p. 31), and they are the equivalents of the paths through which the lab rats in the Kavli Institute navigate their mazes.[6]

EDGES are linear barriers or obstacles in Gibson's terminology (GIBSON, 2015, p. 31). Rows of buildings, walls around a square, along a street etc., but also by typical barriers like a railroad, a waterfront or the perimeter of a development form edges in the city. Historically the perimeter of a city would

[5] See also Pisters (2002, p. 70-77) and https://www.architecturenorway.no/questions/cities-sustainability/urban-act/.

[6] https://www.ntnu.edu/kavli/discovering-grid-cells

form an edge. The lack of edges are often in contemporary urban development bemoaned as a cause of 'Loss of Place' (NORBERG-SCHULZ, 1980) or absence of wholeness.[7]

DISTRICTS – also termed neighbourhoods[8] - are parts of a city identifiable as an individual part with an identifiable inside and outside, and a certain identifiable character. A district is of a size and a character, which allows us to identify it from the inside as well as from the outside: "I am in Greenwich Village" as well as "Over there is Greenwich Village". Districts are legible entities within a larger context whose extent or edges are beyond direct perception. This larger context is an abstract and maybe not so important 'wholeness'. More important is connectivity and continuity between the parts.[9]

NODES are specific locations, often centres in a district. The typical node is a popular square, a junction of traffic flows or a railroad station. Often a node combines two or more of these programs. Current sustainable urban development emphasises the node of public transportation, the transportation hub, as a centre of growth, of density.

LANDMARKS and nodes are equivalents to 'objects' in Moser terms. Will return to Moser and these 'objects' below. Landmarks are singular architectural objects, public buildings, but also sculptures such as the Eiffel Tower or the Nelson Column. They may be located inside the city, but also outside such as the But de Lion in Waterloo commemorating the defeat of Napoleon, or the Holmenkollen ski jump in Oslo. They can also be natural formations such as the Table Mountain outside Cape Town. Landmarks are visible from a distance and their role in image formation and orientation are obvious.

> "Obviously a clear image enables us to move about easily and quickly: to find a friend's house or a policeman or a button store.[10] But an ordered environment can do more than this; it may serve as a broad frame of reference, an organizer of activity or belief or knowledge." (LYNCH, 1960, p. 4)

2. Navigational properties of the brain

Lynch suggested that our physical environment works as an "organizer of activity or belief or knowledge" (LYNCH, 1960, p. 4). In order for us to profit from this capacity of our environment, we need to navigate it. It has to be legible

[7] Alexander (1987) insists on the importance of 'growing a whole', while one might ask if 'growing continuity' would not be better. When Lynch emphasizes 'The sense of the Whole' (1960, p. 108), he is for all practical purposes referring to continuity between districts.

[8] Cf Jan Gehl (1987) and Jane Jacobs (1961).

[9] Connectivity is a key concept in the study of Space Syntax. Cf Social Logic of Space, by Bill Hiller (1984) and www.spacesyntax.com

[10] Finding a button store is not as easy anymore. Today Lynch might have chosen an Apple store as example.

to us; and hence 'imageable'. So far the properties of the external environment. In order to navigate it and to develop images of it, however, our brains need tools with which to receive, to read, and ultimately, based on these inputs, to produce "activity or belief or knowledge" (LYNCH, 1960, p. 4).

Lynch confidently asserts that "Despite a few remaining puzzles, it now seems unlikely that there is any mystic 'instinct' of way-finding. Rather there is a consistent use and organization of definite sensory cues from the external environment" (LYNCH, 1960, p. 4). Indeed the discovery of place-cells and grid-cells in the brain are about to solve one of the "remaining puzzles".[11] The Kavli Institute at the NTNU seems currently to be rapidly uncovering the architecture of the mammalian hippocampus that enables us to navigate our environment. In popular terms this architecture is referred to as 'the GPS system of the brain'. One main goal of this research is to map the relationship between navigation and memory, and thereby to understand how memory works and to find the reasons for the current dramatic increase of Alzheimer and other forms of dementia.[12]

In a 2013 paper, "Memory, Navigation and Theta Rhythm in the Hippocampal-Enthorinal System", Moser suggests that activities of memory and planning are closely related, and that they have evolved from mechanisms of navigation in the external world (MOSER; BUZSÁKI, 2013, p. 130-138). In 2015 the Mosers move another step further saying that this investigation aims to 'provide important clues about general principles for cortical computation, extending well beyond the domain of space into the realm of thinking, planning, reflection and imagination' (MOSER; MOSER 2015, p. 76).

This research has already identified a pallet of specific tools of navigation and, borrowing Lynch' term, of 'Image'-making. The tools embedded in the mammalian hippocampus[13] are specialized neurons, or cells. The following is a preliminary inventory of that toolbox.

PLACE CELLS were the first type to be identified; by John O'Keefe in 1971. These cells are a kind of 'pyramidal' or multipolar neuron. These neurons are among the first to fire up when the animal gets excited. When the animal enters a particular place (cf Lynch: 'node'), or a place field (cf Lynch: 'district'), the place cells fire up in a pattern, which is specific to that particular place. The pattern enables the animal to recognize and to identify the place. The parallel between

[11] John O'Keefe (UCL) discovered place cells in 1971, and Edvard and May-Britt Moser (NTNU) the grid cells in 2005. In 2014 they were jointly awarded the Nobel Prize for medicine for their discoveries.

[12] From 2004 – 2010 the total number of cases of brain diseases in Europe increased with about 30%; far more than what can be explained by increased life span.

[13] It is important to note that the research has so far only been done on rats in the Moser Lab, but expectations are that in broad lines the results are valid for most mammals – including humans.

'place' and 'place field' with Lynch' elements of the external environment 'node' and 'district' seems attractive.

While place cells are good at identifying a place, it needs assistance to locate or to find it.

GRID CELLS on the other hand are specialized in understanding where in space a place is located. When the lab rat moves freely in an open space, its grid cells fire at points with the same distance from each other. In this way they generate an abstract, hexagonal grid. This grid provides nothing in terms of recognition.

The grid is abstract and global. Grid cells in combination with place cells, however, form an efficient navigation system. While grid cells provide the equivalent to the little red marker on the google map that tells you where your destination is, is doing a comparable job to what our grid cells do. We can compare the street view function to that of the place cell. It conveys certain characteristics of a place, but nothing that gives away its location.

Think of how the Romans shaped and managed their world. Roman cities were nodes, organized on a local grid pattern, connected by a system of roads, or paths. While each city was recognizable as a local 'district', a place field, the global system of 'paths' afforded efficient transportation of goods and information within an abstract system that afforded navigation over the entire known world. For a further discussion of this comparison, check CoBE (MØYSTAD, 2017, p. 60 ff.).

It is also worth noting that while the map grid of the Romans as well as the grid we still use in geography and navigation as well as in architecture and urban planning is based on parallel latitudes and longitudes. Erastosthenes of Cyrene is considered the inventor of the parallel grid.[14] The hippocampal grid is however based on triangulation. The brain is in other words more pragmatic than Erastothenes was, because it maps the world as it is: spherical and rugged. Only triangulation can deal with that. It works on one simple algorithm: all points on any given surface must keep the same distance from each other no matter the topography of it. All mammals can relate to that.

SPEED CELLS do what the name suggests; they record the speed by which the animal moves. It sounds banal, but in urbanism time has long been a basic dimension of space. The size, or extent, of an integrated housing and working environment (a 'district') is usually measured in travelling time rather than in kilometres (45 minutes door to door).

Another link between speed and orientation is the speed by which an environment changes. If it changes faster than our ability to adapt, the change will cause vertigo and disorientation. Think of any post disaster or war situation

[14] The invention of a geographic coordinate system is generally credited to Eratosthenes of Cyrene

(MØYSTAD, 2017; 2008). The 'shock and awe' principle is based on the same effect.[15]

HEAD DIRECTION CELLS fire when the animal turns its head in a specific direction relative to the direction of the animal's body. The intensity of the firing increases with the number of degrees until a maximum, usually at 45. Their function is to complement the animal's sense of direction and its position relative to an identified point, object, node or edge.

In a chapter on different systems of reference Lynch mentions the Arunta people of Australia. When they refer to an object, they usually specify its proximity, orientation and visibility relative to the speaker (LYNCH, 1960, p. 129).

BORDER CELLS identify borders, boundaries and edges similar to 'Edge' in Lynch. These cells typically work with place cells and fill in special characteristics of a place field.

The following kinds of cells are still being studied at the Kavli Institute. The rest of this list therefore refers to the Onsager Lecture by May-Britt and Edvard Moser in January 2018.[16]

OBJECT CELLS serve the episodic memory (DESHMUK; KNIERIM, 2011). May-Britt Moser's words: "Object cells provide memories with a content".[17] Objects in the present sense are not only physical objects. They could also be a particular event linked to a particular place, as in 'every time I pass this gate, the outdoor lamp turns on'.

Episodic memory presupposes consciousness. It was therefore considered to be an exclusively human trait. It is however now identified in other mammals too. In itself an interesting fact. By way of comparing with Lynch' list of elements, 'Landmarks' would serve as an 'Object'.

OBJECT VECTOR CELLS record how close is the animal to an object, and in which direction the object is located in relation to the animal. Picture a war movie. The sergeant of an advancing unit turns towards his men and wispers: "Charlie at three o'clock".

TRACE CELLS record the memory of an object. In 2015 a PhD student in the Moser Group, Albert Tsao was studying how a lab rat records the location of an object. He discovered that the rat kept the recording after Tsao had removed the object. Then he started to move the object around in the rat space. The rat

[15] "... term for a military strategy based on achieving rapid dominance over an adversary by the initial imposition of overwhelming force" (KNOWLES, 2006).

[16] The Onsager Lecture at Norwegian University of Science and Technology, January 25th, 2018.

[17] This is how May-Britt Moser described Object Cells at The Onsager Lecture given by Edvard and May-Britt Moser at the NTNU on 25.01.2018. https://www.ntnu.edu/onsager/lecture.

kept traces of all the locations and recorded the historical pattern of changes. Tsao identified the trace cell.

In his novel *Il quartieri di Firenze* from 1947 Vasco Pratolini (LYNCH, 1960) accounts how people in Firenze kept following streets that no longer existed after the bombardments of WW2. In downtown Beirut during the first post war years 1992-5 a similar phenomenon could be observed when people brought plastic chairs to enjoy their coffee from ambulating coffee vendors along no longer existing sidewalks.[18]

ME CELLS or 'pronoun cells' are the latest item in the toolbox. It is currently being studied by a PhD student, Øyvind Høydal. The Me Cell records the position of the observing subject. Obviously: what use is proximity, head direction or speed, if it is not related to some point of observation? When the google map has shown you the location of your destination and you want to get there, you need to know where 'me' is. The little blue dot is the 'me-dot'.

After telling the audience about the ongoing investigation of the pronoun cell May-Britt Moser quipped: how about a preposition cell?

During the Q&A session after the lecture, a very interesting question came up: "Are the different kinds of cells different cells, or are they cells who have learnt to do different things?" Edvard Moser gave a short and concise answer: "Interesting question. We don't know the answer". It is indeed an interesting question. If there are specific cells with specific properties that enable them to do specific tasks, the toolbox is a given. If cells learn to execute their tasks, it would probably mean that they were also able to adapt to new programs – and hence to adapt to new properties in the environment. Let us hope the Moser group will be able to find the answer to that question.

We have seen that Lynch outlines a set of properties in the urban environment that, he believes, makes it legible to us; properties that provide the urban environment with 'imageability'. Systematic and empirically based though the Lynch study is, its foundation remains a hypothesis of imageability or what Karl Friston might call 'an active inference'; "an organizer of activity or belief or knowledge" (LYNCH, 1960, p. 129). Lynch' empirical study of his three cities supports a viable and useful theory about how certain forms and properties of the urban environment, systematized in the list of elements, support the hypothesis. Nothing is, however, scientifically tested or proven and can be held for firm knowledge.

The architecture of the mammalian hippocampus, however, is being mapped and studied scientifically. The research team detects, observes, tests different cells, and the lab experiments prove or disprove the cell's existence and

[18] Personal observation described in Møystad (1998).

as well as their properties one by one. This is possible in a laboratory with lab rats and a controllable environment. Not so with real people in a real city.

One common point between Lynch and the Moser group is however that both parties presuppose that the architecture they study relates to corresponding architectures respectively outside and inside the brain who somehow mirror or resonate with each other.

Given that we were able to establish the relationship between the internal and the external architectures, one would think that a set of proven hippocampal properties might help us specify the corresponding list of external elements on Lynch' list.

On the other hand, if it turns out that cells are not holding a given property, but that they learn to execute certain tasks, one might think that the list of external elements is not a given either. In this case the 'imageability' of the external environment would suggest a more dynamic, and more intrinsically reciprocal relationship between it and the hippocampal architecture.

3. Brain-environment interaction

After Darwin a number of theories have been put forward in order to frame the life world of a particular species in order to distinguish it from nature in general. Certain plants need certain microclimatic conditions and quality of soil. The Ice bear needs ice, the scorpion needs desert and the ant needs a forest. Ants even adapt its lifeworld to its needs by collecting pine needles and building anthills, beavers build dams, and humans build houses, roads and cities.

A species hence occupies, appropriates and uses a part of its environment, and this part is its ecological niche. Important to notice is that the niche is not a habitat, and its 'environment' is defined by its features and not by the territory it occupies. *Niche* concerns the interaction and the interplay between the animal and its environment. A *niche* refers to *how* an animal lives rather than *where* it lives. This importantly distinguishes *niche* from its perversion in the concept of '*lebensraum',* which was adopted by the Nazis [19] in order to justify their occupation of other territories. James Gibson defines *niche* as "a set of affordances" (GIBSON, 2015, p. 151). We will return to the concept of affordance later.

Jacob von Uexküll (1864-1944), a Baltic German biologist, took a primary interest in how nature distributes information. In his *Theory of Meaning*[20] He saw the exchange of meaning between animals and plants, between hunter and

[19] Cf. Bollnow (1963, p. 257). See also https://www.architecturenorway.no/questions/identity/moystad-on-cns/.

[20] This work is included in Uexküll (2010).

prey, between mating individuals etc as a basic level of life and of the life world of an animal. Uexküll termed this life world *Umwelt*. Uexküll construes *Umwelt* as constituted by the continuous semiosis between the organism (animal) and its environment. Each element[21] of an *Umwelt* signifies something particular to the animal, and hence it represents the animal's model (cf. Lynch' 'Image') of the (its) world. Uexküll illustrates how a dead object like a stone can become a carrier of meaning by entering into a relationship with a subject. Picture a man walking along a paved country road. Towards him comes a dog, sneering and showing its teeth. The man picks up a loose cobblestone from the road and throws it at the dog. The dog runs away. From a hill near by an observer has witnessed the episode. The observer now enters the scene and picks up the stone. "The stone, which lies as a relationless object in the hand of the observer, becomes a carrier of meaning as soon as it enters into a relationship with a subject." (UEXKÜLL, 2010, p. 140). Allowing ourselves a moment of confabulation, let us say that the observer was an architect. Through his relationship with the stone, he might develop the stone's meaning further by letting the stone serve as keystone in an arch over the entrance to a house he is designing. The stone would then become part of another subject's life world. Let us leave the stone and the architect here and return to it below.

Uexküll opened the field of biology to semiotics[22]. A number of biologists and semioticians have fruitfully studied biosemiotics later (BARBIERI, 2007).[23] In 1993 the Danish biologist Jesper Hoffmeyer proposed to complement the term biosphere with 'semiosphere' (HOFFMEYER, 1993, 1997). He suggested that the basic level of nature is information, and that the sign is its basic element. In *Introduction to Biosemiotics* (2007) Hoffmeyer contributes a chapter called "Semiotic Scaffolding of Living Systems" (BARBIERI, 2007, p. 149-166)[24]. In this text he outlines how signs are organised in structures that that are designed to guide organisms in their interpretation of what he terms 'cue elements that are present in dynamic situations' (HOFFMEYER, 2008, p. 149). The term scaffold alludes to the scaffolds used to guide and support the constructions of buildings. Semiotic scaffolding provides semiosis with a stability that affords the organism a reliable interpretation and hence the ability to produce effects through interpretation. Hoffmeyer then proposes the term "*Semiotic causation*" for this mechanism (HOFFMEYER, 2008, p. 4). Semiosis alone can however, not produce effects. Semiotic causation needs the support of the behaviour (properties) of the organism as well as of the properties of the environment. Hoffmeyer paraphrases Kant thus: "*Semiotic causation without efficient causation is*

[21] Cf. Lynch (1960).

[22] Semiotics is the science of signs.

[23] This book gives a broad and exhaustive coverage of the field and its history.

[24] The term was first coined in semiotics by A. Clark, and then elaborated by Hoffmeyer.

helpless, and efficient causation without semiotic causation is blind." (HOFFMEYER, 2008, p. 4).

Cobley and Stjernfeld take the concept of scaffolding beyond biology and into the humanities (COBLEY; STJERNFELD, 2015). Producing effects implies agency, and agency is essential to survival and evolution. A growing position in recent cognitive research holds that the brain is not an information processor, which issues behavioural instructions and cultural interactions. The IP metaphor of the brain is losing ground to the concept of cognition as direct interaction and of embodied (and radical embodied) cognition (EPSTEIN, 2016; CHEMERO, 2009). Evolution has probably not been unilaterally producing human culture and civilization. There is growing evidence that human "activity or belief or knowledge" (LYNCH, 1960, p. 4) has been fed back into evolution; to a degree where we are now speaking of an anthropocene world (COBLEY; STJERNFELD, 2015, p. 295).

The concepts of Niche, *Umwelt*, Scaffolding, semiotic causation and agency are all suggesting a cognitive loop of interactive learning and interaction between man and environment. 'Affordances' represent a proposal for a theory of tools for such interaction. It will go beyond the scope of the present text to elaborate on all the theories and discussions on affordances. For our purposes it will be sufficient to outline the main aspects of the concept.

We briefly mentioned the concept of 'affordance' above when referring to '*niche*' as a' set of affordances'. James Gibson developed the concept during the 1970ies and established it in his book *The Ecological Approach to Visual Perception* (GIBSON, 2015). Gibson referred the origin of the concept back to the German psychologist Kurt Koffka (1886-1941) with the following quotation from *Principles of Gestalt Psychology*: "*Each thing says what it is --- a fruit says 'Eat me'; water says 'Drink me'; thunder says 'fear me'; and woman says 'love me*" (KOFFKA, 1935). The architect Louis Kahn gave a similar account of a dialogue with a brick; cf the stone as a carrier of meaning in the Uexküll story above: "'What do you want, brick?' Brick says to you, "I like an arch." If you say to brick, "arches are expensive and I can use a concrete lintel over an opening. What do you think of that, brick?" Brick says: 'I like an arch'" (KAHN; TWOMBLY, 2003).

In Gibson's terms Koffka describes how, in his account, the environment affords its properties to man. Kurt Lewin elaborated on how water, fruit and bricks 'invite' the observer depending on his needs or intentions (GIBSON, 2015, p. 161). Louis Kahn describes an interaction where man and brick offer their features and dispositions to each other. Louis Kahn brought intention and architectural agency to the equation. The brick brought its structural properties. In the buildings for the Indian Institute of Management in Ahmedabad from 1974 he established the relation between his disposition on one hand and that

of the brick on the other in his design (agency) of the lintels of the building's windows. (do Google it)

In other projects, Kahn, and most other architects, have opted for the concrete lintel and no arch, or concrete arches with no bricks. Obviously the 'invitation' of the brick has occasionally come across as a 'repulsor'. This is the dynamic that needs, situations and different intentions will produce. In all cases, however, one may assume that the features of the brick invariably bring a causation to the fore, and man invariably brings his thirst, his hunger and his dreams or his need for a good quality, but affordable house as causations. Kurt Lewis proposes 'Valance' as a neutral term for the dynamics of push/pull of attraction/repulsion (GIBSON, 2015, p. 161) which is playing out between Kahn and the brick, or between man and environment. The 'Valences' implied sets of vectors, picture arrows indicating the directions of pull-push forces. These vectors regulate the behaviour that plays out between the animal (Kahn) and the object (brick). To think that we feature 'vector-cells' as part of our brains!

The concept of affordance is obviously still under discussion, but it has proven surprisingly resilient and able to withstand quite a lot of current hard research. 'Affordance' is still part of the cognitive research discourse, including the discourse of cognitive semiotics.

Gibson laid down an entire ontology of surfaces, materials, and other features of man's environment; not unlike Lynch' work on the city. This work laid the grounds for "a form of realism about meaning, in which meaning (affordances) is a real aspect of the world (...)." (CHEMERO, 2003, p. 193-194). Chemero later repeated and elaborated the material, real world basis of this semiosis stating that "... affordances are relations between animals and features of situations" (CHEMERO, 2009, p. 141).

Concluding remarks

Affordance, Niche, Umwelt, Image, Legibility and the study of the navigation architecture of the mammalian hippocampus all work on the common assumption that there is a basic cognitive interaction between animal and its environment. The approaches all seem to build on the premise that the interaction is reciprocal, and that cognition is somehow a natural process like, let us say, metabolism is a natural process.

We have already hypothesized a cognitive link between brain and built environment. Lynch tells us that when it comes to the form of our built environment "There is no final result, only a continuous succession of phases."[25] Man and his built environment must therefore be understood as an evolutionary

[25] Cf. note 11.

system. This implies that knowledge based on direct interaction between man and his environment may be irreversible, but it is not final. In urban terms we may remind ourselves of the simultaneous presence of various phases, or buildings of various ages. In neurological terms; the colocation and collaboration of planning and memory in the brain.

René Thom helps us understand this through his apology for the concept of 'final causes' in Aristotelian physics (THOM, 1988, p. 219 ff). The objection to this final cause is that it is strictly seen posterior to its effect, which in its turn implies the possibility of influencing one's own past. The act (-of the cause), according to Aristotle (1979), has a goal or a *telos*, which can be understood as a form which it imposes on the future as a morphogenetic field. In the terms of our built environment, we can think of the act as a 'Work of Architecture' and of the field as the 'Field of Architecture'. The quantitative dimension of a space-time entity such as the Work of Architecture is a space-time form, and therefore not final inasmuch as whoever conducts the act will, in the act, influence the evolution of the field. Every new building changes the city and hence its own contextual meaning. The validity of the form thus imposed on the future, is strictly qualitative or *topological*. The finality of the act is in other words conditional inasmuch as any causality implies future. Thom suggests the possibility of a form which on a qualitative level only exists as a projection on to a not yet existing future – in which a quantitative form is anticipated and as such is allowed to influence its own past. That is how urban development unfolds.

Acknowledging that this reasoning represents a delicate balancing act, Thom admits that this may present Aristotle with a dangerous problem: "*du mois, il peut répondre qu'au depart le support matériel est necessaire, mais sans doute pas n'importe quelle matière; il y faut une* materia signata *pourvue d'une 'information appropriée' – un terrain competent, diraient les embryologists*." (THOM, 1988, p. 221). No less dangerously I would suggest that the urbanists might look to the 'Object of Architecture' for '*une* materia signata *pourvue d'une 'information appropriée'*.

In the *Umwelt* of Uexküll there is an evolving semiosis between the animal and its environment. The elements of this semiosis are the animal ('subject'), the carrier of meaning ('object'), and the *Umwelt* in which they live. The interaction between animal and object consists of a sequence of 'perception marks' followed by 'effect marks' (UEXKÜLL, 2010, p. 145). These marks are not physical properties that belong to the object. They are rather marks of meaning produced through the semiosis between animal (subject) and object (carrier of meaning). The perception mark represents a piece of meaning that the animal recognizes and invests as a potentially meaningful property in the object. Think of the story with the cobblestone and the attacking dog. The subject (the man attacked by the dog) marks the carrier of meaning (stone) with a 'perception mark' or 'meaning': 'hard,

blunt and throwable thing'. The sequence then proceeds to the 'effect mark': 'anti-dog missile'.

Uexküll outlines the interaction between animal and object thus: "Since every action begins with the production of a perception mark and ends with the impression of an effect mark on the same carrier of meaning, one can speak of a functional cycle, which connects the carrier of meaning with the subject." (UEXKÜLL, 2010, p. 145). Think of Lynch; the imageability of the environment is a co-creation, or an interaction between features in the environment and man's ability to read and to interpret those features and thus to generate meaningful 'images'. When Uexküll produces an 'effect mark' on an 'object', he reshapes his *Umwelt*.

Bearing in mind that all the elements of this cycle are inscribed in an *Umwelt*, the structure of the 'functional cycle' is resting on these three elements: 'subject'-'object'-'Umwelt'. The semiosis is hence not a linguistic, binary one, but a pragmatic ternary one. It relates to Peirce rather than to Saussure if you will.

The dynamic of semiosis does, according to Peirce (1931-1958), Gibson (2015), Uexküll (2010), Møystad (1994, 2017) and later theories of affordances, 'functional cycles' and other forms of pragmatic and naturalist semiosis, hold an invariable or stable abstract structure. Think of Kahn again. His various dialogues with various materials, economies and clients produce various forces of push and pull. The trajectory from concept through design and production to built object, and onwards to use, maintenance, re-use and eventually to demolition and memory, does nevertheless and in spite of all its complexities, its actors, actants (subjects as well as objects[26]) and variations hold a certain formal and structural stability.[27]

Uexküll did not distinguish between kinds of animals when he construed the 'functional cycle'. Animals, like birds or termites, do adapt their *Umwelt* by building nests and mounds, and we usually assume that they do so for reasons they have – like the need for shelter, or for a spatial organization of their group. We also usually assume that birds and termites are not consciously reflecting on those reasons (DENNETT, 2017, p. 40 ff). *Homo Sapiens*, on the other hand, does reflect consciously on how as well as why to re-design and intervene in his *Umwelt*[28]. By way of illustrating this difference between man and termite, Daniel Dennett shows

[26] Cf Latour's Actor Network Theory (LATOUR, 2005).

[27] Work of Architecture in Cognition and the Built Environment (CoBE) (MØYSTAD, 2017). Cf. also René Thom (1989).

[28] "Thus, master-artists are considered wiser not in virtue of their ability to do something but in virtue of having the theory and knowing the causes" Aristotle (1979, 981b5).

us an image where an African termite mound is juxtaposed with *La Sagrada Familia* in Barcelona.[29]

In his *Sapiens. A brief History of Humankind* Yuval Harari introduces the notion of a cognitive revolution, which happened some 30-70 000 years ago (HARARI, 2015, p. 21). This revolution produced a certain human primacy leading towards what is now understood, for good or for bad, as an *anthropocene* epoch. The main driver of which, according to Harari, is our human ability to create narratives and to reflect on our own role in the universe. This cognitive ability is at the base of our present evolutionary primacy (HARARI, 2015, p. 2-75). The similarities between the termite mound and *La Sagrada Familia* are obvious almost to the point of uncanniness. The difference is embedded in the religious narratives that, beyond the brilliant engineering work and craftsmanship, drove Antonio Gaudi to produce his masterwork.

Maybe, in the future we will discover that animals do have consciousness and do reflect on narratives and the meaning of life, like us. For now, however, we are not able to know. Let us therefore keep the question open and focus on human cognition to begin with. Then we can discuss the epistemological implication of the fact that 'Environment' in terms of 'biological niche' or '*Umwelt*', in the case of humans, is being consciously adapted, shaped, and in the case of our built environment, our cities, even produced by us. What does it imply that this niche holds properties that form a relation of affordance with the brain of the 'animal' who shaped it? It is a semiosis where we are on both sides of the table!

Gibson claimed that "Architects and designers know such facts, but they lack a theory of affordances to encompass them in a system" (GIBSON, 2015, p. 128). In *Cognition and the Built Environment* I have tried to address this lack.

Four final questions

The Moser lab aims at solving the problem of Alzheimer's disease. If the assumption of cognition through direct interaction is valid, would it not make sense to assume that some causes for Alzheimer also rest in our built environment?

Is it possible to perceive an urban form (path, edge, corridor, landmark etc) as an 'Object of Architecture'?[30] If so, could it be awarded to an architect as a commission? Who would write the brief, and who would sign the contract?

The various theories of affordances discuss affordances for sitting, for walking, for eating etc. If cognition, like metabolism, is a natural process, is it possible to imagine affordances for aesthetic enjoyment, for reflection, for

[29] https://geneticliteracyproject.org/2017/02/13/evolution-mind-termite-colonies-termites-models-human-brain/

[30] CoBE part III (MØYSTAD, 2017, p. 95-122).

cognition? Which affordances may have been at play in the creation of *La Sagrada Familia*?

Comparing the 'Field of Architecture' to C. H. Waddington's epigenetic landscape (WADDINGTON, 1957), and based on René Thom's spatiotemporal phenomenology (THOM, 1991), *Cognition and the Built Environment* suggests a topology of the 'Work of Architecture' modelled on the Buttefly - at t<0.[31] Is it possible to construe a 'Work of Architecture'[32] as an affordance? As an active inference? (FRISTON; SAMOTHRAKIS; MONTAGUE, 2012). ●

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[31] CoBE part IV (MØYSTAD, 2017, p. 145-162).

[32] CoBE part IV (MØYSTAD, 2017, p. 123-162).

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Lynch rencontre Moser: cognition, cerveau et environnement

MØYSTAD, Ole

Résumé : L'idée soulevée par Cognition et l'Environnement Bâti (MØYSTAD, 2017) est que l'architecture est un mode de base de la cognition humaine. La production ainsi que l'utilisation de notre environnement est un processus cognitif en soi. Construire l'environnement humain se rapporte à l'environnement antérieur et est informé par celui-ci. Une des observations portées par Christopher Alexander (1987) est que « construire les villes » signifie en fait « changer les villes ». Projet après projet. Cette idée influence la façon dont nous comprenons l'architecture, la façon dont nous comprenons le cerveau humain, et la manière dont ils interagissent. Cet article étudie d'une part (1) l'interaction entre les propriétés spatiales et morphologiques de l'environnement bâti, puis d'autre part (2) certaines des propriétés du cerveau récemment découvertes. Ces dernières semblent refléter des propriétés similaires à celles de l'environnement extérieur. M'appuyant sur ces deux ensembles de propriétés, je porterai ensuite (3) un regard critique sur plusieurs théories semblant suggérer une esquisse, incomplète mais néanmoins utile, de la relation cognitive entre (1) et (2).

Mots-clés : cognition ; cellules de grille ; affordance ; umwelt ; Kevin Lynch.

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